Decision-making theory methods as a tool for choosing construction technology

Nadezhda Cherednichenko, Tatiana Kuzmina and Vladimir Efimov
Moscow State University of Civil Engineering, Yaroslavskoe shosse, 26, Moscow, Russia
E-mail: KuzminaTK@mgsu.ru

Abstract. The article discusses the problem of choosing the construction technology, which arises due to many factors. To find the optimal construction technology, it is proposed to divide the task into four stages. As a result, we come to the conclusion that it is necessary to consider this problem with the help of decision-making theory methods under conditions of uncertainty. Possible criteria for choosing the optimal construction technology are considered. The optimal production option is determined according to each criterion. Since each criterion has its own system for choosing the optimal construction technology, some sitework options do not fit on any of the criteria, therefore, according to the Paretto principle, these options can be discarded. Then, using linear convolution, one optimal construction technology is selected for each criterion. A tool for determination of the best construction technology using the methods of decision-making theory was obtained.

1. Introduction
When designing, there are situations when it is necessary to choose a construction technology among well-known and new ones. In this case, it is difficult to make a choice, since it is not known what consequences this or that choice will entail. There are a large number of factors that influence the choice, so you need to understand how to choose the best construction technology.

2. Methods
Decision making is a managerial type task in which it is necessary for a decision maker to choose the best technology from a variety of alternatives. After adoption, the system under study goes into a new state, to which the environment will respond [1, 2, 3].

The following cases are possible [4, 5, 6]:
1. Decision making under certainty.
   The decision maker knows the environmental response to an alternative choice. The task with the exact answer, there are no alternatives.
2. Decision making at risk.
   The decision maker knows the likelihood of environmental reaction to an alternative choice.
3. Decision making under uncertainty.
   The decision maker does not know the environmental response to an alternative choice.

As practice shows, when choosing a production technology, decision making in conditions of certainty and risk is not suitable, since we do not know the environment reaction [7, 8, 9]. To select a
technology under uncertainty, there are a number of criteria by which various options are selected. Period Matching Modeling[13, 14, 15]

For visual application, it is proposed to select a set of earthmoving machinery. Optimally selected equipment can reduce not only the time spent on the work, but also the customer’s money [10, 12, 15].

The existing method of selecting an earth-moving vehicle cannot be fully attributed to the optimal solution for choosing a given machine, since it is proposed to make a selection based on only one criterion (productivity). As a result, using the existing method, the customer receives a fairly large number of machines that meet the requirements, which makes it difficult to make the most optimal choice [10, 11, 13].

After analyzing the Moscow car market, possible cars and their combinations were identified (Table 1).

| Machine                  | Cost   | Rental period |
|--------------------------|--------|---------------|
| VOLVO EW145B             | 1317.97| 97            |
| HYUNDAI R 140LC-9S       | 1322.31| 98            |

For the planned facility, the period of excavation works was calculated, as well as the cost of renting equipment for the period of work (Table 2).

| Combination No. | Cost   | Rental period |
|-----------------|--------|---------------|
| 1               | 1317.97| 97            |
| 2               | 1322.31| 98            |
In order to evaluate each option, it is proposed to evaluate each set for each parameter according to the psychophysical Harington scale (Table 3, Table 4).

**Table 3. Psychophysical Harington scale**

| Quantitative mark on the desirability scale | Psychophysical assessment | Adapted graduation desirability scale by rental period | Adapted graduation desirability scale by cost |
|--------------------------------------------|---------------------------|-----------------------------------------------------|---------------------------------------------|
| 1.00 – 0.80                                | 1                         | 102 – 86                                            | 1497 – 1261.2                               |
| 0.80 – 0.63                                | 2                         | 86 – 72                                             | 1261.2 – 1060.77                            |
| 0.63 – 0.37                                | 3                         | 72 – 51                                             | 1060.77 – 754.23                            |
| 0.37 – 0.20                                | 4                         | 51 – 37                                             | 754.23 – 553.8                              |
| 0.20 – 0.00                                | 5                         | 37 – 21                                             | 553.8 – 318                                 |

**Table 4. Evaluation of each parameter for all options.**

| Combination No. | Cost | Rental period |
|-----------------|------|---------------|
| 1               | 1    | 1             |
| 2               | 1    | 1             |
| 3               | 1    | 1             |
| 4               | 1    | 1             |
| 5               | 1    | 1             |
| ...             | ...  | ...           |
| 213             | 4    | 5             |
| 214             | 4    | 5             |
| 215             | 4    | 5             |
| 216             | 4    | 5             |

According to the theory of decision-making, in order to choose one solution, you must determine this option by one of the criteria. Knowing the assessment of each variant of the combinations of machines, it is necessary to select the variants according to the following criteria:

1. Maximin criterion.
2. Maximax criterion.
3. Product criterion.
4. Savage criterion

After making a selection for each criterion, we will be able to find out which combinations of cars are suitable for the conditions of our task, as well as make the final choice of combinations the most accurate.
According to the Maximin criterion, the smallest estimate is selected according to two parameters and reduced to the column $Z_i$. Next, the options with the largest sum $Z_i$ are selected (Table 5.)

| Combination No. | Cost | Rental period | $Z_i$ |
|-----------------|------|---------------|------|
| 1               | 1    | 1             | 1    |
| 2               | 1    | 1             | 1    |
| 3               | 1    | 1             | 1    |
| 4               | 1    | 1             | 1    |
| 5               | 1    | 1             | 1    |
| ...             | ...  | ...           | ...  |
| 113             | 4    | 4             | 4    |
| ...             | ...  | ...           | ...  |
| 213             | 4    | 5             | 4    |
| 214             | 4    | 5             | 4    |
| 215             | 4    | 5             | 4    |
| 216             | 4    | 5             | 4    |

According to the Maximax criterion, the largest estimate is selected according to two parameters and reduced to the column $Z_i$. Next, the options with the largest sum $Z_i$ are selected (Table 6).

| Combination No. | Cost | Rental period | $Z_i$ |
|-----------------|------|---------------|------|
| 1               | 1    | 1             | 1    |
| 2               | 1    | 1             | 1    |
| 3               | 1    | 1             | 1    |
| 4               | 1    | 1             | 1    |
| 5               | 1    | 1             | 1    |
| ...             | ...  | ...           | ...  |
| 125             | 5    | 4             | 5    |
| ...             | ...  | ...           | ...  |
| 213             | 4    | 5             | 5    |
| 214             | 4    | 5             | 5    |
| 215             | 4    | 5             | 5    |
| 216             | 4    | 5             | 5    |

According to the product criterion, the evaluation of the criteria is multiplied upon each option and reduced to the column $Z_i$. Next, the options with the largest product $Z_i$ are selected (Table 7).
Table 7. Product criterion selection

| Combination No. | Cost | Rental period | $Z_i$ |
|-----------------|------|---------------|------|
| 1               | 1    | 1             | 1    |
| 2               | 1    | 1             | 1    |
| 3               | 1    | 1             | 1    |
| 4               | 1    | 1             | 1    |
| 5               | 1    | 1             | 1    |
| ...             | ...  | ...           | ...  |
| 125             | 5    | 4             | 20   |
| ...             | ...  | ...           | ...  |
| 213             | 4    | 5             | 20   |
| 214             | 4    | 5             | 20   |
| 215             | 4    | 5             | 20   |
| 216             | 4    | 5             | 20   |

According to the Savage criterion, the largest estimate is determined in each criterion, then the remaining estimates are subtracted from this estimate, after which the largest estimate is determined for each option and reduced to the column $Z_i$, and the option with the lowest $Z_i$ is selected (Table 8).

Table 8. Savage criterion selection

| Combination No. | Cost | Rental period | $Z_i$ |
|-----------------|------|---------------|------|
| 1               | 4    | 4             | 4    |
| 2               | 4    | 4             | 4    |
| 3               | 4    | 4             | 4    |
| 4               | 4    | 4             | 4    |
| 5               | 4    | 4             | 4    |
| ...             | ...  | ...           | ...  |
| 125             | 0    | 1             | 1    |
| ...             | ...  | ...           | ...  |
| 213             | 1    | 0             | 1    |
| 214             | 1    | 0             | 1    |
| 215             | 1    | 0             | 1    |
| 216             | 1    | 0             | 1    |

3. Results and discussions

Let us note that combinations 1-112 and 114-212 are not suitable for further selection by criteria. They can be removed from consideration, while the result of the selection will not change. This affirms the Pareto principle. The remaining combinations will form the Pareto set for this task (Table 9).
Table 9. Choosing an option for each criterion

| Option | Maximin | Maximax | Product | Savage |
|--------|---------|---------|---------|--------|
| 113    | 4       | 2       | 8       | 3      |
| 125    | 5       | 5       | 20      | 1      |
| 213    | 4       | 5       | 20      | 1      |
| 214    | 4       | 5       | 20      | 1      |
| 215    | 4       | 5       | 20      | 1      |
| 216    | 4       | 5       | 20      | 1      |

In order to make a choice of one production option, it is necessary to refer to the linear convolution rule, according to which, if one of the options was selected according to one of the criteria, it is given a score of 1, if it was not selected then 0. Next, it is necessary to sum the estimates and select the option with the highest score (Table 10).

Table 10. Linear convolution

| Option | Maximin | Maximax | Product | Savage | \(Z_i^*\) |
|--------|---------|---------|---------|--------|-----------|
| 113    | 4       | 2       | 8       | 3      | 113       |
| 125    | 5       | 5       | 20      | 1      | 1         |
| 213    | 4       | 5       | 20      | 1      | 1         |
| 214    | 4       | 5       | 20      | 1      | 1         |
| 215    | 4       | 5       | 20      | 1      | 1         |
| 216    | 4       | 5       | 20      | 1      | 1         |

Having determined all the criteria and applying the rule of linear convolution, we can determine the best option for the production of works, which will improve the quality of work, optimize the time of work by this machine, and reduce the financial costs of the customer at the considered stage.

4. Conclusions
It is advisable to use this methodology for the selection of technological solutions as a tool that will improve the quality of the selection of technology according to several criteria.
References
[1] Mushik E, Muller P 1990 Methods of making technical decisions (Moscow)
[2] Orlov A I 2004 Decision-making theory (Moscow)
[3] Khan D 1974 Planning and control: the concept of controlling (Moscow)
[4] Bolshakov D V and Vnuestoskh A Yu 2016 Society and power 1 (57) 97-100
[5] Sazonov A A 2015 Achievements of university science 19 195-200
[6] Belokurov S V and Velichko S V 2004 Synthesis of selection functions at search iterations in numerical models of multicriteria optimization (Voronezh) p 125
[7] Kuzmin K A and Kucherova E N 2016 Economics and entrepreneurship 6 (71) 387-394
[8] Lapidus A A and Cherdenicheno N D 2015 Scientific Review 21 338-341
[9] Oleinik P and Yurgaytis A 2017 MATEC Web of Conferences 00130
[10] Kuzmina T K and Efimov V V 2018 Bulletin of construction equipment 1 (1001) 62-64
[11] Cherdenicheno N D 2012 Engineering Herald of the Don 22, 4-1 (22) 174.
[12] Oleynik P P and Kuzmina T K 2013 Technology and organization of construction production 2 (3) 18-20
[13] Oleinik P., Cherdenicheno N. 2018 MATEC Web of Conferences 04024.
[14] Cherdenicheno N D, Kuzmina T K, And Spade, E A and Laletina N. P 2017 Bulletin of civil engineers 6 (65) 254-259
[15] Lapidus A A and Y V Shesterikova 2018 Systems. Methods. Technologies 1 (37) 90-93.