Journal of Industrial and Systems Engineering
Vol. 11, No. 1, pp. 205-222
Winter (January) 2018

Performance measurement of detection and governmental punitive agency by integrated approach based on DEMATEL, ANP, and DEA

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Abstract

The detection and governmental punitive agency is responsible for supervision on correct implementation of the business laws in Iran. Several criteria are involved in performance assessment of detection and governmental punitive agency. The interaction between criteria and sub-criteria may occur in real situations. Moreover, the performance measurement should be accomplished in a multi-period horizon in order to detect the correct perception of the functionality of the organization. So, in this paper a hybrid approach based on DEMATEL, ANP, and DEA-based Malmquist Productivity Index is proposed measure the performance of detection and governmental punitive agency. First, DEMATEL is used to detect the network of interactive criteria through cause and effect relations. Then, the relative importance of the criteria is calculated using ANP method. Finally, a DEA approach is used to evaluate the productivity of alternatives with multiple inputs and outputs during several planning periods while the relative importance achieved from ANP are also considered as constraints of the system. The proposed approach is used at Detection and Governmental Punitive Agency in all provinces in Iran. The results show that the proposed method is able to assess the performance of a service organization while the assessment is accomplished during multiple periods and the organization is compared with technological progress of the industry as well as its historical technical performance. The proposed method is able to identify the complex relations of criteria, prioritizing the criteria, and assess the performance of service organizations due to technical change and technological change during multiple periods.

Keywords: Data Envelopment Analysis, DEMATEL, Analytical Network Process, Malmquist productivity index

1-Introduction

Decision making in real world problems is mixed with several difficulties and issues. First, the decision making process is involved in several conflictive criteria which interact each other. Interactive relationship between criteria may cause complicated network. Second, the relative importance of conflictive criteria cannot be achieved easily in real world. Some of the criteria are benefit-oriented (i.e., the big values of them is desired), while some other are cost-oriented (i.e., small values of them is interesting).

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ISSN: 1735-8272,

Third, evaluation of alternatives with several criteria is not a trivial task at all. It the planning horizon is greater than one period this task becomes more complicated. Under such circumstances, Professional and flexible decision making approaches should be proposed to handle all aforementioned issues.

Performance measurement of service organizations is not a trivial task due to variety of criteria and indices involved. Moreover, the qualitative nature of services overwhelms this complexity. The detection and governmental punitive agency is responsible for supervision on correct implementation of the business laws in Iran. Several criteria are involved in performance assessment of detection and governmental punitive agency. The interaction between criteria and sub-criteria may occur in real situations. Moreover, the performance measurement should be accomplished in a multi-period horizon in order to detect the correct perception of the functionality of the organization.

The main questions of this research can be categorized as follows: 1) what are the main criteria to assess a service organization such as detection and governmental punitive agency? 2) what is the network of interactions and relations among the criteria? 3) what is the priority of these criteria? 4) How the performance of such service organization can be measured during multiple-periods of time considering both technology and technical changes?

In this paper a hybrid approach based on DEMATEL, ANP, and DEA-based Malmquist Productivity Index is proposed to solve a complicated real world Multiple-Criteria Decision Making (MCDM) problem. First, DEMATEL is used to detect the network of interactive criteria through cause and effect relations. Then, the relative importance of the criteria is calculated using ANP method. Finally, a DEA-based Malmquist Productivity Index approach is used to evaluate the productivity of alternatives with multiple inputs and outputs during several planning periods while the relative importance achieved from ANP are also considered as constraints of the system.

Due to our best knowledge, there is no hybrid approach including DEMATEL, AND and DEA in order to assess the performance of service organizations such as detection and governmental punitive agency. The performance assessment of service organizations is a challenging and interesting task, as there are several criteria involving in such assessment. Moreover, complicated interactions are assumed to be exist among these criteria. Besides these, the performance assessment should be accomplished during multiple periods of planning in order to illustrate the main progress or regress of the organization in comparison with technical and technological changes. So, the proposed hybrid DEMATEL-ANP-DEA approach of this study can handle all of the aforementioned issues.

The remained sections of this paper are organized as follows. In section 2 a literature review of past works is accomplished. In section 3, the proposed hybrid approach is developed. In section 4, the case study is discussed and results are presented. Finally, the paper will be concluded in section 5.

2-Literature of past works

In this section the applications of DEMATEL, ANP, and DEA, which are the basis of the proposed hybrid approach, are briefly reviewed in decision making problems.

2-1- Applications of DEMATEL method

Chiu et al., (2006); Hori and Shimizu (1999); Liou et al., (2009) and Lin and Wu (2008) discussed about the different applications of DEMATEL in finding the areas of marketing strategies, control systems, airline security, competency development of global managers and group decisions, respectively. Lin et al., (2009) used DEMATEL to assess the market of cars. Chen and Tzeng (2009) used DEMATEL to create evaluation intelligent systems of materials for Chinese elites. Also Liou and James (2009) used DEMATEL to select outsourcing service providers in Taiwan. DEMATEL method was used in investigating factors affecting the selection of research and development projects by Lin and Wu (2008). Chu (2009) used DEMATEL method in selecting management systems in small industries in 2009.

2-2- Applications of ANP method

Meade and Sarkis (1998) used ANP to evaluate strategies for logistics and supply chain management systems. Meade and Sarkis (1999) analyzed organizational project alternatives for agile manufacturing processes to improve production speed using ANP. Lee and Kim (2000) benefited the ANP and goal programming for interdependent information system project selection. Karsak et al., (2002) offered a combined model of ANP and planning process in the development of quality duties. Meade and Presley (2002) used ANP in the R & D project selection. Mikhailov and Singh (2003) used ANP for the development of decision support systems. Yurdakul (2003) examined the performance of a manufacturing company in the long run by using ANP. Niemira and Saaty (2004) presented an ANP model to predict the financial crisis. Partovi (2006) presented ANP model to determine strategies for locating facilities and services. Lin (2010) used analytic network process (ANP) and fuzzy data envelopment analysis (FDEA) for personnel selection. Kirytopoulos et al., (2011) presented a method based on Markov chains to calculate the extent of the matrix in ANP. Ergu et al., (2014) used a ANP for risk assessment and decision analysis and proposed an adaptation factor for ANP. Bottero et al., (2011) used AHP and ANP for assessment of wastewater refinement systems. Atmaca and Basar (2012) used ANP to assess electric powerhouses. Milani et al., (2012) used ANP in multi-criteria material selection. Shiue and Lin (2012) used ANP to select the optimal recovery strategy used in the upstream industries in solar energy.

Kirytopoulos (2011) presented a method based on Markov chains to calculate the extent of the matrix in ANP. Ergu et al., (2011) used the ANP, risk assessment and decision analysis, and suggested a maximum limit of eigenvalues as adjustment factors for ANP. Bottero et al., (2011) used AHP and ANP for the assessment of wastewater refinement systems. Atmaca and Basar (2012) used ANP to assess power plants. Milani et al., (2012) used ANP in multi-criteria material selection.Shiue and Lin (2012) used the ANP to select the optimal recovery strategy used in the upstream industries in solar energy.

2-3- Applications of DEA approach

Farr et al., (1992) used DEA to calculate efficiency by minimizing the use of production factors to calculate the Malmquist index. Farrell, (1957) defined an appropriate method for assessing the empirical production function using linear programming techniques and data envelopment analysis with multiple inputs and outputs. Dogan and Fausten (2003) used DEA for assessing regulations facilitation and changing technology of Malaysian banks during the period 1989-1998. Dogan and Fausten (2003) analyzed Bank efficiency with net efficiency, scale efficiency, technological and change efficiency; and suggested technological changes had adverse effects on reducing labor intensity and banking activities. Chen (2002) proposed a non-radial Malmquist approach in three main industries as textile, petrochemical, and chemical. Chen (2002) measured technical efficiency changes in four 5-year periods and concluded that the non-radial Malmquist productivity index was an effective tool in assessing the realization of the country's development programs.

Recently, Pamučar et al. (2017) proposed a novel approach to group multi-criteria decision making based on interval rough numbers. Their method was based on hybrid DEMATEL-ANP-MAIRCA model. Gigović, et al. (2017) proposed GIS-DANP-MABAC multi-criteria model for selecting the location of wind farms. Their applied the proposed model in a case study in Serbia. Gigović et al. (2016) tried to apply GIS - Fuzzy DEMATEL MCDA model for ecotourism development site evaluation in Serbia. Gigović et al. (2016) used the combination of expert judgment and GIS-MAIRCA analysis for the selection of sites for ammunition depot. Dimić et al. (2016) used MCDM methods for strategic transport management problems. They investigated the case study of oil industry using the proposed MCDM method. Gigović et al. (2017) applied the GIS-Interval Rough AHP Methodology for flood hazard mapping in urban Areas.

3-Proposed hybrid approach

This study provides a hybrid method for measuring the efficiency of the similar decision making units (DMUs). This hybrid approach is based on MCDM and DEA. In the first part of this hybrid approach, the interaction between several criteria is recognized using DEMATEL method in form of a network. This network structure can explain the transactions and interactions among parameters involved in the assessment process. Then, using ANP, Network structure and interactions criteria involved in evaluating the performance of service units are modeled and the relative importance of criteria is calculated. The first result of this hybrid approach is obtaining the relative importance of criteria with regard to the mutual relations among them. This relative importance is considered as restriction in the final part of the proposed hybrid approach. In the last part of this hybrid approach, a DEA model with regard to quantitative - Qualitative data simultaneously is provided to measure the performance of service units. The relative importance obtained from ANP is considered in the form of additional restriction in the modeling procedure of DEA. As the assessment is accomplished in a multiple-period, so the DEA-based Malmquist Productivity Index is also developed.

The proposed hybrid approach is very practical and remarkable in terms of combining the two types of commonly used tools in decision-making, network modeling of cause and effect criteria, qualitative and quantitative criteria modeling simultaneously, and considering the relative importance of the different criteria in DEA modeling. And also this approach can be employed in management and engineering sciences in similar situations to evaluate the performance of different systems. In order to provide a clear picture of the performance of the proposed hybrid approach, this approach is used at Detection and Governmental Punitive Agency in all provinces in Iran and the results are analyzed. The parts of proposed hybrid approach are presented as follows.

3-1-DEMATEL technique

Procedure 1. Construct the direct-relation matrix. In this step we ask our experts to specify the impact of perspective i on perspective j using a five-point scale from 0 to 4. Zero indicates perspective i has no impact on perspective j. Four means that perspective i has high impact on perspective j. The mean direct relation matrix D is obtained by collecting ideas and calculating the means for the influence degree of the perspectives on each other as follows:

$$D = \begin{bmatrix} d_{11} & \cdots & d_{1j} & \cdots & d_{1n} \\ \vdots & & \vdots & & \vdots \\ d_{i1} & \cdots & d_{ij} & \cdots & d_{in} \\ \vdots & & \vdots & & \vdots \\ d_{n1} & \cdots & d_{nj} & \cdots & d_{nn} \end{bmatrix} \quad (1)$$

d_{ij} indicates the direct impact of factor i on factor j; and when $i = j$, the main diagonal elements $d_{ij}= 0$.

Procedure 2. Normalize the initial direct-relation matrix. The normalized direct-relation matrix can be obtained by using (2).

$$X = s.D$$

$$s = \min\left[\frac{1}{\max\limits_{i}\sum_{j=1}^{n}|d_{ij}|}, \frac{1}{\max\limits_{j}\sum_{i=1}^{n}|d_{ij}|}\right] \quad (2)$$

Procedure 3. Construct the total-relation matrix. The total-relation matrix T is calculated by using (3).

$$T = [t_{ij}]_{n\times n} = X + X^2 + ... + X^k = X(I - X)^{-1}, i, j = 1,2,...,n \tag{3}$$

where I is the identity matrix, t_{ij} (an element of T) indicates the indirect effects of factor i on factor j, and Matrix T reflects the total relationship between the factors.

Procedure 4. Determine the interconnection matrix. We then determine the network relations by using (4) to calculate the total rows and total columns of Matrix T as r and c vectors:

$$\vec{r} = \left[r_i \right]_{n\times 1} = \left[\sum_{j=1}^{n} t_{ij} \right]_{n\times 1}$$
$$\vec{c} = \left[c_j \right]_{1\times n} = \left[\sum_{i=1}^{n} t_{ij} \right]_{1\times n} \tag{4}$$

where r_i (the sum of the i-th row of Matrix T) shows the total direct and indirect effects of Factor i on other factors. In addition, c_j (the sum of the j-th column of Matrix T) shows the total direct and indirect effects of other factors on Factor j.

Furthermore, when $i=j$, $r_i + c_i$ shows all the effects given and received by Factor i. That is, r_i+c_i indicates both Factor i's impact on the whole system and the other system factors' impact on Factor i. Therefore, the indicator r_i+c_i represents the degree of importance factor i on the system. On the contrary, the difference between the two (r_i-c_i) shows the net effect of factor i on the system. More specifically, if the value of r_i-c_i is positive, Factor i is a net cause, i.e. having a net causal effect on the system. When r_i-c_i is negative, Factor i is a net result clustered into an effect group.

3-2-Analytical Network Process (ANP)

One of the basic techniques of Multi Criteria Decision Making is AHP that is very suitable for solving the most complex problems. AHP was presented by Saati in 1980 as a way to solve the social, economic decisions and after that it was used to solve a wide range of issues and decisions. Basic assumption in AHP is the Operational independence of top part (as shown Figure 1) in a hierarchical structure from down part and from the criteria for each level. Many decision problems cannot be placed in a hierarchical structure because of the Interactions among different factors, that sometimes top level factors are related to down level factors. Because of this, ANP, a generalization of the AHP, was founded by Saati, 1982.In general, ANP method can be summarized in the following steps:

Step 1. Develop a model of decision. This model can be presented as a directional network as Figure 1. The model can be simple to the size of a hierarchy or a feedback network, or can be complicated to the size of the decision structural model.

Step 2. Pairwise Comparisons. Determine the clusters and elements among the factors, and after determining a control and a network element select a couple of elements, and to do paired comparisons this question is mentioned: According to control element which element is the dominant influence over another? This comparison is made using a scale of 9 degrees. Accordingly, the number 9 represents the absolute value and 1 indicates no difference or identical.

Step 3. Compute the Local Weights. Get the relative weight vectors of the paired comparisons matrix obtained from the step 2. It is suggested that solution of the weighting is the only way to gain rank or to reflect dominance in the matrix of paired comparisons when there is an inconsistency in the measurement.

With this index the consistency and consistency rate can be calculated to determine the consistency of judgment.

Step 4. Form Super-matrix and Compute Global Weights. Compose super matrix that is a matrix of categories included the calculated relative weighting vectors in Step 3.

3-3- DEA-Based Malmquist Productivity Index

Malmquist Productivity Index (MPI) determines the productivity using DEA efficiency model, and determines the technical efficiency changes and technology changes for DMU from DMUs in different time periods. In order to achieve MPI for several DMUs, 4 linear programs (LPs) should be solved considering input or output orientations and a given return to scale assumption. In this study, MPI values are achieved using the output-oriented CCR-DEA model considering complementary vector of undesirable outputs and then with the help of the expressed approaches, sensitivity analysis of efficiency evaluation units is run at various time intervals. There are different approaches in dealing with undesirable outputs. In this study we used Directional distance function. Thus, the supplement vector of undesirable outputs is used. In this regard, first to homogenize the data all the data are normalized. In other words, any data is divided by the sum of each column. Desirable and undesirable outputs are normalized using (5) and (6) respectively, in which NRD and NRU are reserved for normal of desirable, and normal of undesirable.

$$NRD = \frac{xij}{\sum_{j=1}^{n} xij} \tag{5}$$

$$NRU = 1 - \frac{xij}{\sum_{j=1}^{n} xij} \tag{6}$$

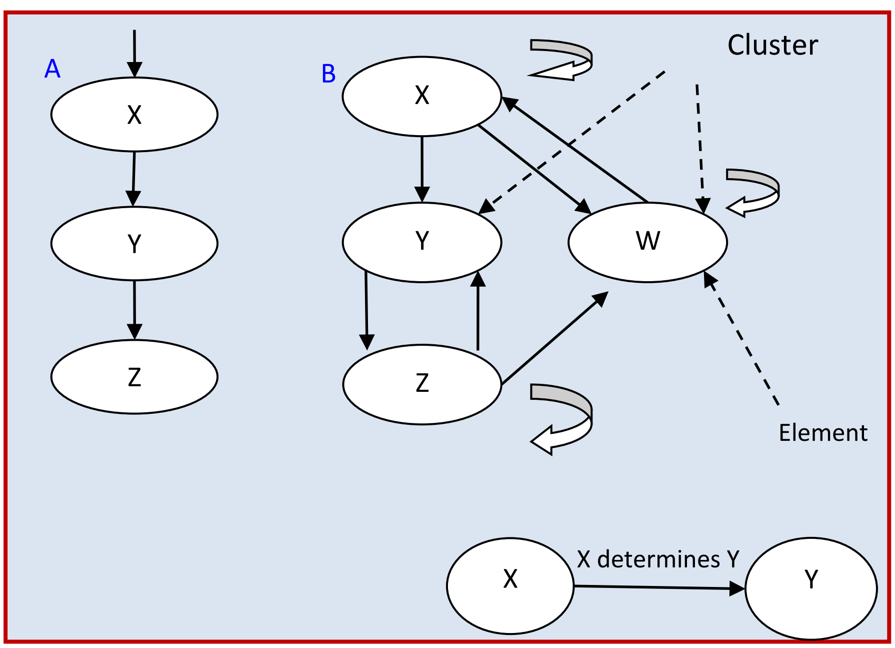

Fig 1. Hierarchical structure (A) and network structure (B)

In this way undesirable outputs are also modeled as the desired output. Finally, to calculate the Malmquist productivity index (MPI), following models are used in period's *t* and *t +1*.
Model (7) calculates the efficiency score of a DMU_o when all data are gathered from period *t*. we call this $D^t\left(x^t{}_o\, y^t{}_o\right)$

$$\begin{aligned}
&\max \theta \\
&st \\
&\sum_{j=1}^{n} \lambda_j x_{ij}^{t} \leq x_{io}^{t}, \forall i \\
&\sum_{j=1}^{n} \lambda_j y_{rj}^{t} \geq \theta y_{ro}^{t}, \forall r \\
&\lambda_j \geq 0, \forall j
\end{aligned} \tag{7}$$

Model (8) calculates the efficiency score of a DMU_o when all data are gathered from period *t+1*. We call this $D^{t+1}\left(x^{t+1}{}_o\, y^{t+1}{}_o\right)$.

$$\begin{aligned}
&\max \theta \\
&st \\
&\sum_{j=1}^{n} \lambda_j x_{ij}^{t+1} \leq x_{io}^{t+1}, \forall i \\
&\sum_{j=1}^{n} \lambda_j y_{rj}^{t+1} \geq \theta y_{ro}^{t+1}, \forall r \\
&\lambda_j \geq 0, \forall j
\end{aligned} \tag{8}$$

Model (9) calculates the efficiency score of a DMU_o when data for $DMU_o$are gathered form period t and the data for other DMUs are gathered from period *t+1*. We call this $D^{t+1}\left(x^t{}_o\, y^t{}_o\right)$.

$$\begin{aligned}
&\max \theta \\
&st \\
&\sum_{j=1}^{n} \lambda_j x_{ij}^{t+1} \leq x_{io}^{t}, \forall i \\
&\sum_{j=1}^{n} \lambda_j y_{rj}^{t+1} \geq \theta y_{ro}^{t}, \forall r \\
&\lambda_j \geq 0, \forall j
\end{aligned} \tag{9}$$

Model (10) calculates the efficiency score of a DMU_o when data for $DMU_o$are gathered form period *t+1* and the data for other DMUs are gathered from period *t*. We call this $D^t\left(x^{t+1}{}_o\, y^{t+1}{}_o\right)$.

$$
\begin{aligned}
&\max \theta \\
&st \\
&\sum_{j=1}^{n} \lambda_j x_{ij}^{t} \le x_{io}^{t+1}, \forall i \\
&\sum_{j=1}^{n} \lambda_j y_{rj}^{t} \ge \theta y_{ro}^{t+1}, \forall r \\
&\lambda_j \ge 0, \forall j
\end{aligned} \tag{10}
$$

It is notable that the relative importance of inputs and outputs which have been calculated by ANP method are added to models (7)-(10) in form of extra constraints as follows:

$$\sum_{j=1}^{n} \alpha_i x_{ij} \ge 0 \quad \forall i \tag{11}$$

$$\sum_{j=1}^{n} \beta_r y_{rj} \ge 0 \quad \forall r \tag{12}$$

Where α_i is the relative importance of i-th input achieved by ANP method, and β_r is the is the relative importance of r-th output achieved by ANP method.

The MPI is then calculated as follows;

$$\mathrm{M}_{\mathrm{j}}^{\mathrm{t+1}}\left(\mathrm{x}^{t+1}, y^{\mathrm{t+1}}, b^{\mathrm{t+1}}, \mathrm{x}^{\mathrm{t}}, \mathrm{y}^{\mathrm{t}}\right) = \left[\frac{\mathrm{D}_{\mathrm{j}}^{\mathrm{t}}(\mathrm{x}^{\mathrm{t+1}}, \mathrm{y}^{\mathrm{t+1}})}{\mathrm{D}_{\mathrm{j}}^{\mathrm{t}}(\mathrm{x}^{\mathrm{t}}, \mathrm{y}^{\mathrm{t}})} \times \frac{\mathrm{D}_{\mathrm{j}}^{\mathrm{t+1}}(\mathrm{x}^{\mathrm{t+1}}, \mathrm{y}^{\mathrm{t+1}})}{\mathrm{D}_{\mathrm{j}}^{\mathrm{t+1}}(\mathrm{x}^{\mathrm{t}}, \mathrm{y}^{\mathrm{t}})}\right]^{0.5}, j = 1, \dots, n \tag{13}$$

Where , $M_o>1$ indicates that productivity has increased and some progress has been made, $M_o=1$ indicates that no change has occurred throughout periods *t* and *t+1*, and $M_o<1$ indicates that productivity has decreased and some regress has been made.

4-Case study and Results

Detection and Governmental Punitive Agency is a specific reference dealing with economic offenses and protection of consumer rights. Appling Correct Economic relations and preventing violations and economic turmoil in the markets and circumstances of economic transactions are some economic tasks of this organization. Therefore, studying the efficiency of this organization and providing guidelines for better performance is an important step in the economic part. Data envelopment analysis based MPI is an important technique to evaluate productivity. In this study, we evaluated the efficiency of these organization branches in 31 provinces.

The criteria in this study are as follows:

(C1) the number of branches: the number of active branches in each province.

(C2) the number of incoming files: The number of files that are referred to each branch in one year.

(C3) the number of remained files in each branch: The number of files that have not yet evaluated.

(C4) the time needed to process each file: Time spent investigating each file.

(C5) the amount of proceeds: After reviewing the file and the approving the sentence by judge, the amount of fine determined for offender individual or business. At the end of the year, the total of these fines has been named as the amount of proceeds.
(C6) the number of closed files: The number of files that is ended their investigation.
The criteria are divided into two categories as input and output. Input criteria are the number of branches, the number of incoming files, the number of remaining files, the duration of the file investigation and the run time, and the output criteria are the amount of proceeds and the number of closed files. Decision making units (DMUs) examined in this study are 31 provinces.

4-1- DEMATEL technique results

In this paper, according to the experts' opinions, a threshold value of 0.28 was determined for deleting a weak relationship. After preparing the matrix of pairwise comparisons of criteria and survey of experts by a five-level scale, direct relations matrix was formed and was normalized. Direct relation matrix is shown in Table 1 while normalized direct relation matrix is presented in Table 2.

Table 1. Direct relation matrix

	C1	**C2**	**C3**	**C4**	**C5**	**C6**
C1		0	3.6	2.7	2	4
C2	1.8		4	3.1	3	4
C3	2	0		3.4	3	2
C4	1.7	0	3		1.6	2.5
C5	0	0	0	0		0
C6	3	0	4	3.1	4	

Table 2. Normalized direct relation matrix

	C1	C2	C3	C4	C5	C6
C1		3	3.6	2.7	2	4
C2	0		4	3.1	3	4
C3	2	0		3.4	3	2
C4	1.7	0	3		1.6	2.5
C5	0	0	0	0		0
C6	3	0	4	3.1	4	

Then the general relations matrix is obtained and shown in table 3.

Table 3. General Relations Matrix

	C1	C2	C3	C4	C5	C6	Impact (R)
C1	0.239359	0.241675	0.593319	0.507065	0.518271	0.544598	0.440
C2	0.211372	0.041218	0.531721	0.458992	0.503976	0.469383	0.369
C3	0.262344	0.051157	0.229872	0.389547	0.403639	0.304695	0.273
C4	0.246535	0.048074	0.388883	0.20394	0.326392	0.322793	0.256
C5	0	0	0	0	0	0	0
C6	0.359561	0.070114	0.513824	0.442754	0.531777	0.25046	0.361
Influence (J)	0.219	0.075	0.376	0.333	0.380	0.315	

Then, the cause and effect diagram is plotted as represented in figure 1.

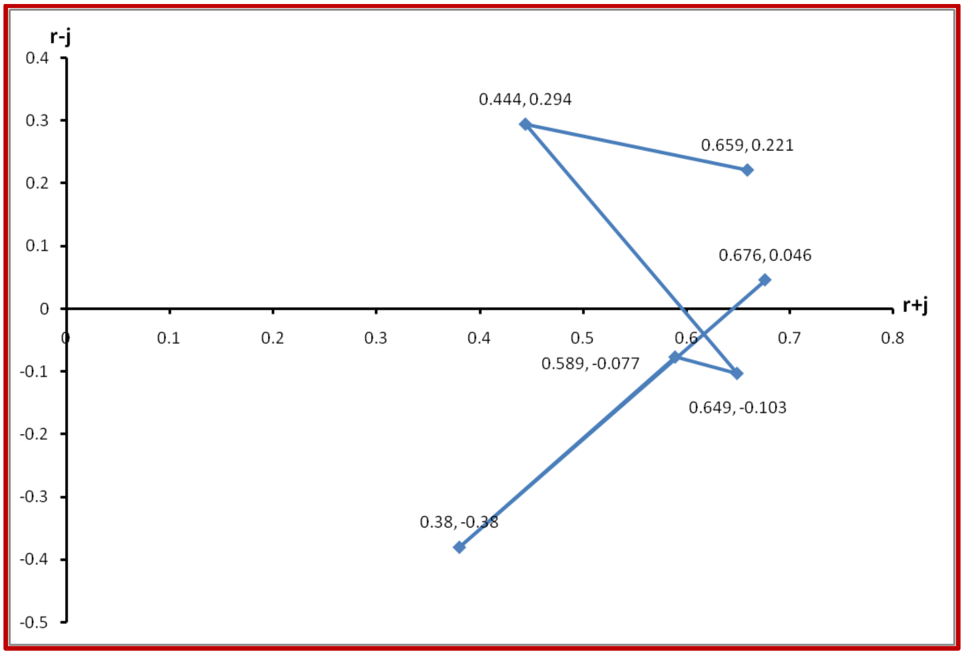

Fig 1. cause and effect diagram

Based on cause and effect diagram, the cause criteria (impact) and effect criteria (influence) were announced as follows:

- The high points of the axis in the positive area are as causal measures with the degree of influence which the highest point on the vertical axis (the maximum value of R - J) is the most causative measure. In this study "incoming" is the most causative measure.
- The bottom points of the axis are as effect measures which the lowest point on the vertical axis (the minimum value of R - J) is the most effective measure. In this study, "proceeds" is the most effective measure.
- Farthest horizontal point than the Origin of coordinates (the largest value of R + J) shows the importance of this criterion in determining the ranking. In other words, this measure has the highest level of involvement in cause and effect process (generally the highest level of interaction) that in this study is "closed".
- Nearest horizontal point than the Origin of coordinates (the largest value of R + J) shows the less importance of this criterion in determining the ranking. In this study "proceeds" is the least importance measure.

Based on cause and effect diagram, contents of table3, and threshold value equal to 0.28, the network structure of the problem is achieved and plotted as figure 2.

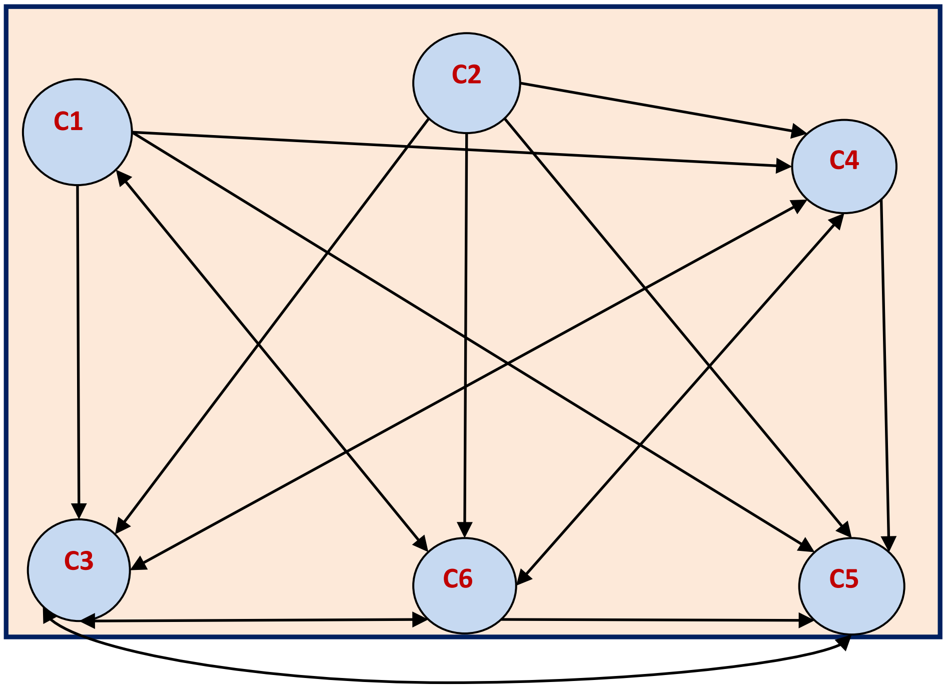

Fig 2. Network Structure

4-2- ANP results

The ANP technique is implemented using *Super Decision* software. DMs are asked to compare the criteria considering the effective cluster. The limit matrix of ANP is shown in figure 3.

0.000000	0.000000	0.590583	0.000000	0.200000	0.000000
0.371464	0.000000	0.118727	0.249310	0.200000	0.000000
0.411755	0.333333	0.000000	0.593634	0.200000	0.000000
0.161797	0.333333	0.227649	0.000000	0.200000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.054985	0.333333	0.063040	0.157056	0.200000	0.000000

Fig 3. Limit matrix of ANP

The final relative values of the importance of criteria are shown in figure 4.

Normalized by Cluster	Limiting
0.20145	0.201447
0.18097	0.180971
0.29398	0.293977
0.18546	0.185461
0.00000	0.000000
0.13814	0.138144

Fig 4. Relative Importance of Criteria

According to the resulting criteria, the number of closed files, the number of branches, the time needed to process each file, the number of the remaining files and the amount of proceeds respectively achieved the highest weights and the number of imported files achieved lowest weight. These weights are used as extra constraints in DEA-based MPI.

4-3- DEA-Based Malmquist Index Results

The results of MPI for period 2010-2011 are shown in table 4. The green rows show the progressive DMUs while the yellow rows show the stable DMU. The blow rows show the regressive DMUs.

Table 4. Efficiency Scores and MPI results

DMU	Dt(xt,yt)	Dt(xt+1,yt+1)	Dt+1(xt,yt)	Dt+1(xt+1,yt+1)	MPI
1	0.9942568	0.93262485	1	0.94025825	0.939134484
2	0.9908349	0.94092877	0.9837985	0.93298813	0.948992348
3	0.974355	0.9435796	0.9866943	0.95276051	0.967010583
4	0.977025	0.94266486	0.9753647	0.94025285	0.96441651
5	0.9199724	1	0.930099	1	1.081055555
6	1	0.95163161	1	0.95908744	0.955352252
7	0.9759443	0.96639151	0.9909028	0.97122786	0.985165202
8	0.9296027	1	0.9325206	1	1.074044081
9	0.9970472	0.98256266	1	1	0.992709684
10	0.9319594	0.98713409	0.9300932	0.98509036	1.059166855
11	1	0.95402624	1	0.94889895	0.951459138
12	0.9315107	0.99010372	1	1	1.030970946
13	0.9288773	1.00466348	0.9223926	0.99768089	1.08160591
14	0.9656791	0.95270814	1	0.95324868	0.969765279
15	0.9844647	0.94282653	1	0.95573147	0.956717629
16	1	1	1	1	1
17	0.9911317	0.94608865	1	0.95245951	0.953506163
18	0.9594344	0.94995414	0.9687526	0.95150484	0.986149433
19	1	1	1	1	1
20	0.9555053	0.97436523	1	1	1.009820877
21	0.9913151	0.9330764	0.987519	0.93052591	0.941768674
22	1	0.944798	1	0.94096773	0.942880922
23	0.9612453	0.95939099	1	0.9749562	0.986445876
24	0.9963068	0.94939695	1	0.9689776	0.96091338
25	0.9774316	0.94335618	1	0.95972265	0.962426416
26	1	0.96225099	1	0.97385103	0.968033634
27	0.9935385	0.9439299	1	0.95563621	0.952848416
28	0.974997	0.95865696	0.9772363	0.95732238	0.98142993
29	0.9774691	1	0.980972	0.99826691	1.020336697
30	0.9849847	0.93731535	0.9828677	0.93663706	0.952283489
31	0.9787117	0.98728476	0.9726088	0.98962233	1.013116665

The results of the Malmquist index are as follows. Provinces with improvements in performance include: Hormozgan, Qazvin, Khuzestan, Khorasan Razavi, Bushehr, Tehran, Alborz, Kurdistan, Zanjan and South Khorasan.Provinces with backward in performance include: Yazd, Hamedan, Mazandaran Markazi, Lorestan, Gilan, Golestan, kohgiluyeh Boyer, Kermanshah, Chahar Mahal Bakhtiari, Ilam, Isfahan, Ardabil, West and East Azerbaijan Provinces with no change in their performance include: Qom, Sistan, Baluchestan and North Khorasan.

It is notable that real data for 2010-2011 are reported in Appendix A and Appendix B for readers who are interested in implementing the proposed approach.

5-Conclusions and suggestions for future research

Performance assessment of service organizations is a complicated task. There are lots of criteria and sub-criteria involved in performance assessment of service organizations. Moreover, network of interactions among criteria and sub-criteria exists in real world application. In performance assessment problems several criteria have different priority and weights that should be considered during evaluation. Besides these, performance assessment of service organizations should be accomplished during multiple-periods of planning considering both technical and technological changes over the time periods.

In this study a hybrid multiple-criteria decision making (MCDM) approach is proposed based on DEMATEL, ANP, and DEA-based MPI in order to assess the performance of a service organization called detection and governmental punitive agency. The combination of aforementioned techniques is capable to handle all aforementioned issues. DEMATEL is used to identify the complicated network of interactions among criteria and sub-criteria. ANP is used to rank the criteria and sub-criteria considering the network structure achieved by DEMATEL. Finally, DEA-based MPI is used to achieved the productivity index for alternatives due to both technical and technological changes during multiple-periods of time.

The whole procedure was applied on a real case study in Detection and Governmental Punitive Agency in 31 provinces in Iran. Each province called a Decision Making Unit (DMU) for sake of anonymity. Six criteria were selected to assess the DMUs as (C1) the number of branches, (C2) the number of incoming files, (C3) the number of remained files in each branch, (C4) the time needed to process each file, (C5) the amount of proceeds, (C6) the number of closed files. The network of interactions among criteria and sub-criteria was identified using DEMATEL method. The relative importance of the criteria and sub-criteria was calculated using ANP. The regress and progress of each DMU was also determined using DEA method. The study was conducted using data gathered 2010 and 2011. It is recommended that a longer period of time is used in future studies to better monitor the progress or regress of the units under review and accordingly, be able to plan to improve performance levels. The proposed hybrid approach may be used in other real world applications considering required customization. Incorporating uncertainties may be useful for future researches.

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Appendix A: Real data of inputs, desirable outputs, and undesirable outputs for 2010

	Inputs		Desirable Outputs		Undesirable Outputs	
DMU	**x1**	**x2**	**y1**	**y2**	**b1**	**b2**
1	18	18893	24 983 491 890	18996	357	16
2	19	26207	55 428 358 952	26110	388	12
3	10	18664	14 075 197 807	18594	257	20
4	25	50341	20 731 990 824	49115	4039	19
5	6	21119	4 090 836 412	20246	2808	113
6	9	8708	2 028 258 775	8555	720	29
7	7	7871	6 247 719 082	8091	384	39
8	55	165998	79 631 090 510	169393	124392	71
9	7	9264	3 807 158 504	9250	365	28
10	23	64013	14 632 540 356	62255	9786	82
11	4	8544	3 140 637 948	8431	351	32
12	7	3730	5 697 055 790	3533	419	34
13	22	28829	19 248 114 577	28695	2779	44
14	8	6774	12 678 332 578	6658	290	28
15	5	9664	4 417 136 852	9513	192	14
16	12	18776	78 211 641 117	18455	2426	21
17	16	30900	13 436 023 117	30308	1559	18
18	4	10774	5 707 832 922	10650	420	29
19	5	21628	5 744 466 973	21593	426	19
20	9	8756	12 590 665 288	8644	274	8
21	15	28044	28 254 959 392	27940	313	22
22	16	29383	7 137 471 925	29420	801	36
23	8	7372	1 735 690 040	7424	345	9
24	13	10542	3 428 438 221	10524	143	13
25	13	22602	8 660 573 413	22305	616	7
26	11	30997	6 747 831 066	31034	1270	22
27	18	37195	4 525 127 440	37049	579	30
28	11	13428	12 139 043 346	13305	260	54
29	6	18712	21 374 269 487	18543	1257	66
30	13	16933	17 689 746 799	16834	367	19
31	11	13486	4 523 573 234	13250	842	53

Appendix B: Real data of inputs, desirable outputs, and undesirable outputs for 2011

	Inputs		Desirable Outputs		Undesirable Outputs	
DMU	x1	x2	y1	y2	b1	b2
1	16	19031	27 759 435 434	18188	1303	11
2	17	27996	53 296 498 993	26863	1424	5
3	11	21883	15 639 108 675	20661	1409	16
4	26	51492	23 294 371 713	48995	5310	20
5	6	21957	4 050 333 082	19441	4451	108
6	8	8840	2 090 988 428	8548	859	29
7	8	8942	7 350 257 744	8476	1070	29
8	57	168094	83 822 200 537	150585	145296	70
9	5	9489	4 479 010 005	9132	708	24
10	24	65993	14 931 163 629	59471	14550	83
11	5	9260	3 109 542 523	8620	878	23
12	7	3657	7 033 402 210	3236	643	28
13	23	35914	20 696 897 395	32437	6122	46
14	7	8216	12 806 396 544	7622	768	29
15	7	9973	5 386 752 259	9458	556	14
16	11	18386	77 437 268 433	17698	2793	20
17	17	35682	14 447 336 685	34306	2343	9
18	6	9976	5 945 659 294	9288	984	23
19	4	23967	5 687 591 063	22692	1666	9
20	10	9156	12 223 946 882	8361	957	9
21	16	32671	29 128 824 116	31462	1418	13
22	15	28939	8 397 025 795	28209	1568	35
23	6	7927	1 907 351 693	7352	972	12
24	11	12150	4 232 639 780	11692	583	14
25	15	23278	8 248 165 156	21985	1612	10
26	9	33121	6 956 526 873	31906	2522	22
27	19	41345	5 656 409 301	39736	2042	26
28	11	13988	11 672 157 064	13241	884	56
29	8	19011	30 944 231 082	17883	2216	69
30	13	20015	19 334 378 093	19142	1141	18
31	10	14723	4 663 477 561	14031	1298	44