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Strategic Environment Analysis Using DEMATEL Method Through Systematic Approach:

Case Study of an Energy Research Institute in Iran

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Abstract: A combined model for Environmental Analysis (EA) in strategy formulation process is presented in this paper. EA is the critical element in strategic planning. Because of direct effect on quality of results, different quantitative or qualitative approaches have been developed. In this paper, steps of EA using values tools such as System Dynamics, expert panels, DEMATEL method, designed and explained in the integrated model. In first step, all different factors are identified and classified, and then using a questionnaire, related factors are listed. The causal model identifies the main causes and effects. DEMATEL method specifies priorities of each factor. By using the influenced-influencing matrix, key factors will be determined. In all stages, panel of experts plays complementary and approval role. Finally we applied this model in strategic planning processes of an energy research institute in Iran as a case study.
Key words: Environmental Analysis; Systems Approach; Causal loop diagram; DEMATEL Method; Expert Panels

1. INTRODUCTION

Strategic management consists of those decisions and measures required for formulating and executing policies in order to regulate the relation between an organization and its environment so that the organization can meet its objectives. In other words, strategic management is a process used to promote an organization from its current status to the desired status.

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Developing the strategies of an organization is carried out based on key environmental factors of an organization. Therefore, one the most important steps for the process of strategic planning is to recognize environmental factors, analyze them, and select ultimately the most important environmental factors in an organization (David, 2008; Bryson, 2004).

All formulated strategies are based on result of this step. Outcome of this step would be a valuable basis of action planning, implementation and even evaluation process. If the defining method and priority setting of key environmental factors had not enough verification and integrity, therefore final key factors would be wrong or weak and the other parts of strategic planning like strategies would be invalid.

Needless to say, the most important procedure is to propose a correct model which conducts choosing the key factors step in an accurate direction.

Using commonly approaches to choose key factors are so simple. Most of them are qualitative approaches; however there are some quantitative approaches like MCDM.

In this paper, a new combined approach has been introduced using the resource-based theory, system analysis and DEMATEL methods which recognize the key elements of research institute environment.

Section 2 describes the E.A basics and methodologies. In section 3, the proposed model is explained. The whole model and detail parts of it are described completely. Finally, authors applied the model in a case study which is demonstrated in section 4.

2. ENVIRONMENTAL ANALYSIS

Environmental analysis is the main step of strategic planning in different models and approaches. Environmental analysis is divided to two parts: Internal & external. Internal analysis posed internal factors to scan strengths and weaknesses of the organization .external analysis refer to macro and micro environment of the organization .In the macro environment the following factors are studied: political, economic, social and cultural, technological, legal\ governmental factors. These factors are called PEST factors (Johnson, 1999). Numerous approaches are used to scan this environment in the basis of various strategy schools which lead to the diversity of application and analysis of environmental factors. For instance, in planning approach and locating approach matrixes of EFE and IFE or SWOT are used. Moreover, the structural analysis of industry (Hax & Majluf, 1996) through Porter's Five Forces Analysis in external environment and value chain in internal environment, and identifying competitive advantages are other examples of this field.

Through these approaches qualitative and quantitative tools are established improving the key strategic organizational factors identification. In the absence of quantitative tools, authors offer a new integrated quantitative model of environmental analysis. For the purpose of this paper, the system approach and factor analysis through the matrix of DEMTEL and the extraction of key factors of strategic planning are used. Following, brief description of the mentioned tools would be presented.

2.1 Systems Approach

Models are simplified representation of reality. The most important goal of system dynamics modeling is to achieve better understanding of system's interactions to investigate possible policies which improve system's state. (Shi & Gill, 2005; Coyle 1996). Due to interactions among different parts of a system, it is necessary to consider system's behavior through systemic approach. This can be done through studying different parts and their relationships in form of a system (Sterman, 2000).

Systems approach had been developed in late 1950 in MIT by a research group under the supervision of J. W. Forrester (Coyle 1996). Forrester firstly used system dynamics to model and simulate a long-term decision making process in a dynamic industrial management problem (Forrester, 1961). The main idea was to utilize existing rules in system control in the field of electronic and mechanic engineering to deal with social systems. After that, system dynamics has been used to formulate strategy and policy in different

business areas (Barlas, 2002; Sterman, 2000). The approach extended in MIT in 1960 by Forrester (Forrester, 1961, 1968, 1969, 1971).

Today, this technique is utilizing in various scientific areas although it developed in industry and business field (Berends & Romme,1999).

Systems approach has been considered as a way to analyze systems and solve complicated problems (Barlas, 2002; Alessi, 2003). Consequently, many use this approach to deal with complicated systems and to help others to understand these systems (Bruckman, 2001). Systems approach facilitates decision making through focusing on system's general behavior and its effect on system in the future (Coyle, 1996; Helms, 1990). Therefore, systems approach presumes that parts of a system have complicated relationships with each other and informational flow is more important than physical flow (Lane & Oliva, 1998). This approach helps to better understand complicated environments (Coyle, 1996; Spector et al., 2001).

One important tool in systems approach in Causal Loop Diagram (CLD) which is necessary to build up in developing a model which is meant to be applicable in practice (Dyson & Chang, 2004).

In general, it could be concluded that systems approach is a suitable formulated method to analyze a system's parts which has causal relations and logical infrastructure (chen ching ho et al., 2005).

From validation point of view, since the structural validation is prior to behavioral validation (Shi & Gill, 2005), the structural validation of proposed CLD in this paper is examined through expert panel

2.2 DEMATEL Method

DEMATEL method had been applied at the end of 1971 by Fontela and Gabus. This method was used to solve complicated global problems which exploit experts' opinions in scientific, political and economic area Gabus & Fontela, 1972; Gabus & Fontela, 1973)

DEMATEL at first, has been applied in BMI institute to implement a big project in Genev center (GRC).

DEMATEL is a popular method in Japan, because this method is a comprehensive method to formulate and analyze structural models in which there are complicated cause and effect relationships.

DEMATEL method (Fontela & Gabus, 1974, 1976; Warfield, 1976) is applied to depict the interrelations between factors and to discover the key factors to illustrate the effectiveness of them. It has also been successfully applied in many situations, such as, safety measurement (Liou et al., 2007), supervisory control systems (Hori & Shimizu, 1999) Marketing strategy and customer behavior (Chiu et al., 2006), fuzzy approach and expert systems (Wu & Lee, 2007; Lin& Wu, 2008).

Using of feedback application is one of superiority of this method rather others decision making methods. It means, in its structure, each part can exerts on and receives from other equal, superior or inferior level factors .Importance and value of factors, determine by whole factors instead of specific factors.

Foneta and Gabus In 1976, developed above technique and proposed 5 main steps to apply it;

- Generating the direct-relation matrix
- Normalizing the direct-relation matrix
- Attaining the total-relation matrix
- Producing a causal diagram
- Obtaining the inner dependence matrix

Based on the generated matrix from first step, the normalized direct-relation matrix Mn would be achieved throughout following formulas:

$$M_n = k * M \quad (1)$$

Which K factor obtained from following function:

$$k = \frac{1}{\max\limits_{1 \le i \le n} \sum\limits_{j=1}^{n} a_{ij}} \qquad (2)$$

At the end total relation matrix M* obtained from formula() in which the I is symbolized as the identity matrix.

$$M^* = M * (I - M_n^{-1}) \qquad (3)$$

3. PROPOSED MODEL

In order to accomplishment the comprehensive model, some step by step procedures are traversed. First of all, all different factors are recognized and classified, and through using the questionnaire forms, related factors are listed. The casual model identifies the main causes and effects. DEMATEL method specifies priorities of each factor. By using the influenced-influencing matrix, key factors will be determined. In all stages, panel of experts plays complementary and approval role. These steps are coming as follows:

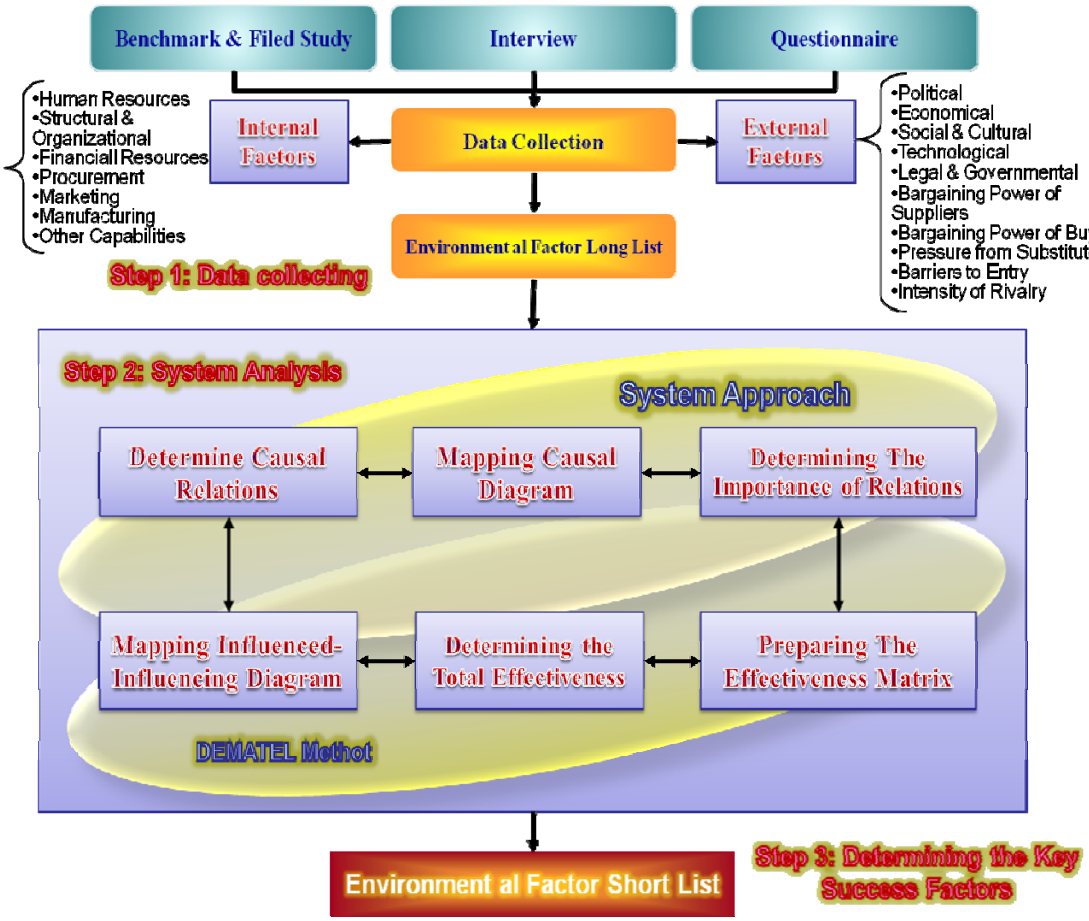

Figure1: Research Methodology

The proposed model of "Environmental Analysis" consists three main phases:

- **First phase:** data collection;
- **Second phase:** system analysis using DEMATEL method;
- **Third phase:** selection of key environmental factors figure 1.

3.1 First Phase: Data Collection

Regarding the sensitivity of this phase in having access to the key factors of an organization, all organizational aspects should be recognized effectively and systematically, then data is to be collected. Various ways of data collection is available, however most three common ways are listed below:

- **Holding meetings and carrying out interviews:** holding meetings consisting of work groups, and interviewing individuals, who cannot attend such meetings, asking views and opinions as regards different environmental factors and strategic problems, which would be solved by the organization.
- **Field Study:** Studying and analyzing the statistic information of the previous years, reports, regulations, bylaws, working processes, mandates, etc in order to recognize key factors;
- **Questionnaire:** Using questionnaire and sending such questionnaires to the members of working groups and Stakeholders, who cannot be interviewed or attend meetings;

3.2 Second Phase: system analysis using DEMATEL method

The most important phase of environmental analysis in this model is analyzing and prioritizing factors. In case there is no comprehensive approach to review environmental factors interacting with each other, and decision making method, and system consisting of all obtained factors, therefore desired and proper results cannot be achieved. In other words, to access key factors in an organization it is required to review an organization and its environment in form of a system. Therefore, in this paper, authors used a tool, which can meet the above mentioned objective. The most important tools are "determining the influenced-influencing of factors", and "cause and effect diagram"

In this model, a process has been developed using the above mentioned tools to access properly internal and external key factors of an organization. Different steps of this process are as follows:

a. Termining cause and effect relationship: in this phase, the relations among the environmental factors were determined through consulting with experts and administers. To identify the relationships, the influenced and influencing of each factor vs. other factors was determined.

b. Eparing cause and effect diagram: after recognizing and approving the cause and effect relationship among environmental factors, the factors and their relations can be illustrated using a diagram. This helps to understand the relations schematically and better. Moreover, this diagram can improve and modify the recognized relationship. Indeed, these two steps can be carried out parallel and completed each other. In such a case, validity and reliability of these two steps is approved by the other one.

c. Termining the importance of relationship: After preparing a valid cause and effect map consisting of environmental factors and their effects on each other, the importance of these relations shall be determined. To clarify the significance of this step, it must be noted that a criterion for selecting key factors among the existing factors shall be decided. In fact, this model is the process of preparing a short but comprehensive list of most important factors in an organization through consulting experts and scholars. The most important factors are those ones effective mostly in an organization and its environment. Therefore, to meet the above mentioned objective, it is required to determine the importance of the effects of each factor on the other factors on the map, in addition to recognizing factors, and determining the relations among factors, and preparing cause and effect map. To measure the importance of the relation

among factors, there are different methods, among which use of the opinions of the experts who are aware of the effectiveness manner of intra- and extra-organizational factors, can be deemed as the most valid and useful ones. For this purpose, we can prepare a matrix corresponding to the cause and effect map. The rows and columns of this matrix show the environmental factors and Cells show the effectiveness intensity **of these factors vs. each other. Then, this matrix is distributed among the** experts and administrators of the organization to determine the average of the opinions and calculate the importance of relationship in a causal map.

d. Eparing the effectiveness matrix: in this step, a matrix named "effectiveness **matrix**" is prepared. This matrix is like the one prepared in the previous step to be reviewed by experts and administrators. Indeed, if the proposed method to determine the importance of the relations of causal map is used, the matrix of this step can be prepared easily through using the conclusion matrix of the previously prepared matrixes. In case any method other than proposed one is used, the matrix of this step should be prepared through final results.

e. Termining the total effectiveness and impressionability (influenced-influencing)**:** the matrix prepared in the previous step shows the effectiveness of factors interacting with each other directly. To discover the most effective and important factors, based on the explanations set forth in the third step, the indirect effects of factor on each other shall be calculated respectively. As it is shown in the figure 2, indirect effects are influenced by a factor (for example factor A), which have impact through one or more environmental factors (factor B) on a third factor (factor C). These effects can also be measured using different methods.

One of the most easy and useful methods to calculate indirect effects is DEMATEL method. DEMATEL-Method stands for Decision Making Trial and Evaluation Laboratory. This method has been developed based on graph theory and has been designed to determine the direct and indirect effects in a graph of interrelated factors. In this method, a set of direct and indirect effects of various levels is calculated using a formula, which is the result of matrix calculations obtained from the graph, i.e. direct and indirect effects were added together using a medium and the result was added to indirect effects using two medium and it continues respectively until all indirect effects are calculated through medium (mediums).

The result of the above mentioned total sum is calculated using the rules governing matrixes and relatively complicated calculations.

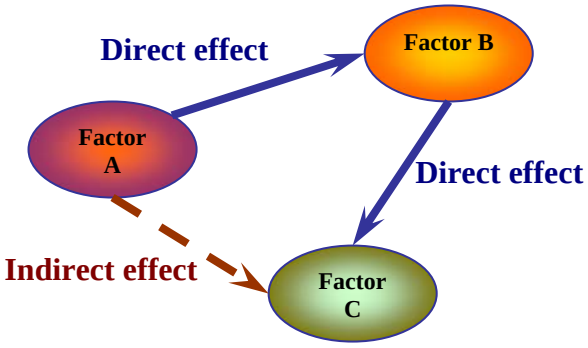

Figure 2: Comparing direct and indirect effect

f. Veloping Effectiveness and Impressionability (Influenced-Influencing) Diagram: In this step, the diagram of effectiveness and impressionability is developed to provide a better understanding from the importance (intensity of effectiveness and impressionability) of factors in an organization. Coordinates of factors in this diagram are obtained using the calculations of previous steps of total effectiveness matrix.

In this diagram, the coordinates of x-axis show the total value of effectiveness of a factor and those of y-axis show the total value of impressionability.

Preparing a matrix similar to figure 3 helps us to review and analyze the environmental factors of an organization more carefully and precisely and decide more easily on selecting the most important factors.

3.3 Third Phase: Selecting Key Environmental Factors:

In the model provided in this paper, a diagram has been designed, which facilitates the selection of key factors of an organization. This diagram is called "diagram of effectiveness – impressionability", which was described in the previous phase. Based on this diagram, a method is provided to prioritize the environmental factors. This diagram divides factors to four groups in terms of their effectiveness and impressionability. As it has been shown in figure 4, these four groups are as follows based on their priority in selecting factors:

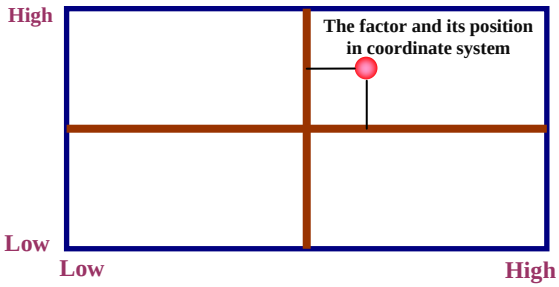

Figure 3: Displaying effectiveness and

Effective (Influencing) factors: factors of this square have the most effect on other environmental factors and have the first priority in terms of the significance of selecting key factors of the organization. They are the most attractive environmental factors and the organization, and in case of a minor change in these factors, material (maximum, major) changes are occurred in other factors.

Mediums (intermediates, intermediates): factors of this square are to be observed more specifically for decision-making, since they are not only those factors have the most effects on other factors, but also they are impressed mostly by other environmental factors.

Therefore, if these factors are selected as the key factors of an organization, material (maximum, major) changes are occurred due to such a selection, and if they are not selected, unpredictable changes will be occurred in them. The undesired changes in these factors other factors are influenced and changed automatically. Therefore, these factors shall be selected more carefully.

Impressionable factors: factors of this square are impressed by other factors and have minor effects on other factors. These factors are less prioritized than the previously described factors. They shall attract attention because of their high impressionability. They can recognize the factors influencing them and smart selection of these factors may help selecting a key factor of an organization and impressionable factors. In other words, by smart selection of other factors influencing impressionable factors, expected changes can be carried out in these factors without selecting important organizational impressionable factors. Considering the limitation of sources in organizations, these selections are regarded as strategic organizational selections.

Ineffective factors: factors of this square are of minor importance in an organization, since these factors do not have considerable effects on other factors and are not influenced by any other environmental ones. Selection of such factors is useless, because assigning sources to these factors does not cause any strategic and significant changes in the organization. Since these factors interact with other organizational factors weakly. Therefore, selecting these factors during choosing key factors of an organization shall be less important than any other factor. By classifying the environmental factors of an organization into these four groups, the selection of key factors of an organization can be decided optimally and intentionally.

4. CASE STUDY

In this paper a research institute, which was active in the field of electricity and energy, was case studied. This organization has 400 personnel and a budget more than 50 billion Rials per annum.

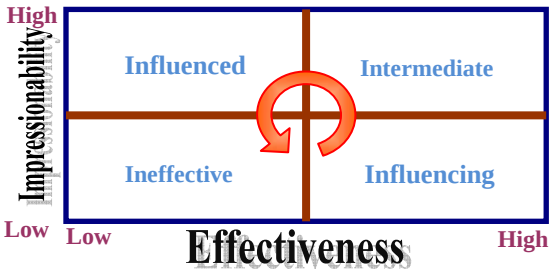

Figure 4: Prioritizing factors in influenced-influencing matrix

Within 2008 a project was conducted aiming to formulate the strategic plan for this organization. According to all strategic planning studies, one of the most important phases, was the phase of analyzing external and internal environment of the organization. In this step, primarily, the experts of the institute were recognized. Then, they were classified into special workgroups to be able to be communicated more effectively.

For this purpose, each main division of the organization was requested to introduce their experienced experts and any other beneficiary outside the organization, who were more aware of the environmental factors and strategic issues of the organization. In this phase 9 workgroups consisting 60 members were defined in the institute. Then, a questionnaire was developed for these workgroups. They also were informed of the environmental factors of the institute (strong points, weak points, opportunities, threats and their examples were provided). They were requested to provide their opinions in form of strong points, weak points, threats, and opportunities in the organization. In this phase, more than 300 factors for each environmental dimensions, divided into four groups.

Then, the results were categorized and approved using numerous sessions and interviews. During these interviews, the collected data were discussed, modified and approved by the experts.

After this phase, a list of environmental factors of the institute was prepared (table 1). It was a proper point for beginning the second phase, which was the systematic analysis. Firstly, the relations among factors were determined by means of experts and the map of cause and effect of the factors were prepared during the course of this phase (figure 5).

After preparing the final map of environmental factors of the institute, the members of the workgroups were requested to determine the importance of the relations illustrated on the map. Therefore a matrix corresponding to the map was designed and submitted to the selected experts to define the importance of the relations. After collecting the opinions, the corresponding matrix of importance and consequently the matrix of effectiveness of environmental factors were prepared. The matrix of effectiveness and calculations through DEMATEL helped us to calculate the total impressionability and effectiveness matrix. The data obtained using this matrix applied to prepare the matrix of impressionability – effectiveness diagram of the environmental factors (figure 6). The team in charge of analysis used the diagram and prioritized the factors through four priorities of effectiveness, medium, impressionability, and ineffectiveness to select key factors of the institute smartly and precisely. The selected factors were submitted to the experts to be approved and modified. Then the key environmental factors of the institute were determined (table 2).

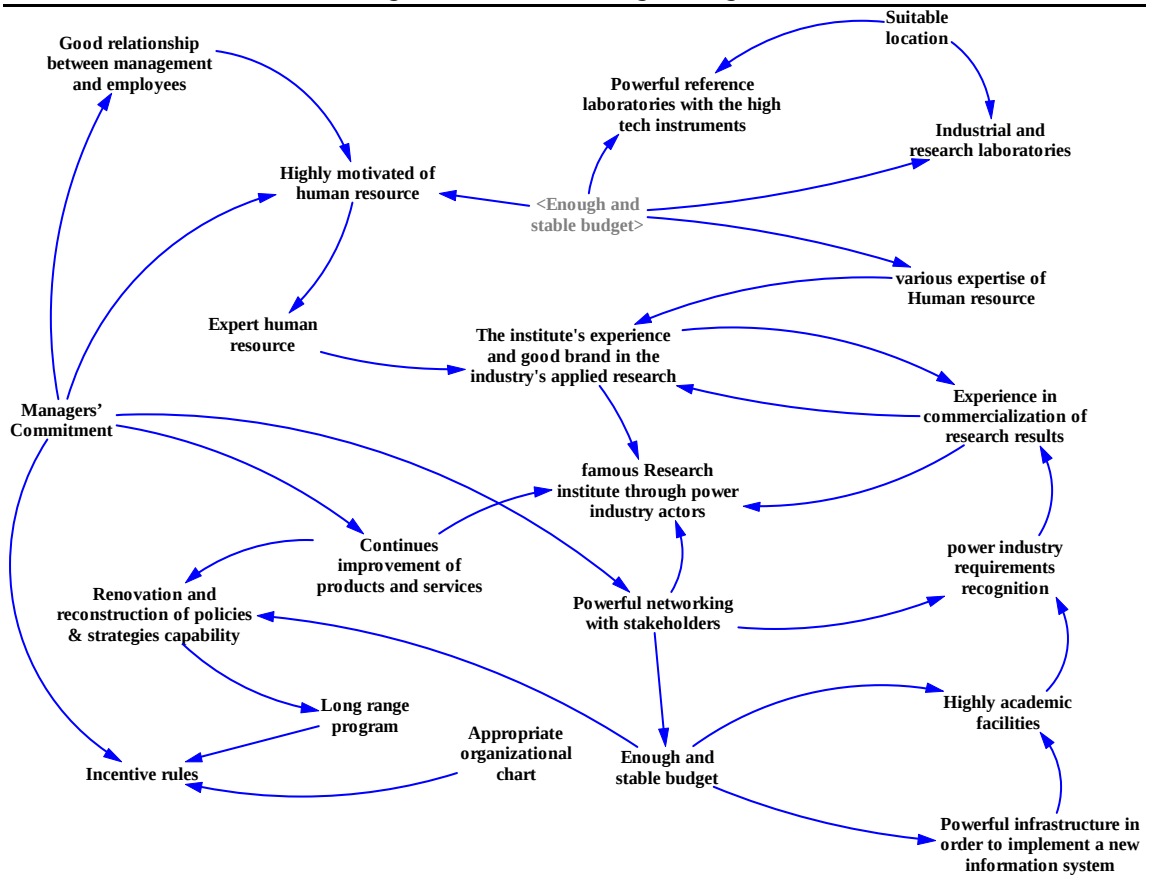

Figure 5: Causal loop diagram of strength factors in the case study

Table1: Resulted strength factors resulting from first step in the case study

Row	Factor name
1	Expert human resource
2	various expertise of Human resource
3	Highly motivated of human resource
4	famous Research institute through power industry actors
5	Experience in commercialization of research results
6	power industry requirements recognition
7	Continues improvement of products and services
8	Incentive rules
9	Powerful networking with stakeholders
10	Managers' Commitment
11	Renovation and reconstruction of policies & strategies capability
12	Powerful infrastructure in order to implement a new information system
13	Powerful reference laboratories with the high tech instruments
14	Enough and stable budget
15	Suitable location
16	Industrial and research laboratories
17	Highly academic facilities
18	Appropriate organizational chart
19	Long range program
20	Good relationship between management and employees
21	The institute's experience and good brand in the industry's applied research

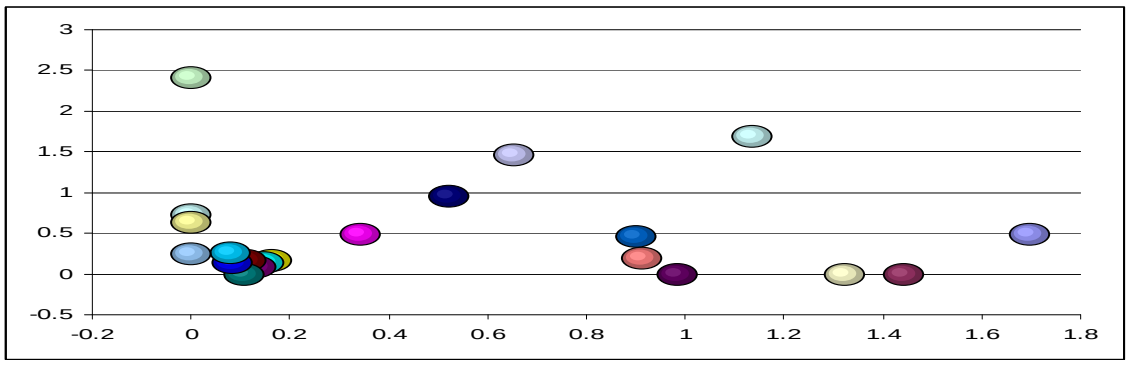

Figure 6: Effectiveness and impressionability in the case study

Table 2: Final strength factors in the case study

Row	Factor name
1	Suitable location
2	various expertise of Human resource
3	The institute's experience and good brand in the industry's applied research
4	Industrial and research laboratories
5	Enough and stable budget
6	Incentive rules

CONCLUSION

As a conclusion, this paper provides a new systematic approach in environmental analysis of the nonprofit research organizations through strategic planning concept. Combination of DEMATEL and effectiveness evaluation matrix and system dynamic approach as a qualitative and quantitative techniques and tools in a one integrated way through environmental analysis is the most important part of this paper. Finally application of the model on a nonprofit research organization in Iran's energy sector, showed the prior and key strengths, weaknesses, opportunities and threats, is the last achievement of this study.

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