
The Results of Numerical Modeling

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Abstract

A model of decision-making of high-tech company on the formation of optimal portfolio structure is considered. In selecting a project among several promising, company takes into account the totality of characteristics like the attractiveness, cost, required personnel, the likelihood of successful implementation and others to launch a new multi-stages innovation project. The model is relevant for high-tech and innovative industries that use multi-stage model of production taking into account the uncertainties that arise in the transition between stages. Numerical results of the formation of optimal portfolios are presented.
Keywords: imitation modeling, fuzzy logic, decision making, multistage production, Monte-Carlo method, portfolio, numerical modelling results

1 Introduction

In this paper, we develop a model of decision-making management of the company to form the optimal portfolio of innovation (venture) projects where each project in the portfolio is analyzed for its parameters such as the attractiveness of the (priority) areas of activity, the duration of the project, cost, availability of the necessary personnel, the forecast profitability of the project, the likelihood of its successful implementation, depending on the scale of the project. The basics of this model are outlined in [1] and this paper shows the numerical results for the formation of the optimal portfolio of innovation (venture) projects.

2 Statement of the problem

Formation of an optimum portfolio.

In order to form an optimal portfolio, company first assesses the direction and determines of the desired distribution of available resources between projects. In the first step, company creates new project for the most attractive direction, for which conducts the procedure of selection of the optimal scale. For this purpose, as stated in [1, 2], possible trajectories of companies state are created using Monte-Carlo method [3]. In the nodes of those trajectories (which are the end of the respective stages) the fate of the project is determined. If the project proceeds, then in the nodes of trajectories the resources for the next stage are deducted from the available resources. For trajectories where the project is terminated by the decision of the management or other circumstances, in their respective nodes the company pays a penalty, and labor and material resources reserved for the next stages of the project are released and added to the existing resources of the company. On those trajectories that end with the successful implementation of the project the necessary resources are deducted in all nodes of the trajectory. The results are aggregated over all trajectories. In the next step of the formation of the portfolio, the company creates the next most attractive project using remaining resources. It can be a project of the same direction or of the less attractive direction. For all trajectories with the new values of resources, the company estimates the optimal scale of the new project using the same procedure.

Simulation results

To simulate the decision process of any high-tech industry the work of experts is required in order to assess the parameters of the model and to formulate specific rules for all the parts of the model. In this paper as an illustration of the work in of model we will use abstract data and quite basic conclusions for forming decision-making rules. As mentioned in [1] as mathematical apparatus
for realization decision-making procedure a Sugeno-type fuzzy inference system [4, 5] was chosen.

**Generating model data.**

For determination direction’s attractiveness model data was obtained as follows. For G input parameters, uniformly distributed set of points are generated in the G-dimensional space. The coordinates of the points set out in the restated from 0 to 1 in accordance with their reversibility. That is, when the most negative value for the company corresponds to its highest in absolute value — for example, the degree of the complexity of development. Thus, all of the generated points are placed in the unit hypercube. We distinguish between two standard points in the parameter space: ideal for a bad evaluation and perfectly good estimate coordinates, respectively, \((0, \ldots, 0)\) and \((1, \ldots, 1)\). Then, taking into account the scale of the selected coordinate \(\sqrt{G}\) — is a distance between the most distant points of the input values (i.e., between standards). By calculating the Euclidean distance between all generated points and the references, normalized on \(\sqrt{G}\), that points can be roughly divided into some group (we have identified five groups):

1) two extreme groups (with very good or very bad characteristics) include points that have a distance from their standards equal to or less than 0.2;
2) two groups with relatively bad and relatively good characteristics include points with a distance more than 0.2 and less than or equal to 0.4;
3) one group of neutral characteristics includes all point that does not belong to any of the above groups.

As an example, the results of study of two fuzzy models for decision-making on the completion or continuation of the project (15,000 trajectories), the output of which are respectively of magnitude: propensity to completion and a tendency to continue working on the project range from 0 to 1.

Fig. 1 shows the resulting distribution conditionally very poor, poor, average, good and very good evaluations of projects to model data for both fuzzy models, and Fig. 2 shows the relationship between the outputs of fuzzy models. As it can be seen in the charts, the range of values calculated from the input data of the respective groups is logically consistent — for input parameter values having a negative sense for the company there is a high propensity for project termination and a low propensity to continue and vice versa.
Fig. 1. The distribution of the fuzzy system output decision on the continuation or closure

Fig. 2. The output of the fuzzy system decision on the continuation of the project (horizontal axis) and the closure of the project (vertical axis) during training on the grid of the generated model data to continuation or termination of the development.

The model parameters and determine the degree of attractiveness of destinations.

Optimal portfolio modeling was conducted for the company of industry that possesses the following characteristics (Table 1).
Model of decision-making of high-tech company

Table 1. Considering stages

<table>
<thead>
<tr>
<th>Stage</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\varepsilon q_k) the proportion of labor costs of the stage in the project</td>
<td>0.28</td>
<td>0.16</td>
<td>0.26</td>
<td>0.08</td>
<td>0.22</td>
</tr>
<tr>
<td>(\varepsilon t_k) the proportion of the duration of the stage in the project</td>
<td>0.18</td>
<td>0.22</td>
<td>0.18</td>
<td>0.22</td>
<td>0.2</td>
</tr>
</tbody>
</table>

After learning fuzzy model to determine the degree of attractiveness of areas for the company for specific areas of the model parameters (Table 2), we limit the resources allocated for the implementation of projects (listed in the last row of Table 2).

Table 2. Parameters of considering directions

<table>
<thead>
<tr>
<th>Directions</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply (Estimate of supply in direction in balls between 1 and 10)</td>
<td>4</td>
<td>8</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Demand (Estimate of supply in direction in balls between 1 and 10)</td>
<td>8</td>
<td>4</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>Difficulty (Estimate of difficulty of project development in direction in balls between 1 and 10)</td>
<td>4</td>
<td>4</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>Benefits (Estimate of profitability of project development in direction in balls between 1 and 10)</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>Duration (duration of average project in direction in days)</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>Yield (Yield of each project in direction)</td>
<td>40%</td>
<td>40%</td>
<td>25%</td>
<td>75%</td>
</tr>
<tr>
<td>Minimum rentability (Project with lesser rentability will be rejected)</td>
<td>25%</td>
<td>25%</td>
<td>15%</td>
<td>35%</td>
</tr>
<tr>
<td>Qmin (Minimal labor cost of project, in man-day)</td>
<td>70</td>
<td>100</td>
<td>60</td>
<td>120</td>
</tr>
</tbody>
</table>

Determining the optimal size of the project company.

Below there are examples of determining the optimal scale of the company’s projects and there is a likelihood of being terminated on one of the intermediate stages or successful completion. For each project a certain direction on the left chart (Fig. 3, 5, 7) statistically expected: revenues, expenses, losses and profits of the company for the project depending on the scale are presented. The best project is considered to be a project which gives a maximum profit; it is indicated in these graphs black diamond.
On the right graph (Fig. 3, 5, 7) there is the probability of closing at some stage or the successful completion of the project depending on the scale. The lower graph shows the dependence of profit and rentability of the project depending on the risk of closure of the project on any of the intermediate stages.

As it can be seen, the first project under consideration (Fig. 3–4) of direction 4 (which is difficult, but profitable and has a good ratio of supply and demand) has a pronounced optimum point, and in excess of the optimal size of the project, its profitability begins to decrease as the total loss increases with an increase of project’s scale. Note practically linear dependence on the profitability of the project risk. This is due to the fact that the reason of closing the projects is stable, the ratio of probability of closing at different stages did not significantly change.
Fig. 5. Dependence of the characteristics of the project of direction 1 on its scale

Fig. 6. Dependence of profits and profitability on the project risk of direction 1 at different scales

Fig. 5-6 shows the results of the search for the optimal scale of the project of direction 1. This direction has a rather low complexity and average profitability, but good ratio of supply and demand. In this case, the growth rate of risk is small compared with the growth rate of profit by increasing scale. Therefore, the scale is selected for the maximum possible in this direction and the dependence of profit on the scale of a monotonically increasing.

Both curves depending on the risk are almost linear, because company, for this direction, could open a project with a larger scale, if it were not restricted at the stage of determining the share of resources for projects of different directions. So in this case, the competitive direction 4 is more attractive than projects of direction 1. It should be noted that the expected profit of optimal project of direction 1 is less than in the direction of 4, even though the project has more labor cost and is less risky.

The optimal scale of direction 2 (Fig. 7) differs from the direction of the project 1, a high level of competition in the market (a poor ratio of supply and demand) and
the optimum point are close to the lower limit, having a significant increased risk by increasing the scale of the project. Profitability of projects in this direction (Fig. 8) increases more sharply with an increase in risk than other directions of the projects. The reason is that for the small-scale project, the termination occurs in the later stage and for the large-scale projects after the first stage.

Fig. 7. Dependence of the characteristics of the project of direction 2 on its scale

Fig. 8. Dependence of profits and profitability on the project risk to the direction 4 at different scales

For the least attractive direction 3 (the lowest profitability and the level of competition is neutral), the company did not open any project.

**Modeling of the optimal portfolio of projects for the company.**

As it can be seen (Fig. 9) depending on the direction, parameters of the optimum projects in the company's portfolio vary considerably:

- direction 4 has large project with a large margin, but high gross costs and low relative risk and the second draft of the same direction with a poor performance;
- a large group of very similar small projects of direction 2 with low profitability and low costs and average risk;
• one project of direction 1 with an average profitability and low risk but high gross financial and labor costs.

![Fig. 9. The parameters of projects in the portfolio](image)

We have chosen to model the high level of uncertainty of the potential state of the company (the ratio of the standard deviation of the state of the company from its start-up company's financial condition increases from 34% to 77%), which is typical for small and middle high-tech companies.

The best company strategy of resources distribution is:
• half of the funds necessary to keep in reserve, while employees need to be involved almost completely;
• increased uncertainty as higher stages of realization of projects while increasing their cost is a major limiting factor in selecting projects, with these restrictions even more important where the experience of the company below and above the competition in the market.
Thus, the model shows the following logic of the portfolio.

• a new complex areas with low competition, even with a high potential margin, should be chosen medium-sized projects;
• a well-researched markets with low competition, low margins have to build large-scale projects;
• in the markets of low complexity, but highly competitive and the average margin of the main factor is the level of competition and the best is the opening of a series of small projects (even if at the expense of more frequent closing them at earlier stages their expected profitability is low).

3 Conclusion

The developed model is designed to describe the mechanism for management decision-making and to obtain a numerical estimate of the innovative high-tech companies facing the choice of beginning a series of new projects in certain promising areas taking into account both the assessment of their own material and managerial capabilities and prospects, complexity and profitability of these projects. For the numerical implementation used software environment MATLAB [6]. In the future we proposed to test the effectiveness of the use of models in the Web-development and pharmaceutics.

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References


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