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Providing an interpretive structural model of implementation of cleaner production in the pharmaceutical industry

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Nowadays, because of globalization, enhancement of the regulations of governmental and nongovernmental organizations and the pressure customers put on these organizations and their demand to observe environmental issues have led the organizations to examine the efforts that must be made for implementing the cleaner production approach in order to improve their economic and environmental performance. The present study has aimed to propose an interpretive structural model for the execution of the cleaner production approach in the pharmaceutical industry. The statistical population of this research has been composed of pharmaceutical companies and 9 senior managers working in these companies have been selected as experts. In the present study, first previous studies and research literature have been carefully reviewed and critical success factors of the execution of the cleaner production approach have been determined and then, the research model has been proposed using the structural modelling technique. Research results indicate that more attention must be paid to the following factors: "cleaner regulations and policies", "cleaner strategic incentives", "cleaner leadership and competence", "cleaner processes" and "cleaner employees". The findings of this research can help the senior managers of pharmaceutical companies in making better decisions and proposing strategic solutions in the field of implementing cleaner production.

Keywords: Cleaner Production, Critical Success Factors, Interpretive Structural Modeling, Pharmaceutical Industry

INTRODUCTION

Recently, after the rapid industrialization of many of the developing countries, a great deal of attention has been paid to the environmental defects and governments all around the world have begun to enforce the environmental protection acts [51]. In the respect of enforcement of these laws, business firms have focused on implementing different techniques for preventing pollution and minimizing wastes and losses in their processes and business model by putting emphasis on the strategy of acquiring economic benefits along with environmental improvements (such as dilution, purification at the end of the line, recycling and reusing materials) [42]. They consider environmental protection as one of the most important factors in creating and activating strategies of development, sustainability, success and excellence in business [43]. Nowadays, customers and beneficiaries of economic firms are important factors in terms of encouraging or forcing business firms to observe environmental laws and execute cleaner business and sustainable environmental management systems [30]. Environmental sustainability comes in the form of concepts such as cleaner production, green production, green productivity, green and sustainable design and it is a preventive approach with an emphasis on productivity [24]. The cleaner production approach is implemented when the processes of an economic firm are able to reduce the costs of environmental protection by reducing wastes and preventing pollution and therefore, protect the environment and improve economic and green productivity [14].

Promotion of cleaner production is of crucial importance when it comes to improving the supply chain and the environmental performance of the companies and the culture related to environment in the society. It is essential for companies to perceive the factors that affect cleaner production and to understand the relationships between these factors in order for them to successfully execute and promote cleaner production [49]. By overviewing literature on cleaner production, the effect of certain factors, including the product and innovations of cleaner processes, application of international standards (ISO 14001), industrial and governmental regulations and an eco-friendly culture, on cleaner production can be reviewed. in particular, clean product innovation factors contribute to any of the cleaner production outcomes including minimizing energy consumption, reducing materials and preventing pollution [13]. The cleaner production process reduced the consumption of water, energy and material and leads to a reduction in the amount of waste that is produced by improving the efficiency of the process. Eco-friendly productivity

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or product innovation and clean process are called eco-friendly innovations [11]. Application of the environmental management system (ISO 14001) of the International Organization for Standardization (ISO) has a positive impact on the environmental performance of productive companies [53]. Observing and implementing legal and industrial regulations affect the efforts that companies make in relations with the environment [1, 45]. Lack of an eco-friendly culture acts as a barrier on the way of promotion of cleaner production in the organizations [31, 51]. Nonetheless, previous studies have shown that only a few researches have focused on the critical success factors of implementing cleaner production and on proposing an interpretive structural model in this field.

An increase in pollution in many cities are in line with the increase of the volume of productive activities that are done nearby them [15]. Therefore, in the respect of realization of the perspective of the country in order to economically grow, effectively reducing pollution near big cities is a quite critical issue for the country. On the other hand, given that the majority of the pharmaceutical industry do their activities near big cities; therefore, it is important to propose a cleaner production model for achieving environmental sustainability in the pharmaceutical industry. Pharmaceutical producers share similar production processes with some of the other productive companies. Some of these shared processes are preparing raw materials, mixing, filling and finally packaging them. Nevertheless, they produce unique wastes in the production process such as solvent water and wastewater at the end of the processes. In addition, many drugs, medicines or pharmaceutical intermediates contain some of these chemical compounds which are quite likely to be contaminated with poisonous or dangerous substances. And if the essential efforts are not made for reducing their harmful effects, they can impose irreparable harms and damages. In this respect, the pharmaceutical industry puts forward a great opportunity for improving the environmental effects of these materials through implementing methods that are based on preventing pollution or reducing the disposal of the remaining wastes and unconsumed solvent water and return of products [60].

An important issue here is that share of the production sector of the pharmaceutical industry plays a considerable role in the advancement of any country; so much so that the role of the production sector of this industry in the growth of economy and environment is quite exponential. Now, considering the necessity and importance of the efficiency of pharmaceutical production in the advancement of environmental and macro economical policies and strategies as well as a few efforts that have been made in regard with the issue of cleaner production in this industry in the past few years, the present study has aimed to extract critical success factors of the implementation of cleaner production by carefully and deeply studying previous studies and to propose a model that would enable pharmaceutical companies to increase productivity and environmental sustainability. By taking the aforementioned points into consideration, the following question has come to the mind of the researcher: "how is the interpretative structural model for implementing the cleaner production approach in the pharmaceutical industry?"

THEORETICAL PRINCIPLES OF THE RESEARCH

Cleaner production

Cleaner production refers to reviewing all decisions, activities and attempts that are associated with improving the environmental performance of a company by reducing the negative effects of the company on the environment and it is not just limited to the activities related to controlling pollution in a production process [44]. Ortolano *et al.* defines cleaner production as an attempt to prevent unpleasant environmental effects throughout the life cycle of the product (extracting raw materials, designing products, producing, using and finally disposing the product)[35]. The official definition of term "cleaner production" will help us organize attractive ideas in this field. United Nations Environment Programme (UNEP) defines cleaner production as a continuous application of an integrated prevented environmental strategy which is applied to the processes, products and services of a company which is followed by increasing overall productivity and a reduction in the risk human beings and the environment are faced with [49]. Figure 1 displays the overall concept of cleaner production.

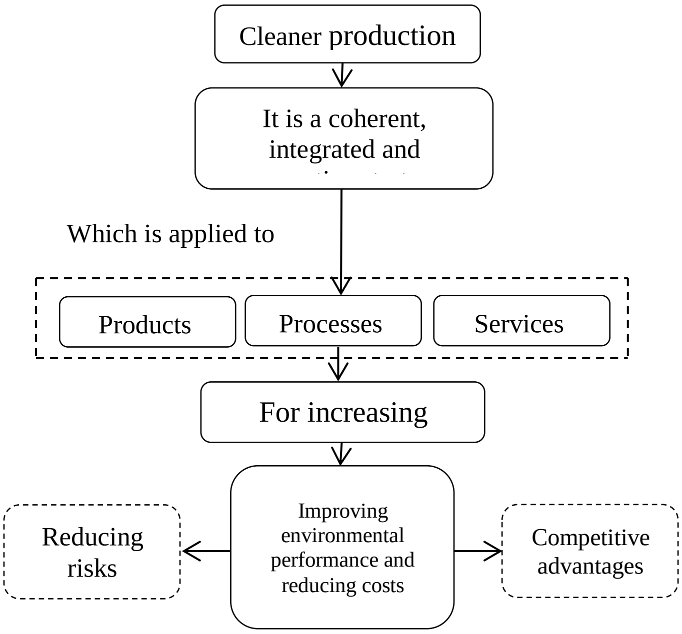

Fig. 1. Concept of cleaner production [49]

Critical success factors for the implementation of cleaner production

So far, many authors have studied the critical success factors for the implementation of cleaner production, but the dynamic changes in these factors has made it way more complicated and difficult both for researchers and those who are somehow active in this field. Critical success factors for the implementation of cleaner production, that have been stated by numerous researchers, have been summarized in Table 1.

Table 1. Critical success factors for the implementation of cleaner production (collected by researchers)

Factor number	**Critical success factors**	**Explanation**	**Reference**
1	Cleaner environmental management	This factor refers to pollution control, establishment of an environmental management (series of ISO 14000 certificates), environmental authentication and energy conservation.	[5, 6, 8, 9, 17, 25, 28, 29, 32, 41, 47, 48, 56, 57, 58]
2	Cleaner processes	This factor refers to the production processes of cleaner products, cleaner logistic processes, cleaner purchasing processes, cleaner operational processes, cleaner maintenance and repairing, and cleaner development and research projects.	[5, 8, 23, 32, 36, 41, 48, 47, 59]
3	Cleaner policies and regulations	This factor refers to commitment to cleaner production policies, compatibility with governmental environmental regulations, compatibility with environmental regulations in the industry at a global level, promotion of cleaner production policies, encouraging policies in the respect of cleaner production and developing cleaner production policies.	[5, 21]
4	Cleaner resource management	This factor refers to optimization of water, energy and chemical substance consumption, reduction and minimization of reliance and dependency to natural resources, internal and external recycling.	[3, 16, 22; 36]
5	Cleaner employees	This factor refers to teaching the environmental concepts to employees, transferring the cleaner production knowledge to employees, participation of employees in cleaner production, hiring workforce that is skilled in the field of cleaner	[5, 18, 19, 33, 41]

		production, and forming a cleaner production team in the organization.	
6	Cleaner strategic incentives	This factor refers to an strategic planning based on cleaner production, focusing on cleaner demands of customers, continuously improving cleaner processes, redesigning cleaner work stations and managing the physical environment for cleaner production.	[2, 12, 19, 20, 40, 47]
7	Cleaner competence and leadership	This factor refers to senior managers' supporting and committing to cleaner production, their participation in affairs related to cleaner production, participation of the executive manager to cleaner production and social responsibilities and environmental competency.	[5, 23, 41, 47, 56]
8	Cleaner suppliers	This factor refers to cleaner production programs in the establishment of suppliers, evaluating cleaner processes of suppliers, cleanness of production of suppliers and a clean image of the supplier.	[10, 21, 28, 56]
9	Cleaner purchasing management	This factor refers to using eco-friendly materials, clean management of wastes and recycling and reusing materials.	[5, 7, 21, 48]
10	Cleaner innovation	This factor refers to innovations in the cleaner production programs, innovation in cleaner products and innovation in cleaner production processes.	[10]
11	Cleaner protective criteria and risk perception	This factor refers to redesigning the product with the purpose of producing eco-friendly products, minimizing wastes and disposing the environmental risk of operations.	[59]
12	Cleaner culture	This factor refers to an eco-friendly culture and the culture of sharing the cleaner production issues with the employees.	[44, 52]
13	Cleaner cooperation	This factor refers to cooperation with clean organizations and clean projects.	[5, 50]
14	Cleaner designing	This factor refers to the compatibility between designing and cleaner production and a cleaner mental image.	[5, 6, 25, 29, 48]
15	Cleaner technology	This factor refers to the technical knowledge of cleaner production and planning for developing and adopting clean technologies.	[5, 23, 29, 32, 34, 41, 47]

RESEARCH METHODOLOGY

The present study is an applied research in terms of its objectives and results and in terms of method, it is a descriptive research. In this study, the library method has been used for collecting information related to describing the subject and research background and the researcher has studied different books and articles in order to gather the required information. In addition, first previous studies and research literature have been carefully reviewed and critical success factors of the execution of the cleaner production approach have been determined and then, the research model has been proposed using the structural modelling technique. The statistical population of the present study consisted of active companies in the pharmaceutical industry (chemical, synthetic and herbal medicine). Senior managers of these pharmaceutical companies who had an over 15-year work experience, a doctorate and had conducted researches in the field of cleaner production were selected as experts. Ultimately, 9 of these senior managers participated in this study as experts. Collecting the opinions of these experts took 3 months and researchers were able to come to a unanimous and coherent opinion through face-to-face visits and continuous follow-ups. This research has been conducted in the spring and summer of 2017.

RESEARCH FINDINGS (DATA ANALYSIS)

After determining the critical success factors for implementing the cleaner production approach in the pharmaceutical industry, the interpretive structural modelling technique was used for designing the interpretive structural model of cleaner production.

The interpretive structural modelling (SIM) technique was firstly proposed by Warfield (1974). Warfield suggested that the ISM technique is based on discrete mathematics/graph theory, social sciences and group decision making [55]. Malone states that it is generally felt that individuals or groups are always faced with complex systems or issues. Complexity of systems or issues is because of the presence of a large number of elements and the interaction between these elements. Existence of direct or indirect elements disturbs the structure of the system which might be implied or explicitly expressed. It is quite difficult to point to a system with an unspecific structure. Thus, it is necessary to develop a methodology which contributes to the recognition of a structure in a system. The ISM technique is among these methodologies [4]. ISM is a strong qualitative tool and it is a suitable modelling technique for analyzing the effect of an element [54] and gives researchers an insight into coming to a collective understanding of these relationships as well as the levels of these relationships. ISM allows researchers and managers acquire a deeper understanding of the relationship between key issues [39]. In general, it can be argued that this technique is an interpretive method; because the decisions about whether or not enablers are dependent and how is this dependency are based on the judgement of the group and the overall structure is extracted from the complex series of enablers based on the relationships. Special relationships and the overall structure are displayed in a graphic model through modelling [38].

In this research, the opinions of experts in association with determining the interaction between the critical success factors for implementing cleaner production have been collected. The steps involved which lead to the development of the ISM model in this research are illustrated below:

Step 1: Preparing a list of the identified critical success factors

In the present study, by carefully and deeply studying previous studies, 15 critical success factors for implementing cleaner production in the pharmaceutical industry have been recognized (table 1).

Step 2: developing the structural self-interaction matrix

After recognizing the required factors, the internal relations between these factors must be specified. The internal relations between the recognized factors have been specified in the structural self-interaction matrix [27]. The symbols presented in table 2 have been used for determining the type of the relationships between these factors.

In the respect of the formation of the structural self-interaction matrix, a questionnaire has been designed (table 3), in which the conceptual and internal relationships between all of the 15 identified factors have been compared with one another. To determine the internal relationships between these factors, the structural self-interaction matrix questionnaire was handed out to 9 experts and the opinions of these experts were collected. Then, the information obtained from these opinions were collected through exchange of opinions with the aforementioned experts. The internal relationships obtained from the critical success factors for implementing cleaner production have been displayed in Table 3.

Table 2. Internal relationships between the factors in the structural self-interaction matrix

Symbol	Explanation of the symbol of internal factors
V	Elements on the row i will lead to factors in column j.
A	Elements on the column j will lead to factors in row j.
X	here is a bilateral relationship between the factors in the row I and the factors in the column j.
O	There is no relationship between factors in the row I and the factors in the column j.

Table 3. Structural self-interaction matrix (SSIM)

Critical success factors for implementing cleaner production (number)	(1)	)2(	)3(	)4(	)5(	)6(	)7(	)8(	)9(	)10(	)11(	)12(	)13(	)14(	)15(
)1(	-	A	A	V	V	A	O	O	O	O	O	O	X	O	O
)2(	-	-	O	O	X	A	A	O	O	V	O	V	V	A	O
)3(	-	-	-	V	V	V	V	O	O	O	V	O	O	O	O
)4(	-	-	-	-	A	A	O	A	O	A	O	O	X	A	A
)5(	-	-	-	-	-	O	O	O	O	V	V	X	V	O	O
)6(	-	-	-	-	-	-	O	O	O	V	V	A	O	X	V
)7(	-	-	-	-	-	-	-	O	O	A	V	A	V	O	O

)8(	-	-	-	-	-	-	-	-	V	O	V	O	X	O	O
)9(	-	-	-	-	-	-	-	-	-	O	V	O	A	O	O
)10(	-	-	-	-	-	-	-	-	-	-	V	A	A	A	O
)11(	-	-	-	-	-	-	-	-	-	-	-	A	O	A	A
)12(	-	-	-	-	-	-	-	-	-	-	-	-	A	V	O
)13(	-	-	-	-	-	-	-	-	-	-	-	-	-	V	V
)14(	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O
)15(	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Step 3: development of the reachability matrix

In this stage, in order to develop the reachability matrix, the symbols of the internal relationships in the structural self-interaction matrix must be converted to numbers zero and one [26]. The rules for of this substitution are as follows (table 4):

- If the (i,j) entry in the SSIM is V, its corresponding entry in the reachability matrix will be 1 and its parallel entry (j.i) will be 0.
- If the (i,j) entry in the SSIM is A, its corresponding entry in the reachability matrix will be 0 and its parallel element (j.i) will be 1.
- If the (i,j) entry in the SSIM is X, its corresponding entry in the reachability matrix will be 1 and its parallel element (j.i) will be 1.
- If the (i,j) entry in the SSIM is O, its corresponding entry in the reachability matrix will be 0 and its parallel element (j.i) will be 0.

Table 4. Internal relationships between variables in the development of the reachability matrix

Index of the internal relationships	(i,j)	(j,i)
V	1	0
A	0	1
X	1	1
O	0	0

The reachability matrix in this research has been presented in Table 5.

Table 5. Reachability matrix

Critical success factors for implementing cleaner production (number)	)1(	)2(	)3(	)4(	)5(	)6(	)7(	)8(	)9(	)10(	)11(	)12(	)13(	)14(	)15(
)1(	1	0	0	1	1	0	0	0	0	0	0	0	1	0	0
)2(	1	1	0	0	1	0	0	0	0	1	0	1	1	0	0
)3(	1	0	1	1	1	1	1	0	0	0	1	0	0	0	0
)4(	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0
)5(	0	1	0	1	1	0	0	0	0	1	1	1	1	0	0
)6(	1	1	0	1	0	1	0	0	0	1	1	0	0	1	1
)7(	0	1	0	0	0	0	1	0	0	0	1	0	1	0	0
)8(	0	0	0	1	0	0	0	1	1	0	1	0	1	0	0
)9(	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0
)10(	0	0	0	1	0	0	1	0	0	1	1	0	0	0	0
)11(	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
)12(	0	0	0	0	1	1	1	0	0	1	1	1	0	1	0
)13(	1	0	0	1	0	0	0	1	1	1	0	1	1	1	1
)14(	0	1	0	1	0	1	0	0	0	1	1	0	0	1	0
)15(	0	0	0	1	0	0	0	0	0	0	1	0	0	0	1

Step 4: adaptation of the reachability matrix

After the reachability matrix is obtained, adaptation of this matrix is reviewed. In other words, the transitivity of this matrix must be incorporated. In a transitive matrix, if A leads to B and B leads to C, then A must also leads to C. If the reachability matrix is not transitive, then the matrix must be adjusted or modified through various methods. The two main methods that are used for modifying the reachability matrix are as follows]27]:

1) Recollecting opinions of experts: in this method, the opinions of experts about the internal relations between the collected factors and then the structural self-interaction matrix and the new reachability matrix are developed. In this method,

this process continues until the reachability matrix becomes transitive. S

2) Mathematical rules: in this method, the reachability matrix to the power of (K+1) is calculated and K≥1. This continues until the obtained matrix doesn't undergo any change. It is noteworthy that this must be done based on the laws of Boolean which is illustrated below:

$$1 \times 1 = 1\,, \quad 1 + 1 = 1\,,$$
$$1 + 0 = 0 + 1 = 1\,,$$
$$0 + 0 = 0$$

In the present study, the second method has been used and the obtained results have been presented in table 6. In the adaptive matrix, entries that come with a (*) indicate that the number in them was zero in the reachability matrix and it became 1 after the adaptation.

Table 6. Adaptive reachability matrix

Critical success factors for implementing cleaner production (Number)	**)1(**	**)2(**	**)3(**	**)4(**	**)5(**	**)6(**	**)7(**	**)8(**	**)9(**	**)10(**	**)11(**	**)12(**	**)13(**	**)14(**	**)15(**
)1(	1	1^*	0	1	1	0	0	1^*	1^*	1^*	1^*	1^*	1	1^*	1^*
)2(	1	1	0	1^*	1	1^*	1^*	1^*	1^*	1	1^*	1	1	1^*	1^*
)3(	1	1^*	1	1	1	1	1	0	0	1^*	1	1^*	1^*	1^*	1^*
)4(	1^*	0	0	1	0	0	0	1^*	1^*	1^*	0	1^*	1	1^*	1^*
)5(	1^*	1	0	1	1	1^*	1^*	1^*	1^*	1	1	1	1	1^*	1^*
)6(	1	1	0	1	1^*	1	1^*	0	0	1	1	1^*	1^*	1	1
)7(	1^*	1	0	1^*	1^*	0	1	1^*	1^*	1^*	1	1^*	1	1^*	1^*
)8(	1^*	0	0	1	0	0	0	1	1	1^*	1	1^*	1	1^*	1^*
)9(	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0
)10(	0	1^*	0	1	0	0	1	0	0	1	1	0	1^*	0	0
)11(	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
)12(	1^*	1^*	0	1^*	1	1	1	0	0	1	1	1	1^*	1	1^*
)13(	1	1^*	0	1	1^*	1^*	1^*	1	1	1	1^*	1	1	1	1
)14(	1^*	1	0	1	1^*	1	1^*	0	0	1	1	1^*	1^*	1	1^*
)15(	0	0	0	1	0	0	0	0	0	0	1	0	1^*	0	1

Step 5: level partitions and prioritization of factors

In order to the determine the prioritization of factors and level partitions, the reachability set or the antecedent set must be determined for each factor [26]. The reachability set consists of the factor itself and the other factors that it may impact; while the antecedent set consists of the factor and the other factors that might impact it. Here, the information obtained from the reachability matrix is used. After determining the reachability set and the antecedent set for each factor, the mutual elements for each factor in the reachability set and the antecedent set are identified and ultimately, the level of the factors are determined. In the first table, the factors with the same reachability set and antecedent set are at the top levels. Once these factors are identified, they will be deleted from the table and the next table will be formed with the remaining factors. Similar to the first table, we specify the factors in the second level and continue this process until the level and priority of each and every one of the factors are found [27]. In the present study, through 7 tables, the 7 levels of the factors were obtained and in order to summarize, only the tables for the first stage of the process and the final results of the levels of the following six tables for each factor have been presented in Table 7.

After determining the relations and critical success factors for implementing cleaner production, a model of them can be developed. To this end, the factors are placed in a hierarchy from top to bottom based on their levels. In this research, factors are placed in seven levels (figure 2). In the top level of the model (level 1), the factors cleaner protective criteria and risk perception has been placed. In level 2, we have cleaner purchasing management, cleaner innovation and cleaner technology. In level 3, we have cleaner environmental management, cleaner resource management, cleaner culture, cleaner participation and cleaner designing. In level 4, we have cleaner suppliers. In level 5, we have cleaner employees and cleaner competence and leadership. In level 6, we have cleaner strategic incentives. In the bottom level of the model (level 7), cleaner policies and regulations have been placed which act as an infrastructure for the interpretive structural model of implementation of cleaner production and we must start with this factor and move up to higher levels. By taking into consideration the relations between the factors, figure 2 displays the collection of experts' opinions for developing the research model. As it can be observed in figure 2, the effectiveness of the factors in each level on the upper level has been specified. This indicates that factors in the lower levels affect the factors in the upper levels and also, some of these factors interact with one another.

Level 6: MICMAC analysis

In the MICMAC analysis, the factors are divided into four areas based on the driving power and dependence power which can be seen in figure 3 [26]. Autonomous variables are in area 1.

Table 7. Determining the levels of factors (reachability and antecedent sets)

Row	Factors	Reachability set	Antecedent set	Intersection between Reachability set and Antecedent set	Level (Intersection = Reachability set)	Driving power	Dependence power
1	Cleaner environmental management	1 ,2 ,4 ,5 ,8 , 9 ,10 ,11 , 12 ,13 ,14 , 15	1 ,2 ,3 ,4 ,5 , 6 ,7 ,8 ,12 , 13 ,14	1 ,2 ,4 ,5 ,8 , 12 ,13 ,14	Level 3	12	11
2	Cleaner processes	1 ,2 ,4 ,5 ,6 , 7 ,8 ,9 ,10 , 11 ,12 ,13 , 14 ,15	1 ,2 ,3 ,5 ,6 , 7 ,10 ,12 , 13 ,14	1 ,2 ,5 ,6 ,7 , 10 ,12 ,13 ,14	Level 5	14	10
3	Cleaner policies and regulations	1 ,2 ,3 ,4 ,5 , 6 ,7 ,10 ,11 , 12 ,13 ,14 , 15	3	3	Level 7	13	1
4	Cleaner resource management	1 ,4 ,8 ,9 , 10 ,12 ,13 , 14 ,15	1 ,2 ,3 ,4 ,5 , 6 ,7 ,8 ,10 , 12 ,13 ,14 , 15	1 ,4 ,8 ,10 ,12 , 13 ,14 ,15	Level 3	9	13
5	Cleaner employees	1 ,2 ,4 ,5 ,6 , 7 ,8 ,9 ,10 , 11 ,12 ,13 , 14 ,15	1 ,2 ,3 ,5 ,6 , 7 ,12 ,13 ,14	1 ,2 ,5 ,6 ,7 , 12 ,13 ,14	Level 5	14	9
6	Cleaner strategic incentives	1 ,2 ,4 ,5 ,6 , 7 ,10 ,11 , 12 ,13 ,14 , 15	2 ,3 ,5 ,6 , 12 ,13 ,14	2 ,5 ,6 ,12 ,13 , 14	Level 6	12	7
7	Cleaner competence and leadership	1 ,2 ,4 ,5 ,7 , 8 ,9 ,10 ,11 , 12 ,13 ,14 , 15	2 ,3 ,5 ,6 ,7 , 10 ,12 ,13 , 14 ,15	2 ,5 ,7 ,10 ,12 , 13 ,14 ,15	Level 5	13	9
8	Cleaner suppliers	1 ,4 ,8 ,9 , 10 ,11 ,12 , 13 ,14 ,15	1 ,2 ,4 ,5 ,7 , 8 ,13	1 ,4 ,8 ,13	Level 4	10	7
9	Cleaner purchasing management	9 ,11	1 ,2 ,4 ,5 ,7 , 8 ,9 ,13	9	Level 2	2	8
10	Cleaner innovation	2 ,4 ,7 ,10 , 11 ,13	1 ,2 ,3 ,4 ,5 , 6 ,7 ,8 ,10 , 12 ,13 ,14	2 ,4 ,7 ,10 ,13	Level 2	6	12
11	Cleaner protective criteria and risk perception	11	1 ,2 ,3 ,5 ,6 , 7 ,8 ,9 ,10 , 11 ,12 ,13 , 14 ,15	11	Level 1	1	14

12	Cleaner culture	1 ,2 ,4 ,5 ,6 , 7 ,10 ,11 , 12 ,13 ,14 , 15	1 ,2 ,3 ,4 ,5 , 6 ,7 ,8 ,12 , 13 ,14	1 ,2 ,4 ,5 ,6 ,7 , 12 ,13 ,14	Level 3	12	11
13	Cleaner cooperation	1 ,2 ,4 ,5 ,6 , 7 ,8 ,9 ,10 , 11 ,12 ,13 , 14 ,15	1 ,2 ,3 ,4 ,5 , 6 ,7 ,8 ,10 , 12 ,13 ,14 , 15	1 ,2 ,4 ,5 ,6 ,7 , 8 ,10 ,12 ,13 , 14 ,15	Level 3	14	13
14	Cleaner designing	1 ,2 ,4 ,5 ,6 , 7 ,10 ,11 , 12 ,13 ,14 , 15	1 ,2 ,3 ,4 ,5 , 6 ,7 ,8 ,12 , 13 ,14	1 ,2 ,4 ,5 ,6 ,7 , 12 ,13 ,14	Level 3	12	11
15	Cleaner technology	4 ,11 ,13 ,15	1 ,2 ,3 ,4 ,5 , 6 ,7 ,8 ,12 , 13 ,14 ,15	4 ,13 ,15	Level 2	4	12

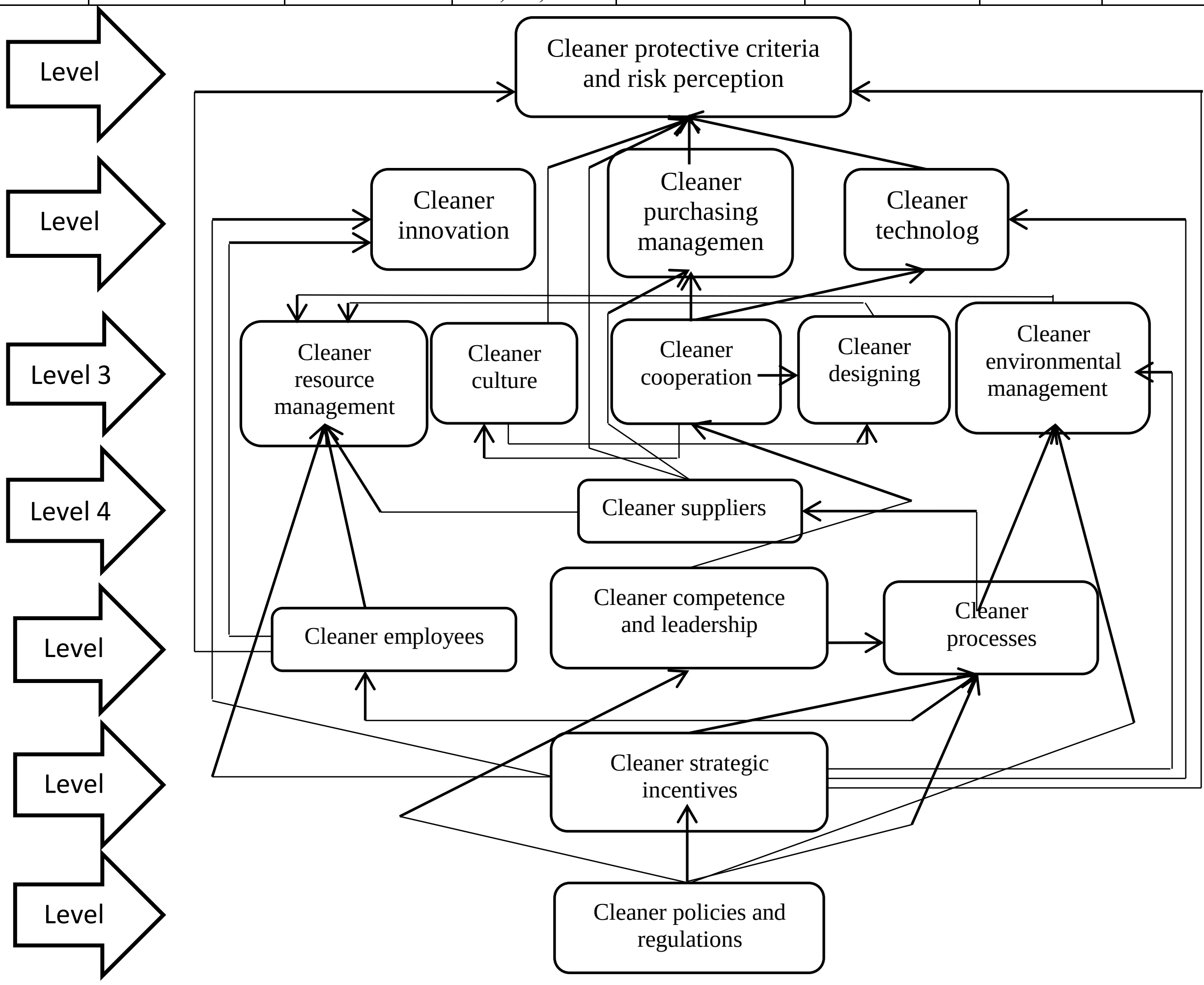

Fig. 2. Interpretive structural model for implementing cleaner production in the pharmaceutical industry

In this area, factors are weak in terms of driving and dependence power. In other words, these have weak relations with the required system. In the present study, none of these factors have been placed in this area. In area 2, dependence variables can be found which are weak in terms of driving power, but they are quite strong in terms of dependence power. These factors do not have a considerable effect on other factors. In the present study, "cleaner purchasing management" (9), "cleaner innovation" (10), "cleaner protective criteria and risk perception" (11) and "cleaner technology" (15) have been placed in this area. Area 3 is associated with linkage variables. These variables are strong in terms of dependence power and driving power. In fact, these variables are nonstationary and unsustainable; because any impact on these variables will affect others or themselves. In this research, the variables "cleaner environment management" (1), "cleaner processes" (2), "cleaner resource management" (4), "cleaner employees" (5), "cleaner competence and leadership" (7), "cleaner culture" (12), "cleaner cooperation" (13) and "cleaner designing" (14) have been placed in this area. Area 4 consists of independent variables which are weak in terms of dependence power and driving power. These variables are known as key factors because they act as the infrastructure (foundation) of the model and to be successful, special attention must be paid to these variables. In this research, "cleaner policies and regulations" (3), "cleaner strategic incentives" (6) and "cleaner suppliers" (8) can be found in this area. The "cleaner policies and regulations" is the most important independent variable which is the most powerful both in terms of dependence and driving power and it acts as the infrastructure of the cleaner production model. In table 7, the dependence and driving power of each of these factors have been presented.

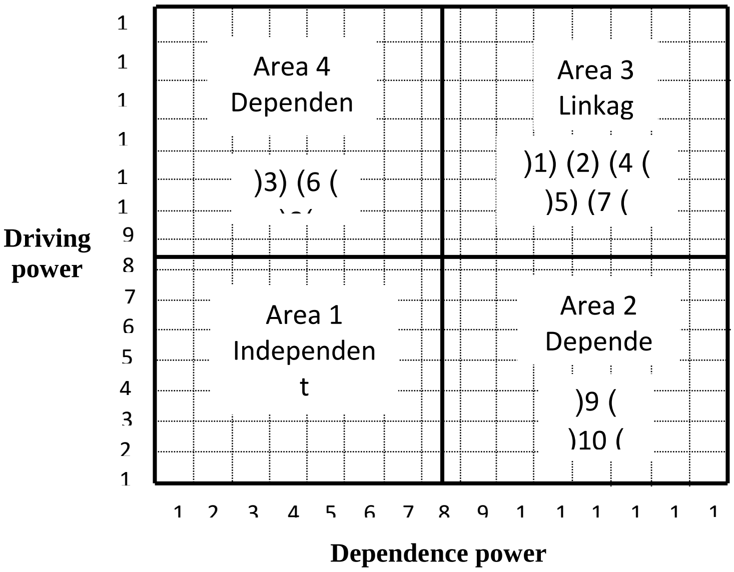

Fig. 3. MICMAC graph (driving – dependence power).

DISCUSSION AND CONCLUSION

Nowadays, cleaner production is regarded as a critical issue for organization; because shareholders, stockholders, government officials, customers, employees, competitors and societies of an organization have put emphasis on it and consider it to be quite important. In this respect, companies that are constantly growing widely use programs such as designing an environment, analyzing lifecycle, managing quality of the environment, managing green supply chain, cleaner production and ISO 14000 standard [46]. As the governmental rules become more and more strict and people become generally more aware, it has become impossible to be indifferent about the environmental issues. Productive companies must follow and observe governmental rules associated with protecting the environment and also voluntarily produce their products according to the eco-friendly and environmental protection standards [37].

In this research, a smooth method for proposing an interpretive structural model for implementing cleaner production in the pharmaceutical industry has been proposed. In the interpretive structural model, 15 factors "cleaner environmental management", "cleaner processes", "cleaner policies and regulations", "cleaner resource management", "cleaner employees", "cleaner strategic incentives", "cleaner competence and leadership", "cleaner suppliers", "cleaner purchasing management", "cleaner innovation", "cleaner protective criteria and risk perception", "cleaner culture", "cleaner cooperation", "cleaner designing" and "cleaner technology" as the 15 critical success factors for implementing cleaner production in the pharmaceutical industry have been reviewed. The identified factors have been supported by various studies such as Chiou *et al.* [5], Yang and Wu [8], Lee et al. [9], Tuzkaya et al. [29], Awasthi et al. [48], Chen et al. [57].

The result of this research is a partitioned model of the critical success factors for implementing cleaner production in which, the factors "cleaner policies and regulations", "cleaner strategic incentives", "cleaner competence and leadership", "cleaner processes" and "cleaner employees" must be paid special attention, in this specific order. One of the first basic and effective steps that must be taken towards dealing with pollution is developing cleaner rules and regulations in various environmental areas. This regulation is sometimes technical associated with observance of environmental directives and standards of the beneficiary organizations and sometimes it is associated with the damages caused by prohibited activities against the environment and how to compensate for these damages. Some of these rules and regulations are criminal and are associated with how environmental violations and criminals prosecuted and punished. All of these regulations have a common objective which is preventing environmental pollution or coping with it.

Cleaner leaders are leads who inspire their followers, encourage them and guide them in a path which benefits the organization. These leaders pay special attention to the needs and improvements and promotion of their inferiors, make them more aware and can lead individuals in such a way that they would look at the environmental issues from new perspectives. Cleaner leadership is a leadership behavior which encourages followers to make efforts in the respect of fulfilling the goals of cleaner production and to make efforts that are beyond expectation in order to achieve an environmental performance such as cleaner creativity.

Consumers increasingly demand cleaner products. Nowadays, consumers are not only careful about the materials their favorite products consist of, but they also care a great deal about the effect the production of these products has on the environment; therefore, the production processes must be more accurate and transparent.

A cleaner employee system examines the quality of the working processes of the employees from the perspective of cleanness. On the other hand, cleaner employees evaluate quality from the perspective of customers. This is a self-monitoring system by using which the conditions would be perceived, problems would be detected and solved accurately. This system refers to maintaining high quality in the working process of employees. In order to fulfill the objective of cleaner employees, it is essential to present a safe environment, proper equipment and educational information and to reassure of the competence of individuals and job security.

In general, it can be stated that these factors are quite important and necessary and it cannot be said that without paying special attention to these factors, successful implementation of cleaner production can be guaranteed. In addition, these factors act as the infrastructure of the interpretive structural model for cleaner production and obtainment of other factors can be facilitated by using the aforementioned ones.

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