Developing a Permutation Method Using Tabu Search Algorithm: A Case Study of Ranking Some Countries of West Asia and North Africa Based on Important Development Criteria

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Abstract

The recent years have witnessed an increasing attention to the methods of multiple attribute decision making in solving the problems of the real world due to their shorter time of calculation and easy application. One of these methods is the 'permutation method' which has a strong logic in connection with ranking issues, but when the number of alternatives increases, solving problems through this method becomes NP-hard. So, meta-heuristic algorithm based on Tabu search is used to find optimum or near optimum solutions at a reasonable computational time for large size problems. This research is an attempt to apply the 'permutation method' to rank some countries of the West Asia and the North Africa based on the development criteria. Knowing the situation of each country as compared with other countries, particularly the respective neighbouring countries, is one of the most important standards for the assessment of performance and planning for the future activities.
Keywords: Multiple attribute decision making, Permutation method, Tabu search algorithm, Countries ranking, Combinatorial problem

1. Introduction

Decision making can be defined as the process of making choices among possible alternatives. Multiple Criteria Decision Making (MCDM) is one of the most common approaches in decision making and can be broadly classified into two categories of multiple attribute decision making (MADM) and multiple objective decision making (MODM). Multiple attribute decision making is an approach employed to solve problems involving selection from among a number of alternatives. This method specifies how attribute information is to be processed in order to arrive at a choice.

MADM methods are classified into the following groups: 1) Compensatory methods where the attributes are not separated which means a good feature of an attribute compensates for a bad or low feature of the other attribute (Yoon & Hwang, 1981). ELECTRE, MDS, MRS, TOPSIS, SAW, Linear assignment are examples of this method. 2) Non compensatory methods where the attributes are independent which means a feature of an attribute does not compensate for the others. Dominance, Lexicography, Elimination, Permutation are examples of this kind of model (Korhonen et al., 1992).

Each of these methods has its own features, and the decision maker cannot apply one method for all decision-making problems. So, in order to use them properly, it is required to consider both the characteristics of the method and the attributes of the problem itself.

Permutation method is one of the MADM techniques that expanded to rank decision alternatives based on decision matrix and weights of attributes. In this method, all the possible priorities of alternatives are considered and assessed to select the best alternatives arrange, which gains the highest score. In this method, if the number of alternatives increases, then the computational time increases exponentially. So in this situation, it is difficult to obtain the final result by this method. Also, Rinnooy (1976) showed that if the number of alternatives increases, the problem becomes NP-hard.

Paelinck (1977) applied the permutation method in an airport location problem. Blair and Karnisky (1994) used the permutation technique to analyse some records of brain electrical wave. Pantazis et al. (2003) analysed some MEG data to reconstruct cortical maps of brain

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activation by applying Permutation techniques. Turskis (2008) utilized this method to assess contractors. Bashiri and Jalili (2010) proposed an approach based on genetic algorithm which could find the best permutation of alternatives. Karimi and Rezaienia (2011) proposed an adjusted permutation method (APM) to compensate for the deficiencies of the permutation method for solving decision-making problems. Also, they introduced a Tabu search (TS) and a particle swarm optimization (PSO) to obtain optimum or near optimum solutions at a reasonable CPU time for large problem instances.

Zavadskas et al. (2011) utilized this method to select the most preferable construction enterprises management strategy. Tavana and Zandi (2012) employed the permutation method to assess the scenarios, which are connected with the travels to Mars. Bashiri et al. (2012) introduced a fuzzy permutation method for MCDM problems. Also, they proposed a Tabu Search (TS) algorithm to find suitable solutions at a reasonable computational time for large size problems. Bashiri and AliAskari (2014) presented a permutation method where there is more than one vector of weights for the attributes and there are uncertainties associated with attributes weights or decision makers are multiple. Also, a multi objective swarm optimization (MOPSO) and a non-dominate sorting genetic algorithm (NSGA-II) are utilized to find non-dominated solutions for the defined multi-objective problem.

This study deals with MADM problem which uses permutation technique to solve the problem. Due to NP-hardness of the problem by using permutation method in large-sized, a meta-heuristic algorithm based on Tabu search is proposed to handle the problem and diminish the high computational time for large instances of the problem. The proposed algorithm was compared with the exact method in many test problems with different number of alternatives and attributes. Finally, this paper aims to rank some countries of the west Asia and the North Africa based on various important attributes by applying the proposed algorithm. The rest of this paper is structured as follows. Summary of the classical permutation method is presented in section 2. In section 3, the proposed Tabu search algorithm is introduced. The experimental results are given in Section 4. In this section, the Tabu search algorithm will be used to rank countries based on permutation method and will be tested over various numerical examples. In section 6, the respective attributes for the comparison of countries will be introduced and the concerned countries will be ranked based on proposed method. Finally, section 7 is dedicated to conclusions and suggestions for future research.

2. Permutation Method

In permutation method, all ranking states of alternatives are specified. Each state of ranking is tested and a score is given to it. Finally, the ranking with the greatest score is selected. Consider the Decision Matrix of "D":

$$D = \begin{array}{c} \\ A_1 \\ \vdots \\ A_n \end{array} \begin{array}{c} \begin{array}{ccc} C_1 & \cdots & C_m \end{array} \\ \begin{pmatrix} x_{11} & \cdots & x_{1m} \\ \vdots & \ddots & \vdots \\ x_{n1} & \cdots & x_{nm} \end{pmatrix} \end{array}$$

Fig. 1. Decision Matrix

$A_i (i = 1, \cdots, n)$ Are existing alternatives and $C_k (k = 1, \cdots, m)$ are respective attributes for the evaluation of alternatives. The steps of the method are as follows:

Step 1: Determination of all ranking states whose number is equal to $n!$. For example, if the number of alternatives is 3, the number of states will be 3! = 6 and all states will be as follows:

$$\pi_1 = A_1 > A_2 > A_3 \qquad \pi_2 = A_1 > A_3 > A_2$$
$$\pi_3 = A_2 > A_1 > A_3 \qquad \pi_4 = A_2 > A_3 > A_1$$
$$\pi_5 = A_3 > A_2 > A_1 \qquad \pi_6 = A_3 > A_1 > A_2$$

Step 2: For each ranking, $(A_i > \cdots > A_j)$, we form the matrix of pair comparison in accordance with *S* Matrix. In this Matrix, R_{ij} is the total of the weights of attributes in which the alternative of *i* is higher or equal to *j* option.

Step 3: Calculating the score of *S* Matrix whose quantity is equal to the difference of the total figures over the main diameter from the total figures below the main diameter.

Step 4: Selecting the ranking with the greatest scores as the final ranking of Matrix *D* (Hwangn and Yoon, 1981).

$$D = \begin{array}{c} \\ A_i \\ \vdots \\ A_j \end{array} \begin{array}{c} \begin{array}{ccc} A_i & \cdots & A_j \end{array} \\ \begin{pmatrix} 0 & \cdots & R_{ij} \\ \vdots & \ddots & \vdots \\ R_{ji} & \cdots & 0 \end{pmatrix} \end{array}$$

Fig. 2. *S* Matrix

3. Tabu Search Algorithm

As mentioned before, in real world, solving *MADM* problems by permutation method is practically impossible due to the fact that in large-size problems it has high computational time or, in other words, solving a *MADM* problem by applying the permutation technique belongs to *NP-hard* class. Therefore, Meta- heuristic methods have been developed to solve these types of problems. Various

algorithms have been introduced in this regard each having specific characteristics.

The main reason that the permutation method has not become prevalent so far is due to the fact that this method is time-consuming. For instance, if our matrix has only 10 alternatives for evaluation, the number of the states which should be checked by this method is equal to 10! = 3628800 and in practice, the review of these numbers of scenarios will be impossible. Our suggestion and method in this research is to combine this method with the meta-heuristic algorithm of Tabu Search.

Tabu search algorithm was originally used by Glover in 1986 to solve the combinational optimal issues. The mechanism of this algorithm is such that it starts from an acceptable solution and moves to the best acceptable solution in the neighbourhood of the present solution and continues this job until it reaches the stopping condition. This algorithm has two basic features. The first feature is that in each movement, it moves to the best solution in the neighbourhood of the present solution which might be better or worse than the present solution.

The second feature is the Tabu list. This list includes a number of recent movements of the searcher which there is no permit to refer them in the present action. After doing each action, the present solution is placed at the top of the Tabu List. If the list is full, the oldest solution is removed from it. This feature protects the searcher from circling around and being confined in local optimal.

The proposed algorithm of TS can be described as follows:

Initial Solution: It plays an important role in generating the neighbour solutions and computational performance of the algorithm. To generate a random initial solution, our procedure performs as follows. Each Initial solution contains a random permutation of k numbers between 1 and k, which k equals to the number of alternatives.

Neighbourhood of a Solution: neighbour solutions are obtained from current solution by a predefined partial modification called "movements". So, the definition of the movements determines the corresponding neighbourhood. We apply pairwise exchanges (swaps), i.e., two places of the alternatives are selected randomly and then they exchange their positions with each other. This method is one of the frequently used move types in permutation problems. At each step, the neighbourhood of a current solution is searched in order to find a neighbour solution with the best objective function which is chosen as the next solution.

Tabu List: This list does not permit to turn back to the solutions visited in the previous t steps which t is the length of the list. The purpose of the Tabu list is to prevent the search process from entering repetitive cycles that lead to the same solution. The Tabu list size plays a great role in the search of high-quality solutions. Short tabu tenures allow intensification, while long tenures allow diversification of the search (Costamagna et. al, 1998). In practice, storing the complete solution in the Tabu list and testing if a candidate solution belongs to the list is unachievable. But it is practical that the Tabu list stores the forbidden move or attributes of forbidden solutions rather than forbidden solutions. In this paper, Tabu list stores the solutions on which movements have recently been performed. In this way, only movements on solutions stored in Tabu list are forbidden; this prevents to visit movement explored recently.

Aspiration level: It is a rule that violates Tabu restrictions, i.e., if a certain move is forbidden by Tabu list and when the aspiration criterion is satisfied, the Tabu list can be overridden and the move can be allowable. Here, the considered aspiration level is to revoke a move in the Tabu list if this move gains a solution which has better objective function, than the one obtained earlier with the same move. The importance of applying aspiration level is to add some flexibility in the TS by directing it toward the interesting moves.

Stopping Criteria: the time limit ran out or when no improvement occurs over the best solution for a given number of iterations or the numbers of iterations reach the maximum allowable number, etc. are among the most prevailing standards for stopping the Tabu search algorithm. Our TS procedure stopped after a given number of iterations independently of the iteration and the best solution obtained so far is returned. This given number has been obtained from the parameter setting.

Among the existing contractual signs in this algorithm, it is possible to refer to S (the set of all justified solutions for the problem), s (one justified solution belonging to the solution space), $\hat{s}$ (the best solution found so far) and $N(s)$ (a neighborhood for the solution of s) (Sterzik and Kopfer, 2013). Pseudo-code algorithm will be as follows:

- Set TabuList= {}; TabuL=TL; k=1;
- Choose an initial solution s Є***S;***
- ŝ=s;
- Repeat
- Generate N(s, k) Є N(s);
- Evaluate each s ЄN(s, k);
- Modify the neighborhood N´(s, k) =N(s, k) –TabuList;
- Choose the best solution s´Є N´(s, k);
- Move to s=s´;
- If solution s is better than ŝ then ŝ=s;
- Update the TabuList and aspiration criteria;
- k=k+1;
- Until stopping condition is met

Fig. 3. Pseudo-code *TS* algorithm

It will reach the permutation ranking in a short time. In fact, instead of studying all existing permutations by using computational intelligence of Tabu search algorithm, studying a proper number of permutations (a review of part of the justified space), it will be possible to reach an appropriate solution which is the same ranking of permutation method. Of course, an important question which might arise is that based on the nature of meta-

heuristic methods which do not review all justified space, how can it be said that the obtained ranking is the same ranking of permutation method?.

In response to this question, it can be said that by testing this method over the matrices of decision which are known before their rankings, like the matrices of income and cost and comparing their ranking with each other, it will be possible to learn about the correctness of the obtained ranking. The other way is that in the decision matrix, some alternatives have a dominating superiority over each other , i.e., in all attributes , they are superior to each other , so observing these types of ranks at the final solution of the proposed method will assure us that the obtained rank is correct.

In applying Meta-heuristic algorithms, inappropriate values of parameters can drastically worsen the objective function value, or the computation time. So, In order to determine the tendency for the values of parameters, several tests have been carried out to choose the best values of parameters. In this study, the Taguchi method is applied to determine the values of the parameters in *TS*.

After several pre-tests, we set each of these parameters at four levels. Eight test problems were used for this purpose. Test problems were made of a variable number of alternatives and a number of attributes. In each step, only one of the parameters was tested. Each test is implemented six times. After completing the tests, Taguchi analysis is applied for the different values of parameters. The considered values for the several parameters required by the proposed *TS* are presented in Table 4. Test results demonstrated that these values were appropriate for the problem.

Table 1
Design of values of the parameters in four levels

Parameter	Values
Number of iterations	80, 130, 180, 230
Number of neighbourhood	20, 35, 50, 65
Length of Tabu list	5, 10, 15, 20

We studied the effects of parameters on the performance of our proposed *TS* using the Taguchi method.

The results of the best values of the parameters are shown in Table 5.

Table 2
Results of the Taguchi method for the best values of the parameters

Parameter	Best value
Number of iterations	180
Number of neighbourhood	35
Length of Tabu list	10

4. Numerical Experiments

To evaluate the performance of the proposed heuristic for the problem, a numerical experiment is conducted in this section. The goal is to compare experimentally the effectiveness of solutions generated by the heuristic with the optimum solutions generated by the exact method. The exact method and the proposed heuristic algorithm were implemented using MATLAB 7.11. All the experimental tests were carried out on a PC with 4 GB RAM and core 2 quad 2.5 GHz CPU. Each test was repeated for 5 runs and the best solution was selected.

At first, in order to evaluate our proposed heuristic, we compare it with the complete enumeration method. The other goal is to identify the classes of instances that the exact method is unable to solve them. The numbers of alternatives are between 7 and 13. The results obtained from the complete enumeration method and the proposed *TS* are presented in Table 3. As can be observed, for matrices with the number of alternatives more than 10, the exact method is not capable of solving them because calculation of all permutations is practically impossible. The data displayed in Table 3 show the superiority and full ability of the proposed *TS*.

Table 3
Comparing the proposed method and the complete enumeration method

Problem	Number of alternatives	Complete enumeration method			Proposed *TS*		
		Score	Time (second)	Final Ranking	Score	Time (second)	Final Ranking
No.1	7	12.1	1.61	The Same	12.1	**0.8**	The Same
No.2	8	12.9	13.34	The Same	12.9	**0.86**	The Same
No.3	9	14.9	126.84	The Same	14.9	**1.08**	The Same
No.4	10	21.4	1298.09	The Same	21.4	**1.32**	The Same
No.5	11	-	N/A	-	25.7	**1.61**	-
No.4	12	-	N/A	-	190	**1.94**	-
No.5	13	-	N/A	-	329	**2.43**	-

In order to assess the capability of the proposed *TS*, large size problems are defined. Large size problems were made of a variable number of alternatives and a number of attributes that vary from 14 to 47 alternatives with 20 to 55 attributes. The results of these tests are presented in Table 4. 14-20 means the decision matrix with 14 alternatives and 20 attributes. As it is observed, the proposed *TS* in different sizes of decision matrices could solve them in a short time.

Table 4
The results from the combinational method for different decision matrixes

DM	proposed *TS*	DM	proposed *TS*
14-20	✓	31-15	✓
20-11	✓	31-35	✓
20-20	✓	47-23	✓
20-30	✓	47-35	✓
31-14	✓	47-55	✓

Here, two instances are presented to demonstrate the performance of the algorithm. Consider the fallowing examples, in the decision matrix which is shown in Table 5, 14 alternatives with 8 attributes exist and all attributes with the exception of index 8, have a positive aspect that are type of income. The index 8 is type of cost and has a negative aspect. The data of the matrix is in a form in which each alternative has superiority to its previous alternative in all attributes. So, it is clear what the ranking of this decision matrix will be. The logical and correct ranking of this decision matrix is presented in Table 6.

The score of this ranking is 89.089. Now we solve this decision matrix with the proposed algorithm. As can be observed, the final obtained ranking from this algorithm is the same logical ranking with the same score of 89,089 in the time period of 3.13 seconds.

Table 5
Decision Matrix 1 with 14 alternative and 8 attributes (standards)

Weight	0.084	0.157	0.146	0.1	0.1	0.1	0.146	-0.146
	C1	C2	C3	C4	C5	C6	C7	C8
A1	15	96	80	42	80	66	85	100
A2	35	106	83	61	100	67	104	99
A3	55	116	86	80	120	68	123	98
A4	75	126	89	99	140	69	142	97
A5	95	136	92	118	160	70	161	96
A6	115	146	95	137	180	71	180	95
A7	135	156	98	156	200	72	199	94
A8	155	166	101	175	220	73	218	93
A9	175	176	104	194	240	74	237	92
A10	195	186	107	213	260	75	256	91
A11	215	196	110	232	280	76	275	90
A12	235	206	113	251	300	77	294	89
A13	255	216	116	270	320	78	313	88
A14	275	226	119	289	340	79	332	87

Table 6
Logical Ranking of Decision Matrix 1

Rank	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Alternatives	A14	A13	A12	A11	A10	A9	A8	A7	A6	A5	A4	A3	A2	A1

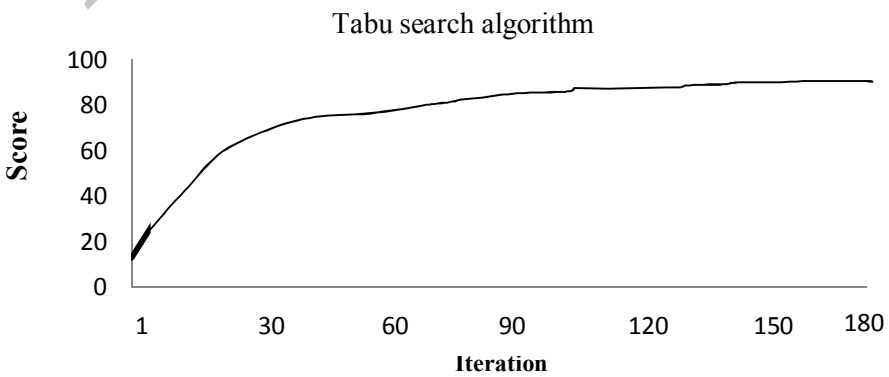

Fig. 4. The outcome resulting from the performance of tabu search algorithm

The second instance: consider the following decision matrix in Table 7. Also, this decision matrix includes 14 alternatives and 8 attributes but with positive aspects. In this decision matrix, some of the alternatives have a dominating superiority as compared with other alternatives, i.e., they have superiority in all attributes. Definitely, this shows the superiority of those alternatives.

Table 7
Decision Matrix 2, with 14 alternative and 8 attributes.

Weight	0.084	0.157	0.146	0.1	0.1	0.1	0.146	0.146
	C1	C2	C3	C4	C5	C6	C7	C8
A1	2.51	0.18	1.395	4.6	3.8	3.3	330.5	4460
A2	2.77	0.206	1.915	4.8	3.8	3.5	400	5450
A3	3.02	0.221	2.637	5.3	4.7	4.4	469.7	14486
A4	2.09	0.137	1.25	4.3	3.4	3	52.5	2579
A5	1.89	0.107	1.122	4.07	2.4	2.5	22.9	1829
A6	3.37	0	4.5	5.8	4.8	4.4	230	46857
A7	2.37	0.232	1.53	3.9	4	3.4	33.6	8707
A8	2.99	0.164	2.432	5.2	4	3.6	11.3	31482
A9	2.92	0.113	3.158	5.4	4.3	3.9	53.4	18013
A10	2.098	0.2068	2	2.5	2.7	3	83.9	872
A11	3.155	0.45	6.429	5.5	4.8	4.7	720.2	19455
A12	3.15	0.28	2.77	4.5	4.2	3.6	615.3	8723
A13	3.21	0.386	6.207	5.1	4.7	5	194.8	26797
A14	2.62	0.229	2.17	3.4	3.7	3.4	166.5	1017

Reviewing this decision matrix, it is possible to learn the superiority of the following alternatives:

1- A11>A3>A2>A1>A4 >A5
2- A11>A3>A10
3- A11>A9>A5
4- A11>A12>A7
5-A11>A12>A4>A5
6- A11>A12>A14>A10
7- A13>A4>A5
8- A13>A7
9- A13>A14

For example, if you consider alternatives 11 and 3 carefully, it is observed that alternative 11 in all attributes has superiority over alternative 3, so in the final ranking of the combinational method, all these priorities should be observed. Now, this decision matrix is solved with the proposed *TS*. With the time average of 3.11, the following ranking was obtained as shown in Table 8.

Table 8
Decision Matrix Ranking 2 by the proposed method

Rank	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Alternatives	A11	A6	A13	A9	A12	A3	A8	A2	A7	A1	A14	A10	A4	A5

The score of this ranking was calculated as 58,643. As it is clear, all priorities which must be observed in the final ranking have been observed.

5. Ranking of Some Countries of the West Asia and North Africa

The objective of all countries' strategic planning and development of economic policies is to improve the economic situation (economic development) based on capabilities and infrastructures. Reaching this objective demands an accurate and integrated planning and commitment to perform it. One of the main stages of this work is to realize the internal strengths and weak points (the study and identification of strengths and weak points to remove the weak points and to reinforce the strengths) and to identify the opportunities and threats of external environment (to review and identify the opportunities ahead to use them and avoid of threats and rivals). This research is an attempt to pursue ranking by using diverse attributes to cover different aspects of countries.

Every year, international institutions such as the World Bank, International Monetary Fund and United Nations Industrial Development Organization present reports on the situation of different countries based on different attributes in the world. In such reports, the comparative view is limited to one attribute, whereas for having a just and scientific comparison, there is a pressing need for including some essential attributes.

Thus, in this research, some countries of the West Asia and the North Africa are ranked based on different attributes of the prevailing assessments and with attributes such as Per Capita Gross Domestic Product (general attribute of macro economy), ease of doing business (the study of rules and procedures of countries), logistics performance index, competitive industrial index, etc. by using the combination of Tabu search algorithm and permutation decision making method.

An index can be considered as the data which helps the analyst with the exploration of the secrets of economic changes. Economic attributes are parts of the most valuable instruments which can be used to analyze the economic situation of countries or enterprises. These attributes which are published regularly have certain scopes and limits. The data related to the economic attributes are presented by different organizations among which the most creditable ones are the World Bank and International Monetary Funds.

5.1. *Gross Domestic Product per Capita (GDP Per Capita)*

The total monetary value of the end products produced by economic units inside the country in a certain time period is called *GDP*. Among the macroeconomic attributes, *GDP* is of special significance, because it is not only used as the most important economic performance index in analyses and evaluations, but also many macroeconomic topics are considered to be the side products of its calculation and estimation. The per capita of the GDP is the *GDP* divided by the country population. In fact, it indicates the population difference of countries and shows the economic difference of low population and

high population countries better (Marattin and Salotti, 2001). Data related to this index were extracted based on dollar and from the website of the World Bank 2010.

5.2. Competitive Industrial Performance (CIP)

This index consists of four variables: 'industrial capacity based on the per capita of the added value of the manufacture sector', 'the capacity of the manufactured exports' and 'the intensity of industrialization' which is calculated with two sub-attributes of the share of medium and advanced technology (*MHT*) production in the production added value and the share of production added value in *GDP*. The quality of the exports which is calculated with two sub-attributes of the share of manufactured exports in the total exports and the share of medium and high technology (*MHT*) exports in the manufactured exports. Data related to this index were taken from the report of United Nation Industrial Development Organization (UNIDO, 2011).

5.3. *Logistics Performance Index (LPI)*

The Logistics Performance Index (*LPI*) is a multi-dimensional index which measures the performance of logistics sector of a country in six domains: the efficiency of the processes of goods clearance, quality of commercial infrastructures and replacement, easy access to different commodities with competitive prices, qualification and quality of logistics services, ability to pursue and trace the sent goods and the time of expectation to deliver. This index has a scale of 1 to 5. The higher score shows a better performance (Fawcett and Cooper, 1998). The data related to this index are taken from the report of the World Bank 2010.

5.4. *Consumer Prices Index (CPI)*

Consumer Prices Index (*CPI*) is one of the most effective attributes to show the present situation of inflation in the economy. *CPI* is an analysis of the level of consumer's expenditures to buy a set of basket of goods and services (Moulton and Stewart, 1999).The data related to this index related to the year 2011 and were extracted from the website of the World Bank.

5.5. *Unemployment Rate*

The unemployment rate is the ratio of unemployed individuals or those in search of a job to the population located at the age of activity which is expressed in percentage. This index measures a part of labour force which has not been working or has lost its jobs for various reasons or is searching a job in the time period under consideration (Brown et. al, 2008).The data related to these attributes for the year 2011 were taken from the Data Service of the World Bank.

5.6. *Foreign Direct Investment (FDI)*

Today, many countries across the world, due to insufficient rate of local resources for investment, tend to absorb foreign resources. Out of the foreign financial resources, foreign direct investment has been further noticed due to the fact that it is one of the main methods of having access to capital, technology and possibility of constant economic growth. If foreign direct investment to be made for any reason and in any shape, it will have a noticeable impact on the economic macro variables including reduction of interest rate, reduction of foreign exchange currencies, increase of economic growth, reduction of government's debts, improvement of income distribution, increase of employment, etc. (Lim, 2008). This index is based on billion dollars and for the year 2011 it has been taken from the Data Service of the World Bank.

5.7. *Ease of Doing Business Index*

The business environment, generally speaking, refers to a set of activities which have effects on the performance of an enterprise or are under the influence of its performance but are not easily controllable. The Ease of Doing Business Index is calculated by the World Bank and is the product of the average of 10 secondary attributes. The Ease of Doing Business Index ranks the countries from 1 to 183 and the first rank is the best rank in this index. In calculation of the Ease of Doing Business Index, the weights of all sub- attributes are equal with each other (Pinheiro-Alves and Zambujal-Oliveira, 2012). The data of this index were taken for the year 2011 from the Data Service of the World Bank.

5.8. *General Government Net Debts (Percent of GDP)*

General Government Net Debt is one of the important attributes of macro economy which is stated in form of a percentage of the Gross Domestic Product and shows the financial affairs of the government. The low rate shows the rate of high and sufficient production to repay the debts (Bohn, 1998). The data of this index for the year 2011 were taken from the Data Service of the International Monetary Funds.

5.9. *Current Account Balance (CAB)*

It is the net total of exports of goods and services, net income and net rate of financial exchanges (Chinn and Ito, 2007). This index is based on billion dollars for the year 2011 and has been taken from the Data Service of the World Bank.

5.10. *Total Reserves*

It shows the total reserves such as gold and resources of foreign currencies under control (Havrilesky, 1967). This index has been extracted based on billion dollars from the Data Service of the World Bank. In the region of West Asia and North Africa, there are other countries such as Iran, Iraq, Afghanistan, Tunisia, Libya, etc. and the data related to these countries in most attributes are incomplete. Inclusion of these countries in the ranking will make the final ranking inefficient. So, these countries were not included in the comparison. In order to compare these countries from the perspective of development,

there are other attributes too. However, the attributes used in this research have the least data incompleteness for these countries. For some of these countries, the data for some of the attributes are incomplete and in these cases, decisions were made based on the data of other credible institutes or the data of the previous years and the views of skilled persons. Of course, the number of these cases were very low.

Regarding the issues of multiple attribute decision making, the weight of the attributes has a considerable effect on the quality of ranking. So, efforts are made to have the weight of the attributes equal to the average views of the skilled persons in the area under consideration. For the mentioned attributes in this research, the views of the connoisseur's individuals were obtained and the average of the views is presented in Table 9.

Considering the data of Table 10, it is obvious that Qatar and United Arab Emeritus have superiority over Oman in all attributes. Definitely, these superiorities should be observed in the final ranking. We utilize the proposed *TS* to rank the matrix of comparison of the countries of the West Asia and the North Africa. The final obtained rank is demonstrated in Table 11. As it is clear, the superiority of UAE and Qatar over Oman has been observed. The time average for the proposed algorithm is 2.28 seconds.

Now, with regard to the weights of attributes, the decision matrix of comparison of the Middle East countries is presented in Table 10. The negative coefficient for the weight of some of the attributes shows the negative aspect of those attributes. In these types of attributes, like the index of cost, the least rate has the greatest value.

Table 9
Calculation of the Weight of the attributes based on the Views of Experts

Acronym	Index	Weight
GDP-P-C	GDP per capita	۰.123
CIP	Competitive Industrial Performance	۰.073
LPI	Logistics Performance Index	۰.065
CPI	Consumer Prices Index	۰.08
UR	Unemployment rate	۰.083
FDI	Foreign Direct Investment	۰.11
EDB	Ease of Doing Business Index	۰.12
GND	General government Net debt	۰.113
CAB	Current Account Balance	۰.115
TR	Total Reserves	۰.118

Considering the data of Table 10, it is obvious that Qatar and United Arab Emeritus have superiority over Oman in all attributes. Definitely, these superiorities should be observed in the final ranking. We utilize the proposed *TS* to rank the matrix of comparison of the countries of the West Asia and the North Africa. The final obtained rank is demonstrated in Table 11. As it is clear, the superiority of UAE and Qatar over Oman has been observed. The time average for the proposed algorithm is 2.28 seconds.

The *S* matrix of the final rank is presented in Table 12. In this Table, number 1 shows the dominating superiority of the country which is in the row over the country which is placed in the column. In this matrix, the high total of the main diameter is 46.41 and the low total of main diameter is equal to 19.74, thus , the score of this ranking which is the difference of the total high main diameter and the total of the low main diameter is equal to 26.67. The obtained rank from the proposed method is in agreement with the views of the experts on attributes.

Table 10
Decision Matrix for comparing the some Countries of the West Asia and the North Africa based on Development attributes.

	weight	0.123	0.073	0.065	-0.08	-0.083	0.11	-0.12	-0.113	0.115	0.118
		GDP-P-C	CIP	LPI	CPI	UR	FDI	EDB	GND	CAB	TR
1	Qatar	92501	0.17	2.9	1.9	0.9	534.5	21	28.3	49.4	16.8
2	Saudi	20540	0.02	3.2	5	11.6	56.2	12	-48.1	141	556.5
3	Emirates	45653	0.19	3.6	0.9	10.1	948.3	33	-82.6	33.3	21.7
4	Oman	25220	0.12	2.8	4	15	141.1	49	38.6	9.5	14.3
5	Kuwait	62664	0.16	3.2	4.7	2.1	0.8	67	35.1	73.8	29.6
6	Bahrain	21700	0.14	3.3	3.2	3.7	0.15	38	32	1	4.7
7	Turkey	10498	0.28	3.2	6.4	9.9	9	71	34.9	-77	87.9
8	Jordan	4665	0.19	2.7	4.4	12.9	1.7	96	-13.6	-2.7	12
9	Lebanon	9904	0.14	3.3	5	10	4.2	104	131.1	-5.6	47.8
10	Egypt	2780	0.16	2.6	10	10.4	6.3	110	64.3	-4.6	18.6
11	Syria	2900	0.13	2.7	4.7	9.2	1.4	134	16.5	-2	20.6
12	Pakistan	1194	0.16	2.5	11.9	6	2	105	60.1	0.4	17.6

Table 11
The Final Rank of the some Countries of the West Asia and the North Africa.

Rank	Countries
1	Saudi Arabia
2	Qatar
3	Emirates
4	Kuwait
5	Bahrain
6	Turkey
7	Oman
8	Jordan
9	Lebanon
10	Syria
11	Egypt
12	Pakistan

Table 12
Matrix *S* of the final ranking

	Sau	Qat	Emi	Kuw	Bah	Tur	Oma	Jor	Leb	Syr	Egy	Pak
Sau	0	0.64	0.46	0.58	0.58	0.84	0.72	0.85	0.7	0.76	0.84	0.84
Qat	0.36	0	0.55	0.7	0.94	0.63	1	0.81	0.82	0.77	0.77	0.88
Emi	0.54	0.45	0	0.56	0.92	0.62	1	0.93	0.69	0.92	0.89	0.92
Kuw	0.42	0.3	0.44	0	0.51	0.59	0.69	0.62	0.71	0.78	0.82	0.89
Bah	0.42	0.07	0.08	0.49	0	0.7	0.53	0.59	0.7	0.66	0.7	0.7
Tur	0.22	0.37	0.38	0.41	0.3	0	0.56	0.69	0.74	0.61	0.89	0.8
Oma	0.28	0	0	0.31	0.47	0.44	0	0.62	0.55	0.5	0.62	0.62
Jor	0.15	0.19	0.07	0.38	0.41	0.31	0.38	0	0.5	0.68	0.69	0.57
Leb	0.3	0.18	0.31	0.29	0.3	0.26	0.45	0.5	0	0.61	0.59	0.62
Syr	0.24	0.23	0.08	0.22	0.34	0.39	0.5	0.32	0.39	0	0.63	0.43
Egy	0.16	0.23	0.11	0.18	0.3	0.12	0.38	0.31	0.41	0.37	0	0.57
Pak	0.16	0.12	0.08	0.18	0.3	0.2	0.38	0.43	0.38	0.57	0.43	0

The important point to be realized while analyzing this ranking is the negative effect of population growth on the economic structure which cannot provide an added value to maintain the population welfare in harmony with the growth of population. The greater population will bring about a less per capita income and, consequently, a lower welfare. As per capita attributes are used to compare countries, this has made these types of countries to be presented weaker in comparison with low population countries.

For example, in this research, despite higher growth in most economic areas as compared with lower population countries, due to the growth of higher population, Turkey is in a lower rank in most of attributes such as per capita income in comparison with those countries. Of course, the increase of the population and vastness of countries for these types of countries is ideal in some attributes such as the rate of investment, rate of commercial exchanges, financial reserves, etc. compared with low population countries. In this research, efforts were made to use various attributes to increase the efficiency of the final ranking.

6. Conclusion

In this research, the Tabu search algorithm was used in order to remove the time-consuming problem of the permutation method which is the main reason accounting for the lack of paying due attention to this method. In order to assess the credit of the final rank through this method, many tests were made and the results confirmed the creditability of the final rank. Using the proposed method, the countries of West Asia and North Africa were ranked based on important attributes of development. The weight of attributes was computed by the individuals who were familiar with the attributes and the method of their compilation and finally the rank of the countries was obtained. Proper analysis and attaching significance to these types of rankings can be one of the best models for planning in a country.

It will be a good idea to extend the proposed *TS* to similar problems and develop other meta-heuristic algorithm to cover the deficiency of the permutation method. Also, considering the ranking of other countries based on other attributes can be investigated for future research.

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