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Analyzing the Drivers of Green Manufacturing Using an Analytic Network Process Method: A Case Study

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A B S T R A C T

Todays, some challenges such as soil, water and air pollution, and severe health hazards to humanity are the results of growing manufacturer in the real world. These challenges are so-called posing risk for sustainable development of the planet. In this matter, the need of achieving higher economic prosperity, along with the least environmental impact has led to a new manufacturing paradigm so-called Green Manufacturing (GM). In this way, Small and Medium-sized Enterprises (SMEs) in Iran with ISO 9001 and ISO 14001 certification, and Just-In-Time inventory control, which make up 99.8 percent of all businesses, are responsible for 70 percent of all industrial pollution. In this paper, we explore the drivers of the GM of SMEs' environmental processes in field of the industrial chemistry and their impacts on GM. Unfortunately, there is no proper work considering a wide range of drivers of GM in an industrial chemistry. We evaluate 500 Iran SMEs in the field on industrial chemistry, and select the Tage Company as a case study for this purpose considering its Greenhouse Gas Emission (GHG). This paper aims to gather the common drivers of GM from several sources on a case study in Tage Iran Company, as well as to analyze them by utilizing Analytical Network Process (ANP) in an uncertain environment. To tackle this uncertainty, the fuzzy ANP is utilized to prioritize the barriers to GM based on environmental, social, and economic perspectives. Finally, based on the obtained drivers, the fuzzy ANP identifies essential critical driver and the priority of drivers by utilizing a pair-wise comparison.

Keywords: Greenhouse gas emission, Water and air pollution, Green manufacturing, Analytical network process, Industrial chemistry.

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1. Introduction

Green Manufacturing (GM) is introduced as a manufacturing process that utilizes input data with relatively low environmental impacts, whereas is highly efficient and creates little waste or pollution, and Greenhouse Gas Emission (GHG). In this matter, Johansson and Winroth [1] described that GM tries for continuous improvements of both manufacturing processes in order

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to decrease or prevent pollution to air, water, land and so on. Using these enhancements, there is possibility of reducing risks for both humans and other species as well. Besides, Richards [2] introduced the challenges relevant to GM such as providing the customer requirements for finished products, scheduling the recycling approaches, reducing the materials used, and selecting the raw materials causing low environment impacts. On the other hand, Atlas [3] described that GM would lead to decrease in the cost of materials, the environmental, and safety costs, raising in the production efficiency and so on. Moreover, the value of product consumption can be considerably decreased to greater extent through implementing GM. As a result, GM improves environmental consciousness through 3 Rs, which was called Reuse/ Recycle/ Refurbish activities Singh et al. [4]. This issue enforces us to select the suppliers who have ISO 9001 and 14001. Besides, one supplier who control hazardous consequences in the industries and has obtained green certificate achievements can be considered an efficient supplier.

Several problems such as natural resources, soil, water, air pollution, and severe health hazards to humanity are created. Therefore, the requirement of achieving higher economic efficiency with at least environmental impact would lead to a new manufacturing paradigm of GM. In this matter, ElMaraghy, Mittal, and Sangwan [5] described that GM denotes designing, manufacturing, delivering, and disposing products that has at least negative impacts on both environment and society and that were economically viable. However, many barriers encounter performing GM in industry. For example, the implementation of GM is possible only with collaborated efforts of both government and industry together in a strategic way by mitigating the GM barriers. To identify and remove the barriers, this paper aimed at prioritization of the barriers to GM through Analytic Network Process (ANP), a multi-criteria methodology that is able to consider a wide range of both quantitative and qualitative drivers based on environmental, social, and economic characterizes. The prioritization of GM barriers and their roles will help not only government, but also organization and firms to focus on few crucial barriers to mitigate within limited resources. However, empirical research has evaluated the matter that criteria operating inside the firm – organizational criteria – affects the propensity to adopt GM. Such factors are very critical, for organizational theory and recent empirical research on the adoption of advanced business practices, which show that organizational criteria have sufficient impact in the adoption by firms. To do so, current researches paid attention to the role of “organizational capabilities” in both organizational and performance [5]. To describe our purpose, an analytical model of the relations among these factors (drivers) is presented in Figure 1. This Figure also illustrates a system of interactions between external (both market and regulatory) drivers and multi-dimension of organizational capabilities. Although many researches in this area have explored and studied the critical role of regulatory pressure and market competition on environmental outcomes, we focus on the role played by organizational factors in affecting the adoption of advanced environmental practices of GM by utilizing ANP in industrial chemistry.

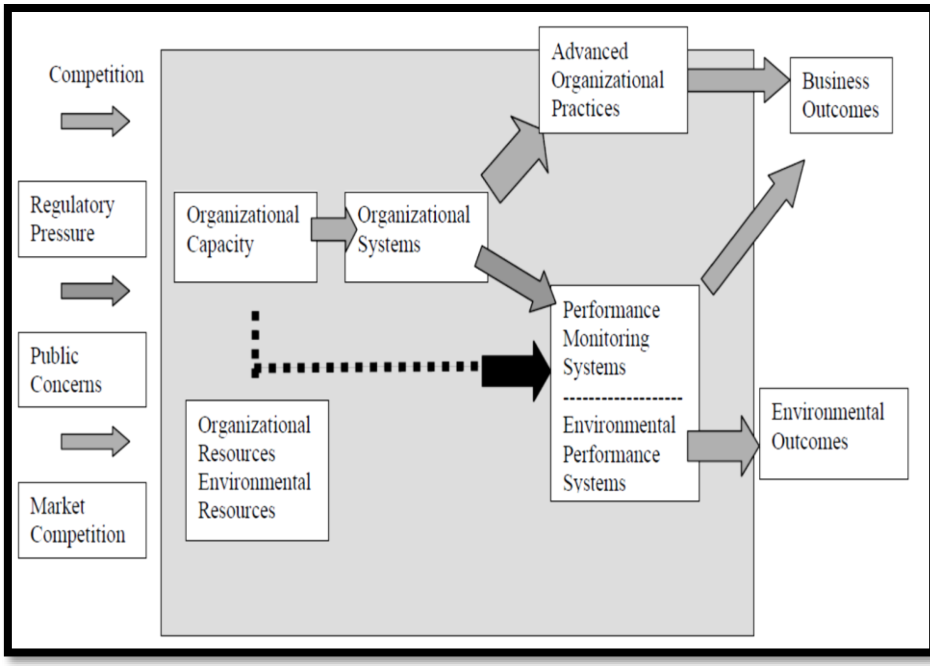

Figure 1. Model of organizational factors, organizational systems, and outcomes.

These questions will be answered through a structured model of a sample of manufacturing organizations. The current research was designed as a quasi-experiment and is based upon "matched pairs." It should be mentioned that the proposed common drivers were conducted at 11 manufacturers and consisted of more than 100 personal interviews in field of industrial chemistry. On the other hand, among the selected manufacturers, the Tage Company with 1100 workers including experimenter, engineers, workers, and managers is chosen for this case study. Small and Medium-Sized Enterprises (SMEs), which make up 99.8 percent of all businesses in Iran, are responsible for approximately 70 percent of all industrial pollution. Based on their significance to the economy and their contribution to pollution, SMEs are not getting the research attention they deserve. SMEs with ISO 9001 and ISO 14001 certification, and Just-In-Time inventory control are likely to perform better on environmental processes, while disposal, design, and EMS are found to be positively impacting performance. That is the reason that the Tage Company is chosen as our case study to investigate the impact of GM on the decision making of this company.

Unfortunately, no study has been done for evaluating the drivers of GM in an industrial chemistry. Generally, GM practices are performed using three main strategies such as green energy, green products, and green processes in manufacturing processes. Therefore, there is a need for establishing the essential impact of GM to the professional's factors. Usually, GM is inspired by the pressures of some factors - external, internal, societal, committal - called drivers. Thus, in the current paper, the drivers of GM are selected as the pedestal. They help to introduce GM to industries either voluntarily or mandatorily. This aim is achieved by collecting the common drivers of GM from various sources to evaluate them through an Analytical Network

Process (ANP). The ANP is a multi-criteria methodology, which is able to consider a wide range of quantitative and qualitative drivers according to a complex model. It should be mentioned that in many real problems, some decision variables could not be structured hierarchically, due to their interactions and dependence between the highest and lowest elements [6].

This study tries to facilitate this gap mentioned above through collecting both the common drivers from existing literatures and from experts' opinions. Based on the common drivers, as there is an uncertain environment, consequently, fuzzy ANP identifies an essential driver and the priority of drivers. A pair-wise comparison is obtained with the help of manufacturing managers in the Tage Iran Company. This study is motivated by evaluating and the priority of the critical drivers in industrial environments and their impacts on the decisions related to industrial environments. In short, the highlights of the differences of this study with the mentioned studies are as follow:

- Proposing both quantitative and qualitative critical drivers of GM and their internal relationships in an industrial environment.
- Developing a fuzzy ANP as a multi-criteria methodology regarding a wide range of quantitative and qualitative.
- Identifying the priority of drivers of GM by fuzzy ANP.

The industrial application of this study is to generate additional opportunities, identifying essential drivers, and cost effectiveness for business and companies that operate in industrial environments. More especially, to answer the following questions, we are looking forward to addressing these responses as follows:

- **Why is the topic important?** The topic is important because the climate change and environmental pollution have become major concerns for a variety of stakeholders especially in Iran.
- **What are research questions?** (1) Identifying an essential driver, (2) and the priority of drivers of Green manufacturing in Iran.
- **What has been studied?** The studies and experiments are implemented in Tage Iran Co.
- **What are your contributions?** The novelty comes from a combination of both theory and experimental techniques to investigate both quantitative and qualitative critical drivers of GM in an industrial chemistry.

To consider both quantitative and qualitative critical drivers of GM and their internal relationships, the ANP method is utilized to achieve this aim. The remainder of this paper is organized as follows: Next section provides the background of the proposed company in Section 2. Problem description is presented in Section 3. Section 4 presents the solving methodology. Section 5 provides the data collection while the Section 6 presents the computational results. Finally, conclusion and future research arrives in Section 7.

2. About Tage (Mahd e Tage)

Mahd-e-Taban Investment Company (Tage) (http://www.mahdetage.com/default.aspx) was established in 2004 via a team of the best experts, executives and specialist members of the detergent, and hygienic industries. The initial reason for generating such Mahd-e-Tage Investment Company (MTIC) was to provide an efficient corporate governance mechanism, and to separate ownership and management issues of a group of companies. In 2001, MTIC launched a new research laboratory with the goal of developing new products, improving the quality of the current products, and research on new raw materials and evaluation methods. Mahd-e-Tage Group Company was established in 1981 with four companies (will be explained later) that complement the company's value chain from raw material supply, production, and distribution of products throughout the country. As the parent company, Mahd-e-Tage Group is responsible for the Strategic Management of its subsidiary companies. Production facilities are located near the city of Qazvin with land area of 32 hectares and more than 104 thousand square meters of buildings. Here, the four companies mentioned above are introduced as follows.

2.1. Pakhsh Pishgam Lia Company

Pakhsh Pishgam Lia Co. was established in 2003. This company has 17 branches and warehouses in major cities and is responsible for distributing and selling products of Behdad Chemical Co. as well as high quality products of the companies outside of the group.

2.2. Jam Partou Company

Jam Partou Co. is a trading company to provide raw materials and production equipment for Mahd-e-Tage Group Co and its subsidiary as well as other customers.

2.3. Behdash Chemical Company

Behdash Chemical Co. was established in 1961. Its sulphonation, sulphation and oelo-chemical plants provide wide range of raw material and intermediate chemicals for detergent, cosmetic, petrochemical and textile industries for domestic and export markets. Behdash Chemical Co. is also the first and the only manufacturer of Zeolite in Iran. In addition to manufacturing, this company provides technical and engineering services for Mahd-e-Tage Group Companies by many years of experience in manufacturing chemical plants.

2.4. Behdad Chemical Company

Behdad Chemical Company, established in 1984, is one of the biggest and oldest producers of variety of detergents, such as detergent powder, washing powder, foam, oily and normal soaps, dishwashing liquid, surface cleaners, laundry liquids, toothpaste, personal hygiene and moisturizers in Iran. Behdad Company also manufactures variety of its own packaging items, including cardboard and bottles. That is why the Mahd-e-Tage is chosen as our case study.

3. The Challenge Definition

Industrialists' adverse impacts of both GM and EMS implementation on profit margins, although its implementation drives a competitive edge and other profits [7]. In this regard, because of raising significance of environmental concerns, the proposed company has to adapt GM as a mandatory rule. Nevertheless, no proper has been yet done to investigate a wide range of quantitative and qualitative drivers of GM in a real industrial environment. Generally, GM is implemented by utilizing three main strategies namely green energy, green products, and green processes. Indeed, the GM is totally different from conventional manufacturing by its "objectives" to minimize the value of natural resources required as well as to produce the products through lower energy consumption, and materials efficient manufacturing processes that also minimize the negative externalities associated with waste and pollution. Some major manufacturing process changes occur in the following categories [3]:

- The dependence changes on human intervention.
- Continuous process is preferred instead of batch process.
- Changing the nature of the steps in production process.
- Eliminating the steps in production process.
- Changing cleaning processes.

Therefore, there is a need of establishing the critical role of GM to the professionals. Generally, GM is initiated by the pressures of some factors-external, internal, societal, committal-called drivers. Thus, in this paper, the drivers of GM are selected as the pedestal. These drivers help to adjust GM to industries either voluntarily or mandatorily. The objective of this work is to gather these common drivers of GM from several kinds of sources to investigate them via ANP. This study tries to explore this problem by gathering both the common drivers from existing literatures and from experts' opinions. From the obtained drivers, ANP identifies a critical driver and the priority of them. As a result, a pair-wise comparison is performed with the help of manufacturing managers in leading firms situated in various parts. The questionnaire comprising common drivers with the sequence of a nine-point Likert scale was derived from production managers. With reviewing of existing literature and experts' opinion, various common drivers of GM in the field of industrial chemistry were determined. Afterward, the critical drivers and then the priority among them are implemented based on the information received by manufacturers in various parts of the sources. The proposed problem is confirmed using a two-phase approach. The first phase is to reveal the common drivers of GM, and the second phase is to identify the essential driver as well as the priority among drivers using the ANP method.

It is worthwhile to note that to gather the common drivers, the literature in the field of GM, environmentally, and green supply chains were reviewed. Afterward, the common drivers were investigated according to several rounds of discussions among the related experts. For these obtained drivers, we used the search terms "green manufacturing," "environmentally conscious manufacturing," "drivers of green manufacturing," and "Green manufacturing in Iran scenario" from leading journals. Secondly, to get the assistance from the field and industrial experts, a one-day program was provided on "green manufacturing," with 120 industrial unit managers. From the 120 company, 90 production managers attended. Then, the proposed program generated the concepts and the requirements for the study to the participating experts. Once the theme of the problem was explained, discussions were held [8]. After several discussions, the common drivers of GM were identified. Collection of common drivers by literature and expert opinions are presented in the following.

3.1. Financial Benefit (D1)

The economic urge pressures to adapt GM as it practices effect on the optimal resource and energy usage, which enhances the financial benefit of the manufacturer. Applying different approaches to minimize the total waste may mean using fewer raw materials per unit of product, reducing the weight and thickness of the packaging, and thus saving money for the firms [9]. Recycling materials (e.g. metal scraps) within the firm can eliminate waste and minimize the SME's purchase of new raw materials. Therefore:

- There is a positive relationship between expected benefits and reduction.
- There is a positive relationship between expected benefits and recycling.

3.2. Company Image (D2)

Reputation plays a vital role in any firm's growth. Hence, to retain the company image, the practice of GM is mandatory. A company's desire to improve image and reputation may lead to design process and environmental management systems. Hillary [10] identifies a range of benefits of SMEs adopting EMS, including enhanced quality, cost savings, new customers, and a better company image, among others.

3.3. Environmental Conservation (D3)

Environmental management is a critical role to enhance organizations' performance. In this way, many customers have exerted pressure on their suppliers to enhance environmental condition [11]. In this regard, due to increasing concerns and importance of environmental issues, manufacturers, and especially electronic companies are seeking the methods to enhance their environmental performance. For example, electronic/electrical firms in China have strong export product markets and have significant close relationships with foreign customers in China. Besides, environmental improvements such as recycling and cooperation with suppliers can be implemented to reduce cost and to increase efficiency [12]. We operationalize environmental capacity as follows: size and tenure of environmental staff, and other related metrics [see Appendix]. The third section of the Appendix shows the related field research for a specified range of advanced business practices including total quality management, ISO 9001 and ISP 14001 certification, and just-in-time inventory management.

3.4. Green Innovation (D4)

Specifically, earlier studies [13] have identified legislation as the key driver of environmental initiatives within firms. Starting in the 1960s, the United States, West European countries, and Japan legislated several environmental and pollution prevention acts. The European Union (EU) demonstrated its zeal for environmental protection by passing 200 legislations by the early 1990s [14]. Finally, the firms that are operating in a reactive mode will primarily respond to rules and regulations. In this way, government regulations mentioned in the literature are a major driver for companies’ environmental management [15]. It is clear that Environmental regulations can be observed as a motivation to innovate and decrease environmental impact. To comply with regulations like ISO 14001 and other certifications, firms are pressured to maintain green environment activities throughout their processes. In this regard, the following relations are presented as follows [16]:

- There is a positive relationship between regulation and treatment.
- There is a positive relationship between regulation and reduction.
- There is a positive relationship between regulation and recycling.

3.5. Stakeholders (D5)

Investors, media, government, etc. are considered as stakeholders who have the power to make a direct impact on the firm’s decisions. Recently, pressures for firms to adopt GM systems have been dominant. Firms need to operate in socially and environmentally responsible ways while maximizing stakeholder value by focusing on economic, environmental and social performance [17].

3.6. Compliance with Regulations (D6)

Recent year’s innovation exists in all forms, due to the momentous role of green innovations; they are emerging in the current realm, which forces the firms to adjust new sustainable techniques.

3.7. Supply Chain Requirement (D7)

Reverse logistics, reverse supply chain, etc. are becoming vital areas that expand day by day. On the other hand, supply chain needs for forcing the manufacturers to produce the finished products with green concerns, for example, easy dismantling, utilizing of recyclable material in the product manufacturing, and so on. Supply chain relationships, in general and for environmental issues, can largely be divided into two categories: (1) arm’s length approach and (2) close partnership approach. This is similar to the classification of reactive and proactive strategies to environmental issues. The arm's length approach may include requiring "green" specifications and ISO 9001, ISO 14001 certification, and Just-In-Time inventory control that are some approaches to do better on environmental processes, whereas disposal, design, and EMS are found to be positively impacting performance certification. Partnership and proactive approach requires close collaboration and relational capabilities such as designing green finished products and processes simultaneously [9].

3.8. Customers (D8)

Customer awareness on green concerns pressures the manufacturers to make their product as green sensitive. Customers have been recognized in the literature as a strong driver for environmental activities [18]. Perez-Sanchez, Barton and Bower [19] concluded that customers are the leading drivers behind environmental activities, followed by legislation. Cramer, Dral and Roes [20] showed that exchange of environmental results was frequently seen between manufacturers and suppliers, rather than between manufacturers and consumers. In this regard, customers affect firms more than suppliers regarding the environmental management systems. Theyel [21] shows that collaborating with suppliers and customers affects firms positively regarding waste reduction and meeting environmental standards. Thus, the following relations can be mentioned:

- There is a positive relationship between customer influence and recycling.
- There is a positive relationship between customer influence and design.
- There is a positive relationship between customer influence and ems.

3.9. Employee Demands (D9)

Many production processes may pollute the environment via the safety of the employees; thus, employees demand the firm to implement GM systems. In this regard, Johansson and Winroth [1] indicated that employee's involvement is a key for developing or implementing the environmental performance in the firm. The Green manufacturing relies on long-term thinking because the environmental impacts created by industries have been generated for many years, so a sudden change will cause more investment on their capital but it is accountable in long term.

3.10. Market Trend (D10)

In current years, GM is popular policy from all external stakeholders. This trend pressures the manufacturers to produce green products through GM activities.

3.11. Competitors (D11)

To stay in the market, manufacturers need to compete with their competitors by introducing innovative launches. Often, green ideas help the manufacturers. In this regard, Corporate Social Responsibility (CSR), or the obligations of a firm to society and specifically to its stakeholders [22], is an important driver for environmental management. In highly competitive markets, CSR provides an effective means for differentiation, and therefore, many firms emphasize their environmental sensitivity within their advertising campaigns.

4. Solving Methodology

Majority of the Multiple-Attribute Decision Making (MADM) methods assume that the criteria are independent of each other, which is not a realistic assumption in many real world problems. Unfortunately, criteria interaction concept is very little issued in the literature. The present paper aims to put a step forward to fill this gap by Analytic Network Process (ANP) method. ANP [23, 24] is widely utilized in territorial decision problem with stakeholders in decision-making. As far as ANP applications are considered, the literature is quite recent and some publications can be found in strategic policy planning [25, 26], market and logistics [27], economics and finance [28], in civil engineering [29, 30], and manufacturing systems [31, 32].

Ghazikalayeh et al. [33] studied a multi-criteria decision making method for selecting the most appropriate combination of drilling, loading, and haulage equipment using fuzzy analytic network process. On the other hand, Montazeri and Jouzdani [34] described the appropriate criteria and desired advertising activities obtained by financial literacy for investment companies which are invested in Tehran Stock Exchange were outlined and these advertising activities were ranked by using the step-by-step approach of ANP. The most effective dimensions of customer relationship management is presented by Serkani [35] using the hybrid approach of Decision Making Trial and Evaluation Laboratory (DEMATEL) and ANP. Pourkhandani [36] ranks the identifiers of improving service quality of dental clinic using quality function deployment approach, combined ANP, and DEMATEL with fuzzy approach.

It is worthwhile to mention that many decision problems cannot be structured hierarchically, because they imply interactions and dependence between the highest elements and the lowest. In fact, not only the importance of the criteria cause the importance of the alternatives, as in a hierarchy, but also the importance of the alternatives causes the importance of the criteria. In this sense, the ANP extends the applications of the AHP to cases of interdependent relationships between the assessment elements and generalizes the approach of the super-matrices introduced by the AHP. The ANP is a multi-criteria approach to consider a wide range of both quantitative and qualitative criteria according to a complex model [6].

4.1. Concepts of the Analytic Network Process

The concept of the ANP along with its stages are described as follows [24]:

- Feedback, inner and outer dependence.
- Influence with respect to a criterion.
- The control hierarchy or system.
- The super-matrix.
- The limiting supermatrix and limiting priorities.
- Primitivity, irreducibility, cyclicity.
- Make the limiting supermatrix stochastic: why clusters must be compared.
- Synthesis for the criteria of a control hierarchy or a control system.
- Synthesis for benefits, costs, opportunities, and risks control hierarchies.
- Formulation to compute the limit.
- Relation to Neural Network Firing-the continuous case.
- The density of neural firing and distributions and their applications to reproduce visual images and symphonic compositions.

Further research in this area is needed to be studied. The application process of the ANP can be summarized in four main phases [24]:

Step 1: Structuring the decision problem and model construction
Three types of model exit that can be extended via the ANP methodology: the simple structured model without any control, the complex network structured as a Benefits, Opportunities, Costs and Risks network, which represented as BOCR [37], the strategic network which is structured as a BOCR model but a further level of analysis is added in order to better catch the strategic elements of the problem in exam [23, 38].

Step 2: Compilation of pairwise comparison matrices
By utilizing the constructed decision model and the relations between the elements, we are able to evaluate the pairwise comparisons between them. The evaluation also takes place in two levels: the clusters and the nodes using the absolute scale of Saaty, which translates verbal reviews in numerical ratings [23, 38]. The assigned ratings will be placed in a matrix of pairwise comparison [23].

Step 3: Construction of Super-Matrices
A super-matrix shows the relationships between the network model and the relative assigned weights. It is an array containing all the priority vectors that are extracted from individual pair-wise comparison matrices compiled during the previous steps of analysis.

The super-matrix is a critical matrix in ANP because we enable to understand certain relationships of influence determined during the development of the network. It also is important because being composed by different eigenvectors; it releases numerical data about the priorities of elements forming part of the decision system [42]. The general form of the super-matrix W^k is described in Figure 1 where *CN* denotes the *Nth* cluster, *eNn* denotes the *nth* element in the *Nth* cluster, and *Wij* is a block matrix that consists of priority weight vectors (*w*) of the influence of the elements in the *Ith* cluster with respect to the *Jth* cluster. If the *Ith* cluster has no influence on the *Ith* cluster itself (i.e. a case of inner dependence) *Wij* becomes zero. The general structure of a super-matrix is constructed as follows:

		C_1	C_2	C_N
		e_{11} | e_{12} | ... | e_{1n1}	e_{21} | e_{22} | ... | e_{2n2}	e_{N1} | e_{N2} | ... | e_{NnN}
C_1	e_{11}, e_{12}, ..., e_{1n1}	W_{11}	W_{12}	W_{1N}
C_2	e_{21}, e_{12}, ..., e_{2n2}	W_{21}	W_{22}	W_{2N}
...	...	...	...	...
C_N	e_{N1}, e_{N2}, ..., e_{NnN}	W_{N1}	W_{N2}	W_{NN}

Figure 2. General structure of super-matrix.

During the development of the ANP methodology, three different super-matrices are extracted:

- The un-weighted super-matrix (or initial super-matrix): It contains all the eigenvectors that are derived from the pair-wise comparison matrixes of the model.
- The weighted super-matrix: It is a stochastic super-matrix obtained by multiplying the values in un-weighted super-matrix by the weight of each cluster. In this way, it is possible to consider the priority level assigned to each cluster.
- The limit super-matrix: The final matrix of the analysis obtained by raising limiting power, the weighted super-matrix, in order to converge and to obtain a long-term stable set of weights that represents the final priority vector.

Step 4: Final Priorities

Finally, the weighted super-matrix is generated to obtain a long-term stable set of weights. The super-matrix is raised to a limit lower, such as in Eq. (1), to obtain a matrix where all the columns are identical and each gives the global priority vector.

$$\lim_{k \to \infty} w^{k} . \tag{1}$$

If there are two or more limiting super-matrices, the Cesaro sum is used to calculate the final priorities. The Cesaro sum is formulated as follows [39]:

$$\lim_{k \to \infty} \left(\frac{1}{N}\right) \sum_{r=1}^{N} w_{r}^{k} , \tag{2}$$

where N denotes the number of limiting super-matrices, and w_r denotes the rth limiting priority. Casero sum is used to calculate the average influences of the limiting super-matrix. Finally, the alternative with the largest priority is selected. Moreover, in a case of the complex network, it is necessary to synthesize the outcome of the alternative priorities for each of the BOCR structures in order to obtain their overall synthesis [23]. Saaty suggests three different formulas in order to synthesize the results: The additive negative formula (B + C – O – R), the additive probabilistic formula (B + O + 1/C + 1/R), and the additive multiplicative formula (B * O * 1/C * 1/R).

5. Data Collection

As mentioned before, to gather the necessary data and to get the assistance from the field and industrial experts, we invited 120 industrial production managers. From the 120 invited, 90 production managers in field of chemical industry attended. Then, a questionnaire was prepared with the twelve common drivers (which were identified from the combined assistance of experts, industrial managers and literatures in the previous steps) based on a Likert 9 point scale and circulated to over 120 different industrial sectors through mail, telephone enquiries, direct meetings, and managerial interviews. Based on obtained questionnaires, 50 were complete and 40 were incomplete from 90 firms responded. In this regard, according to Malhotra and Grover [43], a 20% response rate is enough for any survey and in this case, the response rate is about 45%, so this survey can be judged as bona fide and acceptable. The pair-wise comparison was made based on this response from among drivers of green manufacturing with the assistance of ANP methodology. Table 1 shows the fundamental scale absolute numbers as described by [23].

6. Computational Results

Within the pre-evaluation stage, based on the review of the existing literature and semi-structured interviews undertaken with experts, a list of clusters and related criteria were generated. The list of criteria determined in this way is classified into three main groups that are listed and briefly described as below:

- **Business criteria:** Company Image, Environmental Conservation, Market Trend, Customers, and Competitors.
- **Cost criteria:** Financial Benefit, Supply Chain Requirement, Employee Demands.
- **Technical criteria:** Stakeholders, Green Innovation, Compliance with Regulations.

With determining the critical drivers at the end of the pre-evaluation stage, network structure formation is calculated based on the first step of ANP. By the multi-session brainstorming and knowledge elicitation held with the formed group members (i.e. domain/industry experts), the criteria and the interdependencies among the criteria clusters were identified. At the beginning of the process, the opinion of each expert is collected separately and then multiple focus group studies are performed until a consensus has provided. Based on the consolidated findings, the final model (i.e. the network diagram) is developed. Figure 2 shows the relationship between clusters (outer dependency) and within the cluster (inner dependency) in a simple network diagram. The interdependencies among the clusters are shown by using two-way arrows.

Table 1. Generating parameters.

Intensity of importance	Definition	Explanation
1	Equal importance	Two activates contribute equally to the objective
2	Weak or slight	
3	Moderate importance	Experience and judgment slightly favor one activity over another
4	Moderate plus	
5	Strong importance	Experience and judgment strongly favor one activity over another
6	Strong plus	
7	Very strong or demonstrate importance	An activity is favored very strongly over another; its dominance demonstrated in practice
8	Very, very strong	
9	Extreme importance	The evidence favoring one activity over another is of the highest possible order of affirmation
Reciprocals of above	If activity I has one of the above non-zero numbers assigned to it when compared with activity *j*, then *j* has the reciprocal value when compared with *i*	A reasonable assumption
1.1-1.9	If the activities are very close	May be difficult to assign the best value but when compared with other contrasting activities the size of the small numbers would not be too noticeable, yet they can still indicate the relative importance of the activities

Step 1: Network structure formation

Given a comprehensive set of criteria, which are determined from the application domain experts, first step involved in determining the relationships between/among the criteria, sub-criteria, and alternatives are shown in a graphical network structure. The relationships captured in this step constitute both within clusters and between clusters.

Step 2: Formation of pair-wise comparisons and obtaining local priority values

Depending on the relations in the network structure, pair-wise comparisons are performed and the priority value of each factor in the network structure is obtained. During this step, the following operations are utilized:

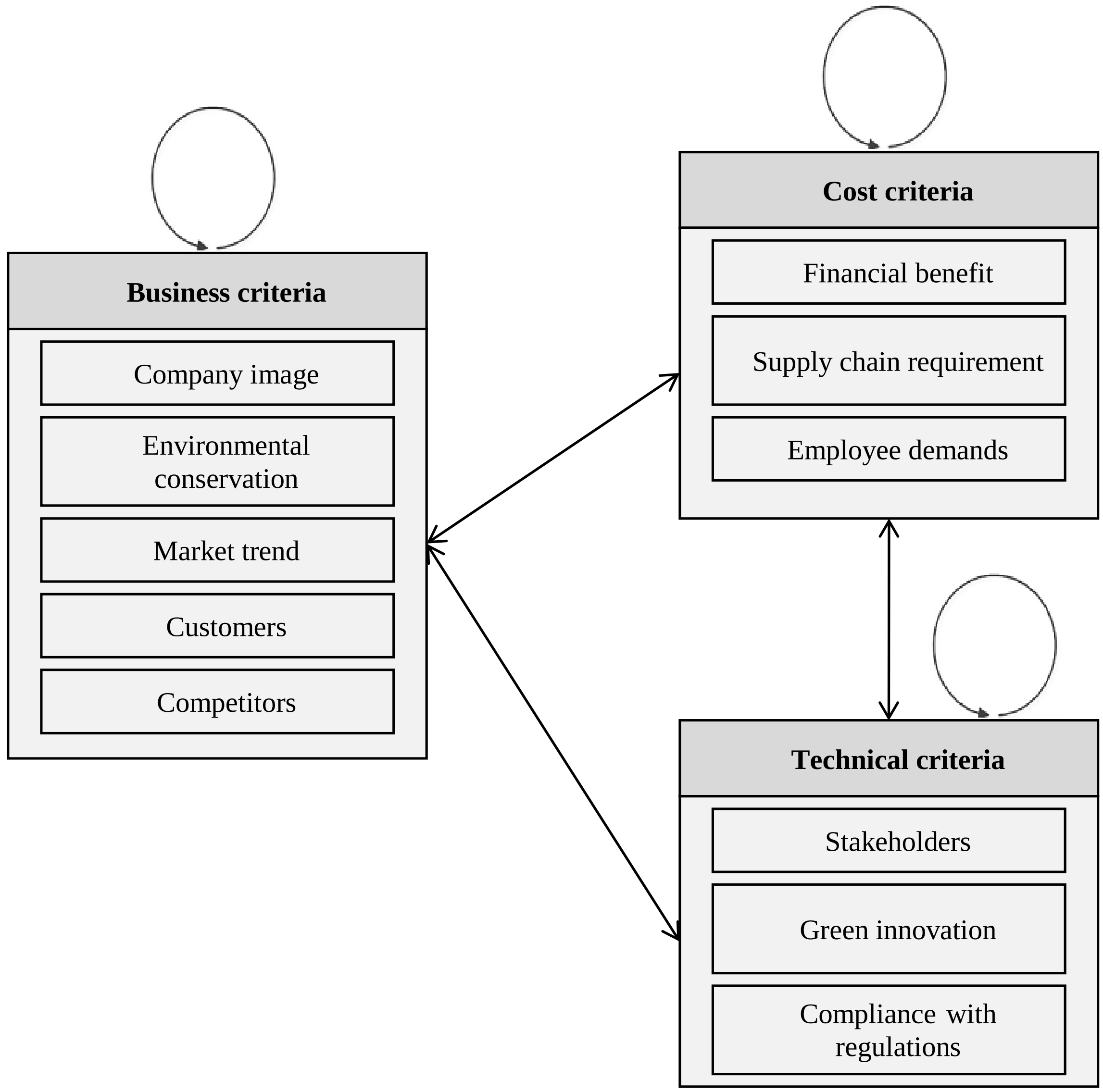

Figure 2. The network diagram used in the study.

1) After assigning the values of pair-wise comparisons in the comparison matrix, local priority vector is calculated from eigenvector, which is calculated using Eq. (3). *A*, *w* and $\lambda_{\max}$ correspond to pair-wise comparison matrix, eigenvector and eigen-value, respectively in the equation.

$$Aw = \lambda_{\max} w. \tag{3}$$

2) The matrix (*A*) shows the pair-wise comparison between the factors, is calculated using Eq. (4). In this equation, a_{ij} indicates the pair-wise comparison value in the pair-wise comparison matrix (*A*).

$$A = \left[a_{ij}\right]_{n \times n} \quad i = 1, 2, \ldots, n \quad j = 1, 2, \ldots, n\,, \tag{4}$$

where the matrix (*A*) is fulfilled as follows:

$$A = \begin{bmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ a_{n1} & a_{n2} & \dots & a_{nn} \end{bmatrix}.$$

3) The normalized pair-wise comparison matrix *B* is obtained. The normalized matrix *B* consists of b_{ij} values, which are calculated using Eq. (5).

$$B = \begin{bmatrix} b_{11} & b_{12} & \dots & b_{1n} \\ b_{21} & b_{22} & \dots & b_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ b_{n1} & b_{n2} & \dots & b_{nn} \end{bmatrix}, \tag{5}$$

where: $b_{ij} = \frac{a_{ij}}{\sum_i a_{ij}} \quad i = 1,2,...,n \quad j = 1,2,...,n$.

The eigenvector (*W*) is obtained by obtaining the eigenvalues (w_i) using Eq. (6).

$$W \begin{bmatrix} w_1 \\ w_1 \\ \vdots \\ w_n \end{bmatrix}, \ and \quad w_i = \frac{\sum_i b_{ij}}{n} \quad for \quad i = 1,2,...,n\ . \tag{6}$$

After that, k_{max} is obtained using Eq. (7) and the consistency property is checked after performing the Eqs. (8) and (9). *CI*, *RI* and *CR* denote consistency indicator, random indicator and consistency ratio, respectively. RI is obtained from a standard random index table showing the random index values for different number of criteria regarded. Consistency ratio must be smaller than 0.10.

$$W \begin{bmatrix} w_1 \\ w_1 \\ \vdots \\ w_n \end{bmatrix}, \ and \quad w_i = \frac{\sum_i b_{ij}}{n} \quad for \quad i = 1,2,...,n, \tag{7}$$

$$CI = \frac{\lambda_{\max} - n}{n-1}, \tag{8}$$

$$CR = \frac{CI}{RI}. \tag{9}$$

Step 3: Formation of the unweighted, weighted and limit super matrixes and obtaining final priority values

By locating the local priority vectors on convenient columns, the super matrix (called as partition matrix) is obtained. In general, the sum of one column in super matrix is greater than 1. The cluster is weighted and normalization is performed to obtain a stochastic matrix where the sum of column values is 1 unless a stochastic super matrix is obtained. This newly obtained super matrix is often called as weighted super matrix [40, 41]. If k displays a big random number, an increase is provided in the supermatrix to power $2k + 1$ and so there becomes an approximation to limit, which is the importance weight. The new matrix is then called limit super matrix. By normalizing each column in the super matrix, the priorities of the alternatives can be obtained [40, 41].

After performing the first step of ANP, which is the network structure formation, the second and the third steps of ANP are performed using a specialized software package. In short, the factor priority values are determined after assuring the consistency of comparison matrices and the unweighted super matrix, the weighted super matrix and the limit super matrix. The detailed findings of these two steps are summarized in Tables (2–4).

Table 2. Unweighted super matrix.

	Financial benefit	Company Image	Environmental conservation	Green innovation	Stakeholders	Compliance with regulations	Supply chain requirement	Customers	Employee demands	Market trend	Competitors
Financial benefit	0.2355	0	0.21328	0.75	0.8877	0.25	0.75	0	0	0	0
Company Image	.5881	0	0.25002	0.25	0.4236	0.75	0.5457	0	0	0	0
Environmental conservation	0.5588	0	0	0	0.11588	0	0.25	0	0	0	1
Green innovation	0.3541	1	0	0	0	0	0.4587	0	0	0	0
Stakeholders	0	0.1958	0	0	0	0.0011	0	0	0.66558	0.249	1
Compliance with regulations	1	0.49339	0	1	0	0	0.20587	0	0.49339	0.593	0
Supply chain requirement	0	0.22081	0	0	0	0.75002	0	0	0.31081	0.157	0
Customers	0.44788	0	0	0	0.5	0	0	0	0	0.0041	0
Employee demands	0	0	0	0	0.5	0	0	0.3333	0	0	0
Market trend	0.2233	0	0	0	0	1	0	0.66667	1	0	0
Competitors	0	0	1	0	0	0	0	0	0	0	0

Table 3. Weighted super matrix.

	Financial benefit	**Company Image**	**Environmental conservation**	**Green innovation**	**Stakeholders**	**Compliance with regulations**	**Supply chain requirement**	**Customers**	**Employee demands**	**Market trend**	**Competitors**
Financial benefit	0	0	0.24998	0.75	0	0.25	0.75	0	0	0	0
Company Image	0	0	0.75002	0.25	0	0.75	0	0	0	0	0
Environmental conservation	0	0	0	0	0	0	0.25	0	0	0	1
Green innovation	0	1	0	0	0	0	0	0	0	0	0
Stakeholders	0	0.1958	0	0	0	0.24998	0	0	0.1958	0.249	1
Compliance with regulations	1	0.49339	0	1	0	0	0	0	0.49339	0.593	0
Supply chain requirement	0	0.31081	0	0	0	0.75002	0	0	0.31081	0.157	0
Customers	0	0	0	0	0.5	0	0	0	0	41	0
Employee demands	0	0	0	0	0.5	0	0	0.3333	0	0	0
Market trend	0	0	0	0	0	1	0	0.66667	1	0	0
Competitors	0	0	1	0	0	0	0	0	0	0	0

Table 4. Limit super matrix.

	Financial benefit	**Company Image**	**Environmental conservation**	**Green innovation**	**Stakeholders**	**Compliance with regulations**	**Supply chain requirement**	**Customers**	**Employee demands**	**Market trend**	**Competitors**
Financial benefit	0.10988	0.10988	0.10988	0.10988	0.10988	0.10988	0.10988	0.10988	0.10988	0.10988	0.10988
Company Image	0.0439	0.0439	0.0439	0.0439	0.0439	0.0439	0.0439	0.0439	0.0439	0.0439	0.0439
Environmental conservation	0.01248	0.01248	0.01248	0.01248	0.01248	0.01248	0.01248	0.01248	0.01248	0.01248	0.01248
Green innovation	0.03614	0.03614	0.03614	0.03614	0.03614	0.03614	0.03614	0.03614	0.03614	0.03614	0.03614
Stakeholders	0.08667	0.08667	0.08667	0.08667	0.08667	0.08667	0.08667	0.08667	0.08667	0.08667	0.08667
Compliance with regulations	0.22182	0.22182	0.22182	0.22182	0.22182	0.22182	0.22182	0.22182	0.22182	0.22182	0.22182
Supply chain requirement	0.12396	0.12396	0.12396	0.12396	0.12396	0.12396	0.12396	0.12396	0.12396	0.12396	0.12396
Customers	0.10157	0.10157	0.10157	0.10157	0.10157	0.10157	0.10157	0.10157	0.10157	0.10157	0.10157
Employee demands	0.07719	0.07719	0.07719	0.07719	0.07719	0.07719	0.07719	0.07719	0.07719	0.07719	0.07719
Market trend	0.16406	0.16406	0.16406	0.16406	0.16406	0.16406	0.16406	0.16406	0.16406	0.16406	0.16406
Competitors	0.02218	0.02218	0.02218	0.02218	0.02218	0.02218	0.02218	0.02218	0.02218	0.02218	0.02218

6.1. The Results Description

From Table 4, the computational results show that the driver of "Compliance with regulation" takes the high rank, based on which it is revealed due to the momentous importance of green activities, green innovations are emerging in the current realm, which forces the manufacturers to adopt new sustainable tactics. Afterward, the driver of "Market trend" takes 2th important driver, which means a logical result; the green products are popular and gain more support from all external stakeholders. This trend pressures the manufacturers to produce green products via green manufacturing activities. Here, it is worth mentioning that the main important point is the driver of "Environmental conservation" that is relatively a little critical driver, which means the internal environmental management is a little key to enterprises' performance enhancement. Large customers have exerted pressure on their suppliers for better environmental performance, which results in greater motivation for suppliers to cooperate with customers for environmental objectives. Figure 3 shows this effectiveness well. Finally, the results confirm the applicability of the proposed model and the methodologies taken to solve the problem not only in the Tage Company regulation in Iran, but also in other part of the world. The Appendix presents the overall scores and major variables in the analysis.

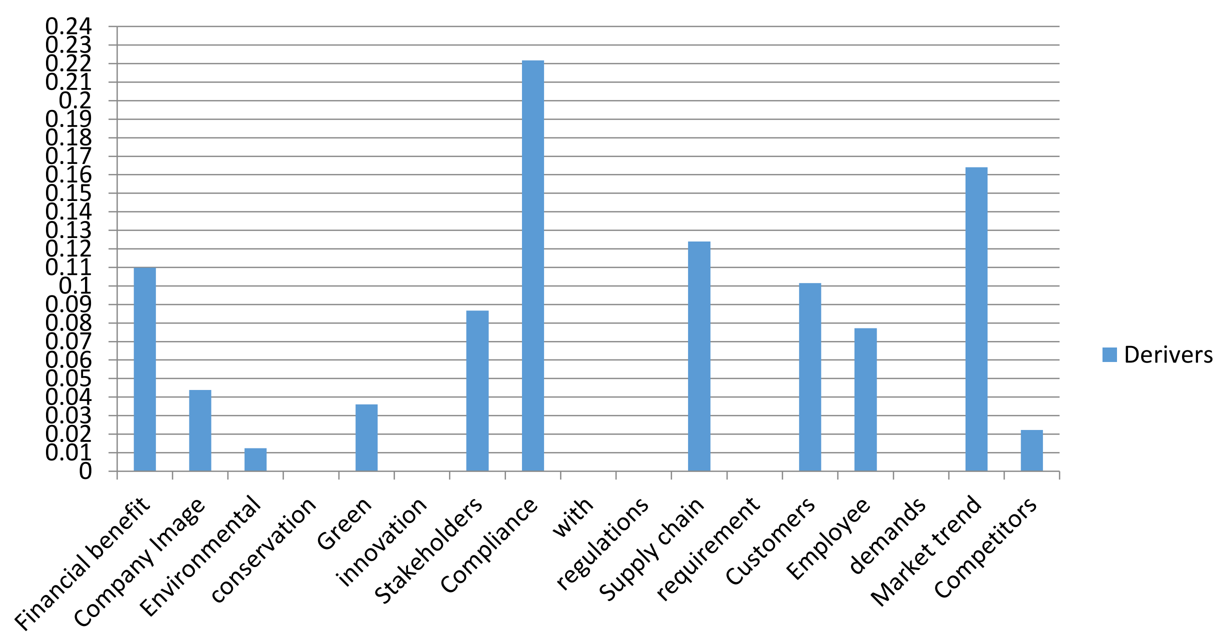

Figure 3. The comparison between the mentioned derivers.

7. Conclusion and Future Research

In this paper, after performing the first step of ANP, which was the network structure formation, the second and the third steps of ANP were performed using a specialized software package. The factor priority values were determined after assuring the consistency of comparison matrices and the unweighted super matrix, the weighted super matrix and the limit super matrix. The research was designed as a quasi-experiment and was based upon "matched pairs" of plants in several industries. Field research was conducted at 11 manufacturers and consisted of more than 100 personal interviews in the field of industrial chemistry. After that, among the selected manufacturers, the Tage Company with 1100 workers including experimenter, engineers, workers, and managers was chosen for this case study.

The computational results showed that the driver of "Compliance with regulation" took the high rank based on which it was revealed due to the momentous importance of green activities, green innovations were emerging in the current realm, which forced the manufacturers to adopt new sustainable tactics. Afterward, the driver of "Market trend" took 2th important driver as a logical result. The green products were popular and gain more support from all external stakeholders. This trend pressured the manufacturers to produce green products via green manufacturing activities. The main important point was the driver of "Environmental conservation" and a little critical driver relatively, which means that the internal environmental management is a little key to improving enterprises' performance. Large customers have exerted pressure on their suppliers for better environmental performance, which resulted in greater motivation for suppliers to cooperate with customers for environmental objectives. Finally, the results confirmed the applicability of the proposed model; moreover, the methodologies were taken to solve the problem in the Tage Company. The grey rational and stochastic programming are future research suggestions.

References

[1] Johansson, G., & Winroth, M. (2009). Lean vs. Green manufacturing: Similarities and differences. *Proceeding of the 16th international annual euroma conference on implementation realizing operations management knowledge*, (pp. 14-17).

[2] Richards, D. J. (1994). Environmentally conscious manufacturing. *World class design to manufacture*, *1*(3), 15-22.

[3] Atlas, M., & Florida, R. (1998). Green manufacturing. In R. Drof (Ed), *Handbook of technology management* (pp. 1385-1393). CRC press.

[4] Paul, I. D., Bhole, G. P., & Chaudhari, J. R. (2014). A review on green manufacturing: it's important, methodology and its application. *Procedia materials science*, *6*, 1644-1649.

[5] Mittal, V. K., & Sangwan, K. S. (2014). Prioritizing barriers to green manufacturing: environmental, social and economic perspectives. *Procedia CIRP*, *17*, 559-564.

[6] Saaty, T. L. (1980). Analytic Heirarchy Process. *Wiley statsRef: Statistics reference online*.

[7] Hui, I. K., Chan, A. H., & Pun, K. F. (2001). A study of the environmental management system implementation practices. *Journal of cleaner production*, *9*(3), 269-276.

[8] Kapur, A., Baldwin, C., Swanson, M., Wilberforce, N., McClenachan, G., & Rentschler, M. (2012). Comparative life cycle assessment of conventional and Green Seal-compliant industrial and institutional cleaning products. *The international journal of life cycle assessment*, *17*(4), 377-387.

[9] Vachon, S., & Klassen, R. D. (2007). Supply chain management and environmental technologies: the role of integration. *International journal of production research*, *45*(2), 401-423.

[10] Hillary, R. (2004). Environmental management systems and the smaller enterprise. *Journal of cleaner production*, *12*(6), 561-569.

[11] Govindan, K., Diabat, A., & Shankar, K. M. (2015). Analyzing the drivers of green manufacturing with fuzzy approach. *Journal of cleaner production*, *96*, 182-193.

[12] Corbett, C. J., & DeCroix, G. A. (2001). Shared-savings contracts for indirect materials in supply chains: Channel profits and environmental impacts. *Management science*, *47*(7), 881-893.

[13] Henriques, I., & Sadorsky, P. (1996). The determinants of an environmentally responsive firm: an empirical approach. *Journal of environmental economics and management*, *30*(3), 381-395.
[14] Preuss, L. (2005). *The green multiplier: A study of environmental protection and the supply chain*. Springer.
[15] Diabat, A., & Govindan, K. (2011). An analysis of the drivers affecting the implementation of green supply chain management. *Resources, conservation and recycling*, *55*(6), 659-667.
[16] Agan, Y., Acar, M. F., & Borodin, A. (2013). Drivers of environmental processes and their impact on performance: a study of Turkish SMEs. *Journal of cleaner production*, *51*, 23-33.
[17] Sawyer, J., & Evans, N. (2010). An investigation into the social and environmental responsibility behaviours of regional small businesses in relation to their impact on the local community and immediate environment. *Australasian journal of regional studies*, *16*(2), 253.
[18] Green, K., Morton, B., & New, S. (1996). Purchasing and environmental management: interactions, policies and opportunities. *Business strategy and the environment*, *5*(3), 188-197.
[19] Perez-Sanchez, D., Barton, J. R., & Bower, D. (2003). Implementing environmental management in SMEs. *Corporate social responsibility and environmental management*, *10*(2), 67-77.
[20] Cramer, J., Dral, P., & Roes, B. (1991). Product information exchange about environmental aspects between producers. *Ministry of housing, physical planning, and environment*. The Netherlands.
[21] Theyel, G. (2006). Customer and Supplier Relations for Environmental Performance. In J. Sarkis (Ed.), *Greening the Supply Chain* (pp. 139-149). Springer, London.
[22] Smith, N. C. (2003). Corporate social responsibility: whether or how? *California management review*, *45*(4), 52-76.
[23] Saaty, T. L. (2005). *Theory and applications of the analytic network process. Pittsburgh*. PA, RWS Publication.
[24] Saaty, T. L., & Vargas, L. G. (2002). *Decision Making With the Analytic Network Process*. Springer, Boston, MA.
[25] Lee, Y., & Kozar, K. A. (2006). Investigating the effect of website quality on e-business success: An analytic hierarchy process (AHP) approach. *Decision support systems*, *42*(3), 1383-1401.
[26] Ulutaş, B. H. (2005). Determination of the appropriate energy policy for Turkey. *Energy*, *30*(7), 1146-1161.
[27] Kumar Sharma, S., & Bhat, A. (2014). Modelling supply chain agility enablers using ISM. *Journal of modelling in management*, *9*(2), 200-214.
[28] Niemira, M. P., & Saaty, T. L. (2004). An analytic network process model for financial-crisis forecasting. *International journal of forecasting*, *20*(4), 573-587.
[29] Neaupane, K. M., & Piantanakulchai, M. (2006). Analytic network process model for landslide hazard zonation. *Engineering geology*, *85*(3-4), 281-294.
[30] Piantanakulchai, M. (2005). Analytic network process model for highway corridor planning. *Proceedings of the ISAHP*, 8-10.
[31] Das, S., & Chakraborty, S. (2011). Selection of non-traditional machining processes using analytic network process. *Journal of manufacturing systems*, *30*(1), 41-53.
[32] Milani, A. S., Shanian, A., Lynam, C., & Scarinci, T. (2013). An application of the analytic network process in multiple criteria material selection. *Materials & design*, *44*, 622-632.
[33] A. Rahimi Ghazikalayeh; M. Amirafshari; H.M. Mkrchyan; M. Taji (2013). Application of Fuzzy Hybrid Analytic Network Process in Equipment Selection of Open-Pit Metal Mines. *International journal of research in industrial engineering*, *2*(3), 35-46.
[34] Montazeri, A., & Jouzdani, J. (2018). Prioritization of the Advertising Activities of Tehran Stock Exchange Investment Companies based on Investors' Financial Literacy using Step-by-Step ANP Approach. *Journal of applied research on industrial engineering*.
[35] Shariatmadari Serkani, E. (2015). Using DEMATEL–ANP hybrid algorithm approach to select the most effective dimensions of CRM on innovation capabilities. *Journal of applied research on industrial engineering*, *2*(2), 120-138.

[36] Pourkhandani, M., Iranban, S., Seyedi, S. (2014). QFD Application Using Combined ANP-DEMATEL Approach for Improving Service Quality: A Case Study of Dental Clinic. *Journal of applied research on industrial engineering, 1*(2), 112-129.

[37] Saaty, T. L., & Ozdemir, M. (2003). Negative priorities in the analytic hierarchy process. *Mathematical and computer modelling*, *37*(9-10), 1063-1075.

[38] Saaty, T. L., & Özdemir, M. S. (2005). *The encyclicon: A dictionary of decisions with dependence and feedback based on the analytic network process*. RWS Publications, Pittsburgh.

[39] Tzeng, G. H., & Huang, J. J. (2011). *Multiple attribute decision making: Methods and applications*. CRC press.

[40] Sevkli, M., Oztekin, A., Uysal, O., Torlak, G., Turkyilmaz, A., & Delen, D. (2012). Development of a fuzzy ANP based SWOT analysis for the airline industry in Turkey. *Expert systems with applications*, *39*(1), 14-24.

[41] Yazgan, H. R., Boran, S., & Goztepe, K. (2009). An ERP software selection process with using artificial neural network based on analytic network process approach. *Expert systems with applications*, *36*(5), 9214-9222.

[42] Bottero, M., Lami, I. M., & Lombardi, P. (2008). *Analytic network process: la valutazione di scenari di trasformazione urbana e territoriale*. Alinea Editrice.

[43] Malhotra, M. K., & Grover, V. (1998). An assessment of survey research in POM: from constructs to theory. *Journal of operations management, 16*(4), 407-425.

Appendix

Table 5. Organizational factor scores sample plane.

S	HIGH-ADOPTERS								NON-ADOPTERS				
FACILITY	A	B	D	F	H	I	K	AVG	C	E	G	J	AVG
ORGANIZATIONAL RESOURCES													
Facility Size	5	5	1	5	5	5	5	4.43	1	1	3	1	1.5
Company Size	5	5	1	5	5	5	5	4.43	5	1	3	3	3
ORGANIZATIONAL RESOURCE SCORE	10	10	20	10	10	10	10	4.43	6	2	6	4	2.25
ENVIRONMENTAL RESOURCES													
Size of Environmental Staff	3	4	3	5	5	5	4	4.14	2	1	2	1	1.5
Experienced Environmental Staff	5	5	3	5	5	5	5	4.71	5	1	2	1	2.25
Tenure of Environmental Staff	5	5	5	5	5	5	5	5	2	4	5	1	3
ENVIRONMENTAL RESOURCE SCORE	13	14	11	15	15	15	14	4.62	9	6	9	3	2.25
BUSINESS PRACTICES													
ISO Certified	0	0	0	5	5	0	0	1.43	5	5	5	5	5
Mission Statements	5	5	0	5	5	5	5	4.29	5	4	3	0	3
Formal Quality Management System	5	5	0	5	4	2	4	3.57	5	0	0	0	1.2
JIT Inventory Control	4	5	0	4	2	5	3	3.29	5	4	5	1	3.75
Cross-Functional Work Teams	2	3	0	5	5	2	1	2.57	5	4	4	0	3.25
Problem-Solving Teams	2	5	0	3	5	5	1	3.43	5	0	5	0	2.5
BUSINESS PRACTICE SCORE	21	23	0	22	21	19	14	3.10	25	12	17	1	3.13
ENVIRONMENTAL MONITORING & SYSTEMS													
Explicit Environmental Objectives	5	5	0	5	5	5	5	4.29	5	0	1	1	1.75
Environmental Performance Monitoring	5	5	1	5	5	5	5	4.43	3	1	1	1	1.5
Provide Environmental Information to Workers	5	5	0	5	4	5	2	3.71	1	1	1	2	1.25
Environmental Cost Identification	1	3	1	4	3	4	5	3	1	2	1	4	2
Chemical Control Process	1	5	0	0	4	4	2	2.29	4	0	0	0	1
Regular Environmental Inspections	5	5	1	4	5	5	2	3.86	5	1	3	1	2.5
Environmental Audits of Suppliers	1	2	0	1	4	5	1	2	1	0	1	0	.05
MONITORING & SYSTEMS SCORE	23	30	3	24	30	33	22	3.37	20	5	8	9	1.5
OVERALL SCORE	67	77	16	71	76	77	60	3.88	60	25	40	17	2.28