Determining Bookkeeping Cash Maximum of Serbian Army Units by Using Multicriteria Optimization

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Abstract: Normal practice of financial management in the defense system is crucial for the performance of assigned tasks. Payment transactions in cash, in addition to non-cash payment system are very important if we take into account the specificity of the defense system. With limited financial resources optimization level of bookkeeping cash limit should provide continuous funding of units and institutions of the defense system. The aim of this paper is to show that using the method of analytic hierarchy process (AHP) we can help optimize the allocation of cash financial funds within the defense system.

Key words: Decision making, bookkeeping, cash transactions, criteria, alternatives

1. Introduction

One of the main challenges with which people are faced in everyday situations is how to make the right decision for the given problem. One way is the use of multi-criteria optimization, which offers a range of representative methods for making the right decisions. Methods of analytic hierarchy process (AHP) is one of the most highly used methods for multi-criteria decision making, where a decision is made based on a number of criteria and multiple time periods. It is this method that is going to be used in the paper to determine the relative weights of the criteria and the optimal solution to the problem, i.e. determining the cash maximum for the Serbian Army (SA) units.

The aim of this paper is to based on rational and scientific approach, show a way of solving the problem of decision-making, using multi-criteria optimization in determining the amount of cash maximum in SA units. It is the applicable aspect of the paper that should arise from the elaborated example which is its fundamental contribution. Multiple criteria decision-making plays a key role in many real-life problems. This has been confirmed in practice, whether it is applied to state authorities, managers of companies or any other businesses, because they all face situations where they choose in a range of alternatives the best one, based on the existing criteria. This paper provides empirical analysis of a multi-criteria problem with which managers in the defense system are faced, with a recommendation for the creation and implementation of a model that will improve the decision-making process.

2. Organization of Cash Operations in the Serbian Army

Area of financial operations in SA is regulated with a number of normative acts, each of which in its area regulates the performance of certain actions and procedures. One of the most important regulations is the Regulation on financial operations in the Ministry of Defense and Serbian Army [1] in which, among other things, the performance of bookkeeping cash operations is regulated.

Serbian Army, as a direct budget beneficiary can use its provided funds for the following purposes [2]:

- acquisition of assets, works and services;
• payment of personnel costs and
• specific purposes.

State and purpose of use of the approved funds must constantly be monitored and recorded in an appropriate manner. Especially significant are the funds that must be provided daily for lesser payments in units, in order to ensure normal functioning. For this reason each units has its own cash operation, and the realization is done through cashiers that were established by formation.

Cash operations include downloading, storing and issuing or trade of cash. It should be taken into account that the regulations limit cash payments up to a certain specified amount. To prevent cash buildup in the cashier’s desk, cash maximum is determined, which represents the largest amount of cash that can be kept in the cashier’s desk. Height of cash maximum is determined by a decision of the Head of budget Administration of the Ministry of Defense. Article 39 of the Regulations on financial operations of the Ministry of Defense and Serbian Army (OMG 17/2011) regulates that the supervisor of the beneficiary authorizes the person that takes over the cash in the manner and procedure prescribed by the regulation on budget execution system.

One of the problems present in the work of financial services authority, which directly make decisions in the budget Administration, is how to determine the maximum cash for each unit. It is the aim of this paper to help solve the aforementioned problem, using the method of multi-criteria optimization.

3. Methods of Multicriteria Analysis

There are numerous methods to solve multi-criteria decision making models that can be divided based on several criteria, and the best in today's time are:
• ELECTRE method;
• PROMETHEE method;
• AHP (analytic hierarchy proccess) method;
• TOPSIS method;
• SAW method and other.

Special attention in this paper will be devoted to the AHP method, which is a method of multi-criteria decision making, created to assist decision makers in solving complex decision problems involving a large number of decision makers, a number of criteria in multiple periods. Methodologically speaking AHP is based on the decomposition of a complex problem into a hierarchy. The goal is at the top of the hierarchy, while the criteria, sub-criteria and alternatives are at lower levels. AHP holds all the parts of the hierarchy in relationship, so it's easy to see how a change in one affects the other criteria.

The process of solving the decision-making problem is often very complex due to the presence of conflicting objectives among the available criteria or alternatives. The problem is to choose the alternative that will best meet the set goals. Field of application of this method is multi-criteria decision making, where based on a defined set of criteria and attribute values for each alternative the most appropriate is selected. In order to easily facilitate the application of this method a software tool in decision support systems has been developed named Expert Choice.

The process of realization of the AHP method includes four main phases [3]:
• Structuring the problem, which consists of decomposing any complex decision making problem into a series of hierarchies, where each level represents a smaller number of manageable attributes. They are then decomposed in a second set of elements which correspond to the next level. This way of hierarchical structuring of any decision making problem is an effective way of dealing with the complexity of real life problems and identifying significant attributes in order to achieve the overall goal of the problem.
• Data collection is the beginning of the second phase of the AHP method. The decision maker assigns relative scores in pairs of attributes of one hierarchical level and does this at all levels of the entire hierarchy. The best known scale used to assign weights is Saaty’s nine-point scale.
• Rating the relative weights implies that the comparison matrix in pairs, is translated into problems of determining their own values, to obtain the normalized and unique own vectors, with weights for all attributes at each level of the hierarchy.

• Determining the solution to the problem is the last stage that involves finding the so-called composite normalized vector. Once the vector of sequence of criterion values in a model is determined, in the next round it is necessary to determine the order of importance of alternatives in the model with respect to the same procedure, within each of the monitored criteria.

3.1 Formulating the Mathematical Model of Multi-Criteria Decision Making

Model of the multi-criteria decision making has the following mathematical formulation [3]:

$$\max \left[f_1(x), f_2(x), \ldots, f_p(x)\right], \quad p \geq 2 \quad (1)$$

with limitations:

$$g_i(x) \leq 0, \quad i = 1, m \quad (2)$$

$$x_j \geq 0, \quad j = 1, n \quad (3)$$

where:

- $n$ – number of variables;
- $p$ – number of criterion functions;
- $m$ – number of limitations;
- $X$ – $n$- dimensional vector of variables $x_j, \quad j = 1, n$;
- $f_k$ - function (goal) of the criteria, $k = 1, p$;
- $g_i(x)$ – set of constraints, $i = 1, m$.

It should be noted that the maximization of the function vector is carried out with the given constraints, since the minimization criteria can be converted into maximization criteria, and:

$$\max f_j(x) = -\min [-f_j(x)], r \in (1, p) \quad (2)$$

By solving the model above a set of permissible solutions is obtained, vector $X$ which belongs to the set of positive integers $X \in \mathbb{R}^n$, for which applies:

$$X = \left[x \mid g_i(x) \leq 0, i = 1, m, x_j \geq 0, j = 1, n\right] \quad (3)$$

Thus resulting set of solutions $X$, to which corresponds a set of values of the function criteria, or the vector $f(x)$, so that the set of permissible solutions $X$ can be mapped into a criterion set $S$:

$$f(x) = \left[f_1(x), f_2(x), \ldots, f_p(x)\right] \quad (4)$$

$$S = \left[f(x) \mid x \in X\right]$$

3.2 Defining the Terms in the Decision-Making Problem

Defining the criteria occupies an important place in the process of deciding on cash maximum amount which is determined for the units. Criterion as a term refers to the attributes that are related to alternatives between which we select. They can be divided into qualitative and quantitative criteria depending on the degree of measurability. Qualitative criteria are those that can be accurately measured and are expressed in different units of measurement. Qualitative criteria are those that cannot be expressed numerically. They can be divided into two subgroups: the attributes whose values cannot be accurately measured, but can be ranked by the "intensity" and attribute basis of which no quantitative comparison of alternatives can be done. There are plenty of ways to translate qualitative criterion values in quantitative. The most commonly used scales are: in-line scale, interval scale and ratio scale. The second criterion, which is also used for the distribution of decision making criteria is the direction of correlation of their values and utility providers. According to the stacking direction there are [4]:

• Revenue criteria;
• Expenditure Criteria and
• Non-monotonic criteria.

In the process of the observed choices there are great number of criteria available, which are more or less important and precisely defined at the beginning, and in our case they are: distance of the unit from the Accounting Centre, unit level, unit size and unit type.
Alternatives are the solutions which are emerging as a choice between which we select the best one. For simplicity of presentation three SA units are taken into consideration between which we select to whom to assign the highest cash maximum. They have characteristics that match the criteria that have been defined.

4. Application of the AHP Method in Multicriteria Optimization of Determining the Height of Bookkeeping Cash Maximum

The process of determining the maximum cash amount in SA units which are the executors of the approved plan of financial resource expenditure represents a problem which we will try to realize using the method of multi-criteria optimization. Mitigating factor during usage of any method of multi-criteria decision-making is the fact that they are all software supported, and the mentioned software in our case can be found at the internet address: www.odlucivanje.fon.rs. However in this paper the emphasis is not directly placed on the application of this software but the logical-mathematical setting of the problem.

Justification of this paper can be ontologically substantiated by facts of appropriateness of the optimization of determining the height of cash maximum from the competent authority within the defense system that is, to show that in practice the use of these methods may lead to an optimal solution. Also an important requirement that is going to be satisfied in this way is the scientific foundation of the procedure of decision-making.

The assumption in this problem is determining cash maximum amount for accounting purposes in order to maintain permanent liquidity of the financial assets in the SA units. In order to find the optimal solution for given assumptions four criteria are used in relation with three possible alternatives which will be considered.

Criteria in this problem are:

- **K1** – Distance of the unit from the Accounting Centre (AC) is one of the criteria to be taken for determining the cash maximum amount, which is the criterion of maximization. It is necessary to determine the distance of the unit from the AC because of the need to determine the time interval in which the documents are submitted to the AC. For example some units due to the physical distance only deliver their accounting documents twice a week making it difficult to justify the consumed cash as a condition to receive newly approved.

- **K2** – Unit level in accordance with the Decision on authorization for management and replacement of movable property and the procurement of works and services to the MoD and SA [5]. By this Decision the commanders of beneficiaries among which are cash funds have the authority delegated by the Defense Minster concerning managing funds. In this regard, depending on the degree of autonomy to manage the funds greater or smaller amount of cash is required, the units will be observed as the commander 1 (the lowest level of authority), commander 2 (medium degree of authority) and commander 3 (the highest level of authority).

- **K3** – Unit size is the maximization criterion, and refers to the number of people within the unit which significantly affects the level of cash maximum due to an increase in personnel expenses. Personnel expenditures conditionally progressively increase due to the increase of personnel during peacetime and war formations.

- **K4** – Unit type is determined depending on the composition and use of a particular unit or institution. Within this criterion in determining the amount of cash maximum it is significant to determine the degree of significance of the quantity of cash as an instrument of maintaining continuous liquidity with a goal to support permanent combat readiness of SA units. As a condition of determining the maximum cash amount it is significant to differentiate between infantry, artillery, armor, special units, logistics and others.

The decision making matrix in this case is shown in
4.1 Evaluation of the Relative Weights of Criteria

At the beginning of processing the problem it is necessary to start by determining the relative weights of the criteria that is, significance of the criteria. To estimate the relative weights of the criteria we will use Saaty’s scale [6]. Based on the data obtained from the evaluation of relative weights of the criteria, using the same procedure alternatives should be observed as well. Comparison of alternatives will also be done by using Saaty’s scale. After forming the tables of comparing the weights in pairs for each alternative, we will calculate own vectors.

Table 1 Decision making matrix

| Alternatives | Criteria | K1   | K2   | K3   | K4       |
|--------------|----------|------|------|------|----------|
| Unit 1       | Commander | 360  |      |      | infantry |
| Unit 2       | Commander | 150  |      |      | armor    |
| Unit 3       | Commander | 90   |      |      | logistic |

Table 2 Quantified input data

| Alternatives | Criteria | K1   | K2   | K3   | K4       |
|--------------|----------|------|------|------|----------|
| Unit 1       |          | 360  | 5    | 2300 |          |
| Unit 2       |          | 150  | 3    | 500  |          |
| Unit 3       |          | 90   | 9    | 80   |          |

Table 3 Evaluation of relative weights of the criteria

| K1  | 1 | (5) | (4) | (7) |
| K2  | 5 | 1   | 4   | (5) |
| K3  | 4 | (4) | 1   | (6) |
| K4  | 7 | 5   | 6   | 1   |
| Σ   | 17| 6,45| 11,25| 1,51|

Table 4 Calculation of own vectors with corresponding own values

| K1   | K2   | K3   | K4   | Σ    | W(Σ/4) |
|------|------|------|------|------|--------|
| 0,059| 0,031| 0,022| 0,092| 0,204| 0,051  |
| 0,294| 0,155| 0,355| 0,132| 0,936| 0,234  |
| 0,235| 0,039| 0,089| 0,113| 0,476| 0,119  |
| 0,412| 0,775| 0,533| 0,662| 2,382| 0,595  |

Table 5 Calculation of own vectors corresponding to own values (Distance of units from the AC)

| Unit 1 | Unit 2 | Unit 3 | Σ      | W(Σ/3) |
|--------|--------|--------|--------|--------|
| 1      | 9      | 7      | 2,329  | 0,776  |
| (9)    | 1      | (3)    | 0,205  | 0,068  |
| (7)    | 3      | 1      | 0,465  | 0,155  |
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Table 6  Calculation of own vectors corresponding to own values (Unit level)

| Unit  | Unit 1 | Unit 2 | Unit 3 | Σ     | W(Σ/3) |
|-------|--------|--------|--------|-------|--------|
|       | 1      | 5      | (7)    | 0,569 | 0,189  |
|       | (5)    | 1      | (9)    | 0,180 | 0,060  |
|       | 7      | 9      | 1      | 2,251 | 0,750  |

Table 7  Calculation of own vectors corresponding to own values (Unit size)

| Unit  | Unit 1 | Unit 2 | Unit 3 | Σ     | W(Σ/3) |
|-------|--------|--------|--------|-------|--------|
|       | 1      | 7      | 9      | 2,251 | 0,750  |
|       | (7)    | 1      | 5      | 0,569 | 0,189  |
|       | (9)    | (5)    | 1      | 0,180 | 0,060  |

Table 8  Calculation of own vectors corresponding to own values (Unit type)

| Unit  | Unit 1 | Unit 2 | Unit 3 | Σ     | W(Σ/3) |
|-------|--------|--------|--------|-------|--------|
|       | 1      | (5)    | (7)    | 0,215 | 0,072  |
|       | 5      | 1      | (5)    | 0,695 | 0,232  |
|       | 7      | 5      | 1      | 2,089 | 0,696  |

Table 9  Determining the amount of cash maximum

| K₁    | K₂    | K₃    | K₄    | Total priorities of alternatives |
|-------|-------|-------|-------|----------------------------------|
| 0,051 | 0,234 | 0,119 | 0,595 |                                 |
|       | 0,776 | 0,189 | 0,750 | 0,072                           |
|       | 0,068 | 0,060 | 0,189 | 0,232                           |
|       | 0,155 | 0,750 | 0,060 | 0,696                           |

4.2 Determining the Solution to the Problem

After assessing relative weights of alternatives with respect to each criterion we approach to determining the maximum cash amount of the observed units. The choice of units is made based on the received own vectors of alternatives and previously obtained own vectors of criteria. Total priorities of alternatives are obtained by multiplying each alternative by its weight within the observed criterion in order and finally adding up the results.

From Table 9 it can be seen that after implementing the procedure of AHP method for the given example, the order of alternatives would be as follows: "Unit 1" (22%), "Unit 2" (18%), "Unit 3" (60%), which shows that the best decision would be to award the highest cash maximum to "Unit 3".

5. Conclusions

Everyone - individuals, politicians, professionals, business men daily consider and make small and big decisions - decisions that affect individuals, families, business systems or social communities - of regions, countries and even the world as a whole. In most cases that is, problems solved there are several solutions. But the question that arises is which solution to choose? One that considers and decides takes into account several aspects of the problem being solved: some reasons speak in favor of deciding in one way, but other reasons say that such decisions are often reviewed and often amended.

Thus the practice of problem solving in the defense system shows that they can be resolved in different ways, taking into account the relevant criteria. The possibility of using a number of representative methods that are available when deciding on the amount of maximum cash makes the work even easier and raises the level of quality of the decision to a higher level. It is an example of using the
AHP method in choosing which unit should be assigned the highest maximum cash is shown in a rather simple way how with a precise procedure a decision can be made, and while doing so recognizing all the set criteria on which the selection is made. It is also in this way shown that there are significant arguments for this method to be based on scientific grounds.

In the specific problem (formulated criteria, assumed input data) people who decide in the defense system, that need to decide on the maximum cash limit will not make a mistake if the decision relates to the choice of alternative "Unit" 3. This decision stemmed from conducted methodological procedure of applying the AHP method, where in a scientific-friendly and reliable manner the solution of multi-criteria problem was got.

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