# NEW VERSION OF DECISION SUPPORT SYSTEM FOR EVALUATING TAKEOVER BIDS IN PRIVATIZATION OF THE PUBLIC ENTERPRISES AND SERVICES

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**ABSTRACT**

In Croatia, Croatian Privatization Fund (CPF) takes the control of the privatization of the public enterprises and services in the state portfolio. In order to provide potential investors with a fair and transparent transaction process CPF established tender procedures. The success of a privatization is highly dependent on selection of a good investor which is done according to multiple criteria such as the price, further investments, the time of keeping the actual employees and others. In order to help CPF in this selection process we developed a decision support system (DSS) based on compromise programming, grouping of privatization bids according to their similarities and Monte Carlo simulations. This DSS is the improved version of the DSS developed in (Vlah et al. 2007).

**KEYWORDS**
Decision making, multiple criteria, decision support system, compromise programming, grouping, Monte Carlo simulations, privatization

## 1. INTRODUCTION

As we mentioned above, in Croatia, Croatian Privatization Fund (CPF) takes the control of the privatization of the public enterprises and services in the state portfolio. The success of a privatization is highly dependent on selection of a good investor. Simply looking for investor offering the highest price is not "efficient sourcing" even almost most important. Multiple criteria need to be followed and taken into account when selecting the investor. Usually, besides the price, the potential investors are asked to propose the further investments, the time of keeping the actual employees, the intention of paying the creditors and to satisfy other requests. CPF has to choose the best bid according to the criteria defined in the tender. These criteria depend on the special case of privatization. The problem is if all the criteria are equally important or we have to assign them some weights? How to assign the weights? In the literature there are mathematical models based on multi criteria optimization, data envelopment analysis, analytic hierarchical process (AHP) and other multi-attribute rating techniques. In order to help CPF we modeled this problem as a multi criteria optimization problem and created the decision support system (DSS). Our main goal was not to ask the decision maker (DM) for many information. Namely, usually the DM wants to participate in the decision process, but she /he does not want to be involved to much. For this reason we improved the DSS from [5] grouping the criteria in three groups, very important criteria, less important and the least important criteria. And this is the only task that a DM has to do.

In the following pages, two heuristic methods for evaluating takeover bids in privatization will be described. Besides the grouping of criteria in three groups by DM, we have grouped the bids according to these groups of criteria. The grouping algorithm that is used for grouping the bids according to their similarities will be described in the next section. The similarities will be considered regarding the criteria in the same group, for all three groups. Afterwards, two heuristics for evaluating takeover bids will be proposed. The first one will consider the same weights of the criteria inside the considered group of criteria. The second one will assign the weights to the criteria inside a group based on Monte Carlo simulations. This will be followed by an example and computational results of the proposed heuristics and DSS based on them. The conclusions and future research will be given in the last section.

## 2. GROUPING ALGORITHM

The motivation for introducing similarity in groups is found in idea to consider the privatization bids that are similar to each other. Namely, if two of the investors offered approximately the same price and level of further investments and basically approximately have the same values for all other criteria by which the bids are being evaluated, one could consider them approximately the same in satisfying the criteria used in the particular tender.

For our purpose, the problem of grouping can be well motivated by considering the set of points shown in Figure 1.

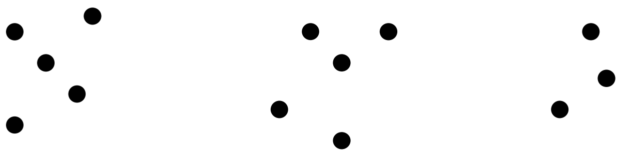


Figure 1: How many groups?

Typically, a human observer will easily perceive three groups of objects in the image. On the other hand, there has been a tremendous amount of effort devoted to achieving the same level of performance in computer vision. Prior literature on the related problems of clustering, grouping and image segmentation is huge. In this paper we are using the results obtained in (Shi and Malik 2000). They treat image segmentation as a graph partitioning problem and propose a criterion of normalized cut for segmenting the graph.

A graph $G = (V, E)$, where the nodes are the points of an image and an edge is formed between every pair of nodes with the weight $w(i, j)$ representing the similarity between them, can be partitioned into two disjoint sets, $A, B, A \cup B = V, A \cap B = \varnothing$ by simply removing edges connecting the two parts. But, Shi and Malik propose a new measure of disassociation between two groups. Instead of looking at the value of total weight connecting the two partitions, their measure computes the cut cost as a fraction of the total edge connections to all the nodes in the graph. They call this disassociation measure the normalized cut (Ncut):

$$Ncut(A,B) = \frac{cut(A,B)}{asso(A,V)} + \frac{cut(A,B)}{asso(B,V)},$$

where $asso(A,V) = \sum_{u \in A, t \in V} w(u,t)$ is the total connection from nodes $A$ to all nodes in the graph and $asso(B,V) = \sum_{u \in B, t \in V} w(u,t)$ is defined in the same way.

Given a partition of the nodes of a graph, $V$, in two sets $A$ and $B$, let $x$ be an $N = |V|$ dimensional indicating vector where the $i$ th component is 1 if node $i$ is in $A$, and –1 otherwise. Let $d(i) = \sum_j w(i, j)$ be the total connection from node $i$ to all other nodes, $D$ an $N \times N$ diagonal matrix with $d$ on its diagonal, $W$ be an $N \times N$ symmetrical matrix with $w_{ij} = w(i, j)$ as elements.

From [4] we have the following grouping algorithm:

(1) Given a set of points, set up a weighted undirected graph $G = (V, E)$, compute the weight on each edge and summarize the information into $W$ and $D$
(2) Solve $(D - W)y = \lambda Dy$ for generalized eigenvectors with the smallest eigenvalues
(3) Use the eigenvector with second smallest eigenvalue to bipartition the graph
(4) Decide if the current partition should be subdivided and recursively repartition the segmented parts.

## 3. HEURISTICS

This section introduces the two heuristics that will be used by the DSS for evaluating takeover bids that will be created.

Prior to use of any of the heuristics that will be described here the data on privatization bids are being filtered according to the criteria that have eliminating nature. Namely, criteria may have upper or lower bounds on their values and the bids that do not satisfy them will be eliminated from further consideration.

As the next step, the elimination of takeover bids that are dominated by all other bids is made. Dominated bids are the bids where the values of all criteria are less than the values of the criteria from at least one of other bids and will not be taken into account for sure. In case of existence of a takeover bid that dominates all other bids, there is no need for further investigations because the choice should be obvious. If there are bids left for evaluation, the decision making process comes to the third stage where it will require a heuristics for solving the problem.

The data about the bids will be normalized in order to avoid the problem of comparing values of criteria which have different scales of measure. The normalization will be done using the linear transformation of the data by which the criterion values of all bids are dived by the maximum offered value of that criterion. Without loss of generality, it is assumed that the highest values are preferred for all of the criteria.

Furthermore, it is important to mention that the heuristics that are proposed here will allow changing of the criteria which are taken into account. This means that the DSS will be created generally and can be adapted to any specific privatization case because it will allow the DM to import any criteria he considers important for a privatization of a certain public enterprise.

It is assumed that the DM can provide the information on the criteria importance by simply ordering the criteria by their importance. Since some of the criteria may be of the same importance, it can be thought of as grouping the criteria according to their importance. Thus, the decision maker should say which of the criteria taken into consideration are of highest importance, which are of the lowest importance and which are somewhere in between. In this way the DM will not be burdened by defining the exact weight of each criterion or pairwise comparisons of the bids criteria values.

### 3.1 Heuristic procedure 1

The first heuristic proposed is based on successive grouping of the privatization bids where the grouping is performed using the algorithm described in previous section. The measure of similarity between bids will be the difference in distance from the ideal solution i.e. ideal bid. Ideal solution corresponds to the best value that can be achieved for each criterion, ignoring all others. In this particular problem, evaluation of takeover bids, it is easy to obtain the ideal point since the number of bids is never very large. Thus, we obtain the ideal solution by taking the best value for a given criterion among the given takeover bids. For example, if the criterion was price, we would like to achieve the maximum price possible. Thus the best value would be the highest price offered among the bidders.

In the first iteration the heuristic groups the bids according to the most important criteria group where we take the sum of all criteria with the same weights. Afterwards, the best of the groups made in such a way is chosen for the next iteration. The group of bids that is considered to be the best will be the group that contains the bid that is closest to the ideal solution. The process of finding the solution that is closest to the ideal solution is known as compromise programming [1], [2]. Compromise programming can be thought of as an effort to find a solution that comes as "close as possible" to the ideal values, i.e. the best approximation of ideal bid.
To be more precise, we consider a situation where the DM evaluates $I$ takeover bids based on $J$ criteria. The values for each criterion for every bid are given as $a_{ij},\ i = 1,\ldots,I,\ j = 1,\ldots,J$. For example, if the first criterion is price, the value $a_{11}$ is the price offered by the first bid. The bid that is closest to the ideal point will be the bid with minimum value of

$$\left[\sum_{j=1}^{J}\left(a_j^{\ *} - a_{ij}\right)^2\right]^{1/2},$$

where $a_j^* = \max_i\left(a_{ij}\right),\ i = 1,\ldots,I,$ are the best values of criteria. To be more precise, the sum over the index $j$ in the first iteration is the sum over indices of the most important criteria. In the second iteration, the index $j$ is the index of the less important criteria and in the third iteration the index of the least important criteria.
The heuristics continues by grouping the bids obtained by the first iteration according to the group of the criteria which is the next one by importance. Again, the best of the groups obtained in such way is chosen for the next iteration.
The process continues until there is only one bid left in the group of best bids or if the criteria are exhausted.

### 3.2 Heuristic procedure 2

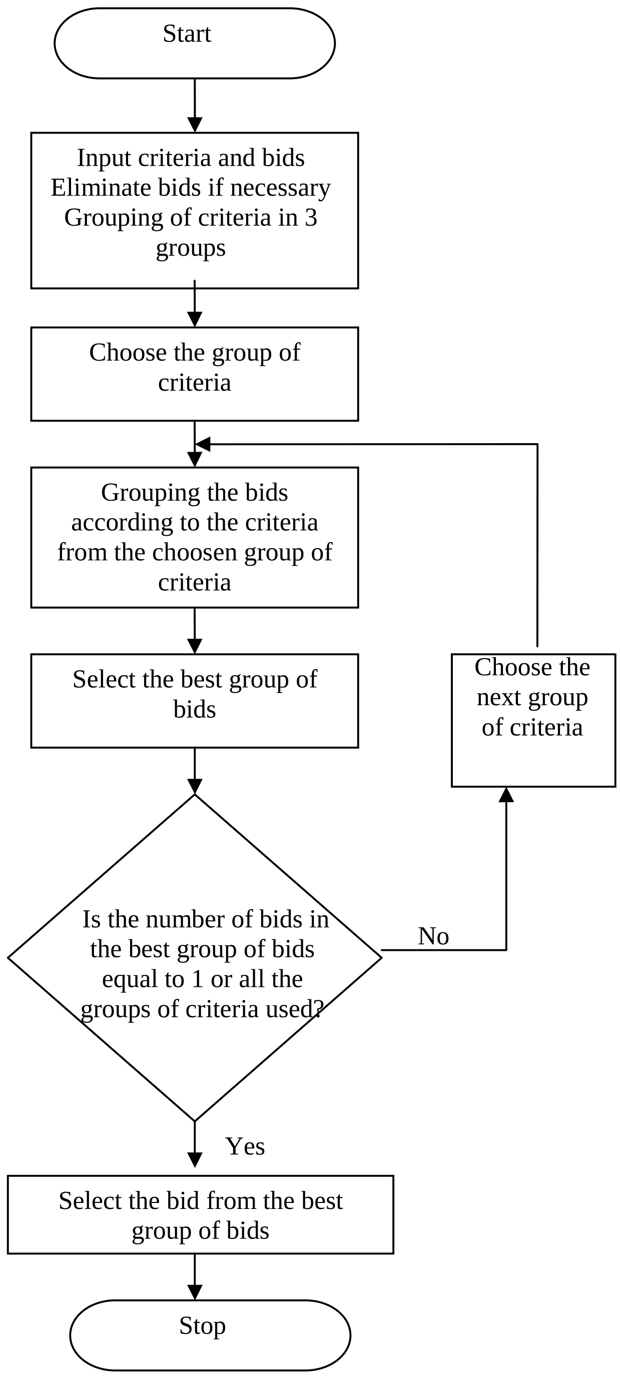
The second heuristics that is proposed here is again based on grouping of the privatization bids where the grouping is performed using the algorithm described in previous section. However, the grouping here is done with all the criteria taken into account at the same time. Thus, the measure of similarity will be the weighted distance to the ideal solution:

$$\sqrt{\sum_{j=1}^{J} w_j\left(a_j^{\ *} - a_{ij}\right)^2},$$

where $a_j^* = \max_i\left(a_{ij}\right),\ i = 1,\ldots,I,$ are the best values of criteria and $w_j,\ j = 1,\ldots,J$ are the criteria weights. To be more precise, the sum over the index $j$ in the first iteration is the sum over indices of the most important criteria. In the second iteration, the index *j* is the index of the less important criteria and in the third iteration the index of the least important criteria. Since the exact weights are not given by the DM, the heuristic uses Monte Carlo simulations [3] with different values of the weights following the criteria ordering (that is, following the importance groups of criteria) given by the DM.

The heuristic basically performs a large number of groupings of the bids. In each grouping it selects the best group of bids. The result is the percentage of being selected for the best group for each bid. Thus, the heuristics ends with numbers that can be thought of as probability of belonging to the best group of bids. Finally, it is up to the DM to select the bid according to the calculated probabilities.

The block diagram for both heuristics is the same. The difference is in defining the objective function according to which the grouping of bids is performed. In the first heuristic, the objective is to minimize the sum of the distances to the ideal point according to the criteria from a chosen group of criteria (with the same weights). The grouping is performed once. The best bid(s) is(are) the bid(s) from the best group. In the second heuristic, the objective is to minimize the weighted sum of the distances to the ideal point according to the criteria from a chosen group of criteria. The weights are chosen using Monte Carlo simulations following the importance of the criteria and the grouping is repeated many times. The best bid is the bid with the highest percentage of being chosen in the best group of bids.




**4. COMPUTATIONAL RESULTS ON AN EXAMPLE**

These two heuristics are implemented in the form of DSS created using Microsoft Excel Visual Basic. The graphical surface is very friendly and easy to use. First the DM has to input the criteria and bids. After that, she/he has to choose the heuristic, 1 or 2. Then the criteria with lower and upper bound are typed and grouped by the DM. The final step for the DM is to press the button “Group the criteria” and the solution of the first iteration is obtained. The process continues with the group of less important and ends with the group of the least important criteria. To illustrate the process of evaluating privatization bids an example set of bids for evaluation is given as follows:

| Criteria / Bids | Price | Keeping of actual number of employees | Number of new employees |
|---|---|---|---|
| A | 5000000 | 3 | 400 |
| B | 4000000 | 4 | 500 |
| C | 6000000 | 4 | 400 |
| D | 10000000 | 3 | 350 |
| E | 11000000 | 3 | 300 |
| F | 13000000 | 2 | 200 |
| G | 13100000 | 2 | 190 |
| H | 13200000 | 1 | 0 |

The criteria in this fictive tender are the price, the number of years the actual employees will be kept and the number of new employees. Also, there is a lower bound on price and the minimum price level is 5000000. It is presumed that the DM set the price to be the most important criterion and the other two criteria are less important than price but equally important among themselves.

In that case, the decision support system would firstly eliminate bid B because it does not satisfy the lower bound on price criterion. Afterwards, bid A would be eliminated because it is dominated by all other bids.

If the DM would use the first heuristic that is proposed, the decision support system would first group the bids according to price which would result with following bids as the bids in the best group:

| Criteria / Bids | Price | Keeping of actual number of employees | Number of new employees |
|---|---|---|---|
| F | 13000000 | 2 | 200 |
| G | 13100000 | 2 | 190 |
| H | 13200000 | 1 | 0 |

In the next iteration, the decision support system would group the remaining bids according to next two criteria which would result with following bids as the bids in the best group:

| Criteria / Bids | Price | Keeping of actual number of employees | Number of new employees |
|---|---|---|---|
| F | 13000000 | 2 | 200 |
| G | 13100000 | 2 | 190 |

The process of heuristic 1 ends because the set of criteria is exhausted which leaves the DM with the final step of choosing the bid among bids F and G.

If the DM was to use the second heuristics that is proposed, the decision support system would make large number of simulations, in each of the simulations performing grouping of the bids using different weights while following the order of criteria importance which would result in the following information:

| Criteria / Bids | Price | Keeping of actual number of employees | Number of new employees | Probability of belonging to the best bid group |
|---|---|---|---|---|
| C | 6000000 | 4 | 400 | 0% |
| D | 10000000 | 3 | 350 | 82% |
| E | 11000000 | 3 | 300 | 92% |
| F | 13000000 | 2 | 200 | 70% |
| G | 13100000 | 2 | 190 | 70% |
| H | 13200000 | 1 | 0 | 2% |

Since bids E and D have the highest probabilities of belonging to the best group of bids, the DM should consider making the final decision of selecting the final bid among those to bids. However, bids F and G also have high probabilities which suggest they should not be completely eliminated from consideration either.

In the end, final decision is always made by the DM and it is advised he combines the two heuristics that were proposed here, especially taking into account their differences. Namely, the first heuristics is more rigorous in term of following the criteria importance more rigidly. On the other hand the second heuristics is more prone to compromises between the given criteria.

## 5. CONCLUSIONS AND FUTURE WORK

In this paper we presented the decision support system (DSS) developed in order to help Croatian Privatization Fund (CPF) to make a decision of choosing the investor in a process of privatization. When CPF announces the tender for privatizing a public enterprise it should give the criteria which will be evaluated during the process. The potential investors should apply giving their bids. The investor is chosen according to all criteria not only to one of them. For evaluating takeover bids in order to make the decision according to given criteria, we developed (DSS) based on compromise programming, grouping of privatization bids according to their similarities and Monte Carlo simulations. This DSS is the improved version of the DSS developed in [5]. We presented an example. In order to make a decision, for the DM (in this case CPF) it is not necessary to know any optimization technique. The only thing she/he has to do is to specify the criteria, rank them in three groups and input the data about the bids. Sometimes, at the end the DM has to choose among few bids, but we believe that this is not a problem. Indeed, sometimes is a good marketing to include the DM in the decision process but in the reasonable way not asking her/him to do a great effort. Also, the advantage of this solution method regarding the others known in the literature is the fact that the DM does not have to specify the weights for the criteria.

The DSS developed here could be used in a more general case where a decision according to more criteria should be made. It is not limited only on the case of privatization. The only request is to have numerical data, that is, the qualitative data should be measured in a certain way. Also, this DSS could be a part of more global system and incorporated in it without many problems.

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