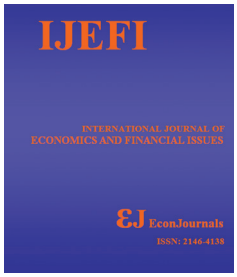

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Identification and Classification of Effective Operational Plans on Sustainable Production Using Repertory Grid and Principal Component Analysis: A Case Study on Industrial Production Companies in Semnan Province, Iran

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ABSTRACT

Attenuation of natural resources, climate changes, environmental pollution, ecological incompatibility of industrial activities with the environment, and decrease in quality of human's life due to the acceleration of global industrialization are critical factors intensively pushed production to resist against the problems while keep its competitiveness. In this regard, sustainability and, especially for production, moving towards sustainable production in order to respond to challenges that industrial countries may be encountered with in this route are of significant importance. Sustainability is an increasingly important necessity for human activities and making a sustainable development is a key goal of human development. Sustainable development is an approach targeting various social, economic and environmental issues, generally and simultaneously, in the development process. The concept of sustainable production, which is closely related to the concept of sustainable development, targets the production companies and service providers. The current paper is focused on sustainability of productive businesses and aims to identify the structures of sustainable production and to evaluate and classify more effective plans in this field. In this regard, the dimensions and structures of sustainable production were identified using interview and repertory grid method through the viewpoints of the managers of 33 successful industrial production companies with at least 5 years continuous and sustainable activity in Semnan province, Iran. Based on the interviews, 33 individual repertory grids and 175 primary individual structures of sustainable production were created. After analyzing these structures, the aggregated grid of sustainable production including 87 secondary structures was drawn. In the next step, Principal Component Analysis (PCA) was used to divide the major structures which have more important roles for achieving sustainable production into two groups and to identify their components.

Keywords: Principal Component Analysis, Sustainable Production, Repertory Grid, Personal Structure Theory
JEL Classifications: Q56, E3

1. INTRODUCTION

Sustainability is an increasingly important necessity for human activities and making a sustainable development is a key goal of human development. Sustainable development is an approach targeting various social, economic and environmental issues, generally and simultaneously, in the development process. Sustainability is presented in various fields such as engineering, designing and production and producers are increasingly involved in sustainability. For example, in the industrial societies, identifying the relationship between the production performances and the natural environment is a key important factor. Various products of companies which are presented in the market may have hidden costs and we are not able to realize that how much the other costs of the products and services which are daily used by us and what are the hurts enforced to the earth, human health, society, the environment and the workers through the production of these products and services. In general, achieving the sustainable development is a complicated challenge which is related to factors such as technology and engineering,

economy, environmental supervision, welfare and health of people and their society, social demands, and the strategies of government, producers and policies. In particular, achieving the sustainable production needs to balance and integrity between the economy and social – environmental goals and supportive policies policies (Basmer, et al., 2015. p. 46). The concept of sustainable production has been emerged during United Nations conference on the environment and development, 1992; and it is closely related to the concept of sustainable development (Veleva and Ellenbecker, 2001. p. 519). The conference was concluded that the main reason for failure of the environment is unsustainable pattern of production and consumption, especially in industrial countries. While sustainable consumption targets consumers, sustainable production is related to productive companies and organizations and service providers. Although the concept of sustainability is still unclear, there is an increasingly consensus about this issue that it is necessary to move towards the developing real and practical tools for prevailing and measuring the achievements. Hence, simultaneous to these predictions, an interesting to sustainable development and its related internal challenge was grown up so that the concepts of industrial ecology and industrial coexistence were entered to the field of production as an opportunity for development in 90s (Erkman, 1997. p. 1). Although the measures related to industrial ecology and industrial coexistence can be considered as new measures in the field of production, these concepts are mainly defined as the science of sustainability since the industrial ecology and industrial coexistence are created from the similarity between the nature that should be analyzed and improving the sets, logistics, and industrial consumers as well as energy and material issues (Cohen-Rosenthal, 2000. p. 245; Costa et al., 2010. p. 815).

The current paper is focused on the sustainability of productive businesses and it aims to achieve a local understanding about the structure of sustainable business in industrial companies of Semnan province, Iran, through a descriptive - interpretative approach based on personal structure theory and using the structures drawn for viewpoints of their managers. Based on this approach, two main questions will be answered; what are the operational plans of the managers of industrial companies for understanding the sustainable production and what is the importance of each plan. In this regard, after the literature review and establishing the research method, the operation of repertory grid method is explained and the structures of managers about the sustainability of production are collected in a combined repertory grid and finally, the structures are analyzed through principal component analysis (PCA) method.

2. RESEARCH BACKGROUND AND FUNDAMENTALS

Companies have been commonly used standard financial indices for determining the successfulness of their businesses; in recent years, however, numerous companies are using social indices (e.g., M. Shell, Amoco, Interface) and environmental, health and safety indices (Veleva and Ellenbecker, 2001. p. 519). Despite the number of sustainability indices are increasing in the literature, none of those cannot help us for operationally understanding of corporate sustainability. The investigations performed on the fifty corporate sustainability reports (Sustainability, Team Spotlights Top 50 Corporate Sustainability Reports GreenBiz, November 15, 2000) also shows that companies are not able to completely control and manage their social and environmental effects. As a result, we are lost in a great sea of confusing, contradictory, imperfect and incomparable information without any consensus about some principles of production sustainability. In addition, lack of "standard measure criteria" indicating the main obstacle on the way toward future efforts of businesses for implementing sustainable business strategies. Hence, it can be argued that achieving a set of sustainable indices, more applicable and compatible with each company or organization, is not easy and it needs to investigate all measures of each company in a comprehensive model and establish a general model for the concept of sustainable production in addition to investigating the sustainability route of each company and successful management experiences for maintaining the sustainability of production. In this regard, University of Lowell, Massachusetts, defined sustainable production as "producing goods and services using non-pollutant processes and systems; saving the energy and natural resources; economically appropriate; non-dangerous for workers, societies and customers (safe and healthy); and socially and creatively satisfying for all working people". This definition is compatible with the current understanding on sustainable development since it emphasizes on environmental, social and economic activities of companies. Moreover, it is more operational and effective since it emphasizes on six main aspects of sustainable production:

- Using the materials and energy (resources)
- Natural environment
- Development of society and social justice
- Economic performance
- Personnel
- Products.

Therefore, regarding the sustainable production, companies must manage these six aspects and must not transfer the risks between various aspects of sustainable production to other processes (e.g. between environmental protection and personnel health and safety). In addition, 9 specific principles are defined as following:

1. Products and packing should be safe, healthy and have ecologically good conditions in all their life cycles (water using, energy consumption, using raw materials, soil contamination, energy propagation, propagation into the air, discharging into the earth, and issues such as odor and noise).
2. Wastage and by-products incompatible with the environment should be continuously reduced, removed and or recycled.
3. Energy and materials should be conserved and managed while various types of energy and materials which used in production are the most appropriate ones.
4. Chemicals, physical factors, technology and working procedures that endanger the health and environment should be continuously reduced and or removed.
5. Working spaces should be designed so that physical, chemical, biological and economic dangers to be removed and or minimized.

6. Management is committed to cooperative process and continuous improvement evaluation is focused on longtime economic performance of company.
7. Productivity and creativity of personnel should be maintained and increased.
8. Safety, welfare of personnel, development of talents and their capacities and abilities are of importance and priority.
9. Societies and the surrounding environment of working place are respected and considered and improved from economic, social, cultural and physical points of view; further, justice and equality are continuously increasing.

These efforts are followed by numerous companies and organizations such as International Standard Organization, global reporting initiative (GRI), World Business Council for Sustainable Development (WBCSD) and Center for Waste Reduction Technologies (CWRT) in order to develop the sustainability knowledge. However, the main emphasis of most models is on environmental, economic and personnel issues; while development of society, social justice and products are not strongly considered. Using the materials and environmental protection, are appropriately covered in all evaluated frameworks and are supported and emphasized; however, the issues related to the society, personnel and products are less considered in the available index frameworks. In some cases that personnel issues are considered, their health and safety are covered not their welfare and job security; except to GRI which provides a complete list of indices measuring the working place and human rights methods (e.g., management quality, child working force, salary and benefits, non-discrimination and freedom for communications and making unions). Many frameworks are willing to consider economic performance but still using old economic indices (e.g., market contribution, sell, sharing price, profitability) which are not true measuring criteria for sustainability. Hence, there is a clear tendency towards developing standard indices, i.e. applicable indices for each company. GRI, WBCSD and CWRT are proposed common measuring criteria for evaluating the performance of business sustainability (e.g., using water, energy consumption, market contribution, sharing price), most of those are frameworks aiming to consider and control global issues but those are merely environmental (e.g., global warming, ozone layer depletion, oxidation). Chertow (2000) proposes that industrial ecology affects sustainable production in three different levels (Chertow, 2000. p. 313).

Styles et al., 2003. p. 633 argued that industrial coexistence (meddle level, Figure 1 is one of the widely used applications of industrial ecology in the context of sustainable production which its activities are not only including inter-organizational transfers of materials, water, energy and wastage but also human resources, technologies, experiences and sciences (Posch, 2010: 242). In this regard, we can summarize the proposed thoughts about sustainable production and their differences as listed in Table 1.

Table 2 lists some recent researches performed about this topic during last decade.

3. WELL–KNOWN MODELS IN SUSTAINABLE PRODUCTION

By reviewing the researches and measures of scientific and academic centers in the field of sustainable production, some of the most important global models can be represented as listed in Table 3 (Joung et al., 2012. p. 148).

4. METHODOLOGY

In recent years, an interpretational paradigm has been developed to force itself to the process of science production. In the current research, personal structure theory of (Kelly, 1955. p. 61) is applied as a theoretical base of research methodology in the field of interpretational paradigm and specifically, constructivism. In order to explain how similar events can lead to emerging different behaviors in different people, Kelly was focused on investigation about the person and psychological processes in interpretation of each person on its focused world (Ma and Norwich, 2007. p. 213). He believed that the attitude of human to the world is based on possibilities and expectations who imagine in its mind for solving the problems of life. In personal structure theory, it is assumed that each person observes the world from the window of his/her mental structures (Styles et al., 2003. p. 633) and creates his/her method for observing the world through making a personal system consisting of mental structures (Bourne and Jenkins, 2005: 411). So, the foundation of personal structure theory is based on the metaphor of "scientist human" (Niu and Esterbook, 2007. p. 57) and is accepted a human with a dynamic and active role. As a result of this explanation that theorizing is not exclusive for theorists and scientist and any normal person is able to create, not exactly similar to but analogous to a theorist, some theories about the phenomena and events happen in the surrounding and his/her daily experiences (structures), any person can validates these theories based on his/her experiences in real life. Finally, any person can approve or modify these theories, similar to a scientific theory, based on his/her experiences (Wright, 2008. p. 754). Based on this approach, personal structure theory of Kelly, as a metatheory, is a theory about the theories that create by people to give meaning to the surrounding world (Ma and Norwich, 2007. p. 213). In Kelly's viewpoint, therefore, personal theories can be considered in a same level with scientific theories. Hence, by considering this approach and using repertory grid method as an applicable method of personal structure theory in the current paper, personal theories of managers about the sustainable production are investigated (Fard et al., 1394. p. 324).

In addition, principal component analysis is used in order to analyze the results obtained from repertory grid method which in fact, it is based on factor decomposition for reducing data and determining the most important effective variables on creation of phenomena. For reducing the variables, factor analysis can be used as an appropriate method. Applying the method, primary variables are transformed to new, independent components (with zero correlation coefficient for each component). The newly created components are a linear combination of primary variables. Using these techniques, combinations of P primary variables

Table 1: The proposed thoughts about sustainable production and their differences

Thoughts	First level management based on gaining maximum profit (1800-1920)	Second level management based on reliance (1920-early 1960)	Third level managing the quality of life (last 1960-today)
Attitudes	Only personal benefits	Personal benefits Benefits of beneficiaries of organization	Personal benefits Benefits of beneficiaries of organization Benefits of society
Economic values	Whatever is appropriate for me, is appropriate for the society Maximizing the profits My money and health are important Don't let buyer to know somethings Work force is a good which can be sold and bought Managers should only be responded to owners	Whatever is appropriate for me, is appropriate for the society Enough profit Money is important but people also are important Don't cheat on customer Worker has rights which should be considered. Managers should be responded to customers, owners,personnel, presenters and other beneficiaries in the society	Whatever is appropriate for me, is appropriate for the society Profit is necessary People are more important than money Give enough information to customer Personnel are respectful Managers should be responded to owners and the society

Table 2: Researches about sustainable production

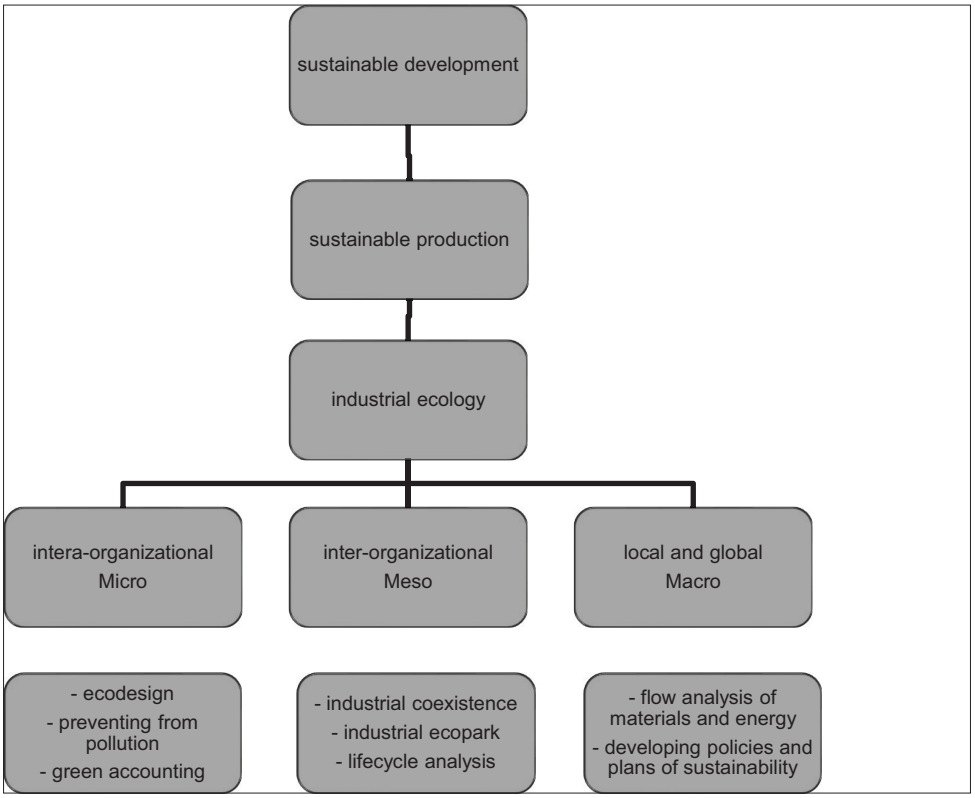
Researcher(s)	Year	Main focus of research
	2001	Sustainable production indices
	2012	Concepts and requirements of sustainable production
	2014	Lifetime approach for sustainable and clean production
	2014	Green and sustainable production
	2015	Theory of beneficiaries and sustainable production
	2015	Developing production strategies with sustainability approach
	2015	Evaluation of sustainable production in cement industry
	2015	Sustainable production indices in designing
Nazari	1387	Sustainability of supply chain
Mohseni	1391	Sustainable supply chain
Kazemi et al.	1392	Green management in dairy industry
Gholamhossein and Shokati	1392	Modelling the natural cycles in industry
Kooshk Baghi	1392	Environmental and safety standards in steel industry
Nekoonam and Choopan Kaveh	1393	Consumerism with sustainable products approach
Sardarabadi et al.	1393	Ecologic trace
Khaled and Arasteh	1393	Quick and green production
Azizi et al.	1393	Human development indices and green gross production

Table 3: Aspects of well–known and validated global models in the field of sustainable production

Model name	Aspects emphasized on the model
University of Massachusetts (Veleva and Ellenbecker, 2001. p. 519)	Products – personnel – development of society – economic performance – environment – energy and materials
Styles et al., 2003. p. 633	Operational performance – industrial development – social welfare – economic grow – environment
GRI model (Styles et al., 2003. p. 633)	Supply chain – effectiveness in the future – products – human resources – performance of society – human rights – environment – economic performance
SEDEX model (www.sedexglobal.com)	Social benefits – business ethics – land usage – health and safety – leadership – human rights – environment – work force
EFQM organizational excellence	Environment – working space – society, market and industry – leadership
Porter supply value	Logistics – market and services – technology suppliers – human resources – organizational leadership
Sustainable indices of ford product (Styles et al., 2003. p. 633)	Social – economic – environmental – health fields
Environmental indices of Yale University (Styles et al., 2003. p. 633)	Ecosystems – air – water – health fields
Dow Jones sustainability indices DJSI (Styles et al., 2003. p. 633)	Social – environmental - economic

(X1, X2, …, XP) are created to make P independent component (equal to the number of primary variables used) (Z1, Z2, …, ZP). Lack of correlation between these components is useful since it means that components show different aspects from primary variables (Manly, 1986). In this method, instead of direct use of primary variables, these are firstly transformed to new components and then, these components are used instead of primary variables. Moreover, as all variables use for creating components, the

Figure 1: Performance indices of industrial ecology



information of primary variables can be delivered by the obtained components with minimum loss. In these methods, each primary component can be shown with the following sequence:

$$Z_i=a_{i1}X_1+a_{i2}X_2+....+a_{ip}X_p \quad (1)$$

In equation (1), Z_i is the considered component, a_{ij} is coefficient related to primary variables and X_i is primary variable. Coefficients related to primary variables can be obtained by solving this equation:

$$|R-\lambda|=0 \quad (2)$$

In equation (2), I is unit matric, R is correlation matric between primary variables and λ is eigenvalue.

One of the methods for selecting appropriate variables for factor analysis is applying correlation matric. Since factor analysis is relied on non-causal correlation of variables, correlation matric between variables should be calculated when using this method. Usually, this type of correlation matric shows the relationship between some variables and lack of its relationship with some others. This model creates clusters in factor analysis so that the variables presented into the cluster are not correlated with each other. It is recommended that variables which have not meaningful correlation with any other variable remove from the analysis. As all primary variables may be used in consisting any component, the interpretation of components would be difficult. Therefore, some methods have been developed for solving this problem and making the interpretation of component easier. These methods are rotation of components and divided into two groups as vertical rotation and inclined rotation. One of vertical rotation methods which have been more interested in scientific investigations is Varimax rotation. This method provides better results than other methods and is recommended as standard rotation. This method is well-known as Principle Factor Analysis (PFA) (Manly, 1986).

For factor derivation, there are different methods which are divided based on the value and type of variance that is justified by the variables of each factor in the model. The most basic method is Principal Component Analysis. In this method, factors justify all variances of each variable. Theoretically, the number of factors should be equal to the number of variables in this method; since all variances of each variable should be explained by all factors. In other words, the number of variables is equal to the number of components in this method but finally, factors which show the higher values of variances are extracted.

4.1. Repertory Grid

Based on personal structure theory, each person has a repertory of mental and personal structures about the surrounding world, generally, and or one of its special aspects, specifically. Through this repertory, the person regulates his/her thoughts and experiences and gives meaning to whatever happened in every time (Senior, 1997. p. 34). Obtaining such mental qualities needs a tool for observing the world from the view of the others to understand their interpretations from phenomena and events in the surrounding world which is the foundation of their expectations and in turn, their attitudes, beliefs and thoughts (Fransella et al., 2004. p. 5). Kelly (1955) was presented repertory grid method based on a specific type of a cooperative based structured interview. The process of interviews and formation of repertory grid is through

three main steps: (1) Selecting the title and elements, (2) extraction of structures (3) connecting the elements of structures (Tan and Hunter, 2002. p. 43) which are briefly described in the following.

First step (selecting the title and elements): Whatever that repertory grid forms around it is named as grid title; it is the thing that researcher aims to understand what other people think about it in their mind. Hence, each grid is always based on a specific title and researcher merely extracts those mental structures that the person used for giving a meaning to its experiences about the title (Fard et al., 1394. p. 326). As the aim of the current research is understanding the sustainable production, repertory grids are formed around the title of sustainable production. Further, there are special elements, examples or real samples in a repertory grid which cover the field of research and represent it (Tan and Hunter, 2002. p. 43). The elements apply in repertory grid can be anything, this is entirely depends on the medium that is under investigation (Fransella et al., 2004. p. 18). Elements can be explained in various forms including things, people, events, activities and even fantasy existences. In the current research, the systematic view to production and developing the approaches of production are defined as the factors for achieving sustainable production which identify various types of sustainable production that are the representing elements of research title: Competitive production, pure production, green production, sustainable production and two elements related to companies as current condition of production in the company and ideal condition of production in the company.

Second step (extraction of structures): Kelly (1955) defined the "structure" as the foundation of giving meaning and he believed that people use personal structures created based on their experiences to understand and interpret the events happened in their surrounding world (Tan and Hunter, 2002. p. 43). In other words, Kelly defined the structure as a model which created by people to give meaning to the surrounding realities (Jankowicz, 2004. p. 134). Description of "structure" is not as simple as element; since structure has characteristics which lead to various definitions of it by Kelly. The most important characteristic of a structure is being dipole (Fransella, 2004. p. 15). Based on this characteristic, Kelly believed that giving meaning to the surrounding world by people is based on similarities and differences. According to his viewpoint, people never authenticate anything without denying something else so that the concept of "good" is meaningful only next to the concept of "bad". In the current research, triad method based on differences, which was the main method of Kelly, is used for extraction of structures. In this method, extraction of structures is performed through selecting a set containing three elements among all available elements in the repertory grid and finding their similarities and differences so that among 6 written elements on three separated forms, three random elements are represented to interviewee and ask him/her to find the similarities of two element which is different in another element and the process is continued until the interviewee reaches to saturation point; it means that the interviewee is no longer able to identify any meaningful similarity or difference between elements and to represent new structure and or his/her structures are reduplicative (Wilson and Tagg, 2010. p. 73). In the current research, 175 personal structures are identified through 33 interviews.

Third step (connecting the elements of structures): After selecting the elements and extracting personal structures, the aim of research which is achieving personal structures of managers about the fundamentals of sustainable production is supplied; but for statistical analysis, it is necessary to connect the elements to structures. In this method, in order to evaluate the elements according to each structure, a value is attributed to each element in Likert scale and both bounds of scale are determined by dipole of structure. A widely used scale, seven marks (Von, 2009. p. 72), is used in the current study (Wilson and Tagg, 2010. p. 73; Ralley et al., 2009. p. 150).

4.2. Statistical Population of the Research

The statistical population of the current research is containing the active and paramount managers who have at least 5 years of continuous production and sign and report their production in BEHINYAB system, Ministry of Industry, Mine and Trade and have one or more best rank(s) in national and local evaluation in their various fields of activities.

4.3. Sampling and the Volume of Samples

In the current research, the proportionality of persons with the title and their effectiveness on the title are selected as the basis for selecting the interviewees not their representativeness of generalization of findings. Hence, the smart sampling method is used to select the managers who have the best situation for achieving information (Fard et al., 1387. p. 327). Therefore, the main under investigation group are determined as board of directors, CEOs, representatives of management and managers of factories. The nature of repertory grid method is so that usually a low amount of samples are proposed for investigations; frequently a sample containing 15-20 people can reach to enough structures (Tan and Hunter, 2002. p. 39). In order to determine the volume of samples for repertory grid, saturation point also is represented; i.e. after extraction of structures from a determined number of participants, no new structure would not add to the list of extracted structures from interviewing with other persons and it means that the volume of sample is reached to saturation point (Van de Kerkhof et al., 2009. p. 427). In the current research, based on saturation point, 33 managers from 33 companies are interviewed and this is the base of categorization and interpretation of structures.

5. RESEARCH FINDINGS

Regarding 175 primary structures, since the nature of some structures was similar, content analysis was used to collect and combine similar structures. It should be noted that for reducing possible bias, structures are evaluated by two experts of organizational sustainability, in addition to researcher, and finally, the final content analysis was reviewed by two academic professors based on similarities and correspondence in a posteriori process around the general structure (secondary structure) and according to compatibility value, those are categorized in 87 secondary structures and combined repertory grid is formed as a matric consisting of 87 secondary structure, 6 elements and ratings which are resultant of 33 individual grids of managers (Table 4).

Table 4: Combined repertory grid

Elements of repertory grid of interviewee							
Newly found pole of structure (appropriate)	**Situation of production structure in the company**	**Position of structure in establishing competitive production (technical and economic approach)**	**Position of structure on establishing pure production (legal and systematic approach)**	**Position of structure on establishing green production (environmental approach)**	**Position of structure on establishing sustainable production (human and philanthropically approach)**	**Importance of structure in sustainable and ideal production in the company**	**Figurative pole of structure (inappropriate)**
Following national and international laws	2	4	4	3	1	1	Law aversion
Management of operation	3	3	2	3	2	2	Traditional management
Establishing management systems	2	5	3	2	1	2	Without system
Commitment to values and ethics	2	5	5	3	2	2	Nonprofessional in ethics
Risk management	2	4	4	3	1	2	Non venture
Membership in institutes and organizations	2	4	4	2	1	2	Industrial withdrawal
Gaining authentications and cheers	3	5	5	4	3	3	Lack of presenting in official assessments
Forward thinking	2	4	4	2	1	1	Current thinking
Passive defense and crisis management	3	5	4	3	2	2	Performing at the crisis
Project management	3	5	4	3	2	3	Without structure in the project
Anti-corruption system	2	4	4	3	2	2	Without anti-corruption system
Correct and managed water usage	3	5	4	2	1	2	Without plan in buying and using water
Correct and managed raw material usage	3	5	4	2	1	2	Without plan in buying and using raw material
Measuring and managing the efficiency of facilities	3	5	4	2	2	2	Lack of measuring the efficiency of facilities
Moving towards correct use of clean energies	4	5	4	2	2	2	Without plan in the field of energy
Planning for correct use of land	2	4	2	2	1	2	Without plan for use of land
Resource recovery	4	5	4	2	1	1	Wastage of resources
Measuring and monitoring biological efficiency	4	5	5	1	1	2	Lack of measuring and monitoring biological efficiency
Measuring and monitoring gas distribution	3	4	3	1	1	1	Lack of measuring and monitoring produced gases in the process

(Contd...)

Table 4: ***(Continued)***

Elements of repertory grid of interviewee							
Newly found pole of structure (appropriate)	**Situation of production structure in the company**	**Position of structure in establishing competitive production (technical and economic approach)**	**Position of structure on establishing pure production (legal and systematic approach)**	**Position of structure on establishing green production (environmental approach)**	**Position of structure on establishing sustainable production (human and philanthropically approach)**	**Importance of structure in sustainable and ideal production in the company**	**Figurative pole of structure (inappropriate)**
Measuring and monitoring efficiency of production	3	5	4	2	1	2	Lack of measuring and monitoring efficiency of production
Management of water pollution reduction	3	5	4	2	1	2	Without plan for protecting water from pollutants
Measuring and monitoring air pollution	3	5	5	2	2	2	Lack of measuring and monitoring air pollution
Measuring and monitoring soil pollution	3	4	3	2	2	2	Lack of measuring and monitoring soil pollution
Effects of production on animal/plants life	4	6	5	2	2	2	Threats of production on animals and plants
Management, separation and reduction of contaminant	2	5	4	2	2	3	Lack of management, separation and reduction of contaminant
Reduction of disturbances resulted from production	2	5	5	3	2	2	Making disturbances from productive activities
Management of personnel health (physical and mental)	2	5	4	3	1	1	Without structure in health issues
Non-compulsory at work	1	5	4	4	1	1	Compulsory at work
Structure of teamwork and cooperation	2	5	3	4	1	2	Individualism and self-decision making
Management and enthusiasm for personnel safety	2	5	4	4	1	1	Without structure in safety issues
Structure of workers union	2	7	6	5	1	1	Lack of freedom for workers union
Lack of discrimination	3	5	5	5	3	3	Presence of discrimination
Clear way for job progress	2	5	4	5	2	2	Without plans for job progress
Applying expert human resources	2	5	4	4	1	2	Employment without structure
Satisfaction of personnel	3	5	4	4	1	2	Unsatisfied personnel
Appropriate salary and benefits	2	5	5	4	2	2	Inappropriate salary and benefits

(Contd...)

Table 4: ***(Continued)***

Elements of repertory grid of interviewee							
Newly found pole of structure (appropriate)	**Situation of production structure in the company**	**Position of structure in establishing competitive production (technical and economic approach)**	**Position of structure on establishing pure production (legal and systematic approach)**	**Position of structure on establishing green production (environmental approach)**	**Position of structure on establishing sustainable production (human and philanthropically approach)**	**Importance of structure in sustainable and ideal production in the company**	**Figurative pole of structure (inappropriate)**
Importance of education of personnel	2	4	4	3	1	2	Lack of importance of education for personnel
Solving residence problems of personnel	3	6	5	5	3	3	Without plan for solving residence problem of personnel
Personnel welfare	2	5	4	4	2	2	Commitment to at least work law requirements
Reducing harmful factors in production space	2	5	4	3	1	2	Lack of identification and management of harmful factors
Educating supply chain	3	5	4	4	2	2	Lack of educating supply chain
Establishing and committing principles, laws and ethics for trade	2	5	5	4	2	2	Without structure in the field of suppliers
Developing national suppliers	3	5	5	5	2	3	Supplying from the foreign countries
Variety of suppliers	2	4	4	3	2	2	Exclusive suppliers
Assessment of suppliers	3	5	4	4	2	2	Lack of assessment of suppliers
High and low investment in supply chain	2	4	3	4	1	1	Without plan in developing ownership in supply chain
Outsourcing	3	6	4	5	2	2	Without structure in outsourcing process
Transportation of materials and products	2	4	3	4	2	2	Focused on production
Planning organizational resources ERP	2	4	2	3	1	1	Traditional structure of material supplying
Quality and satisfaction on product	2	4	3	4	1	1	Product without quality
Delivery and packing product	2	4	4	4	1	2	Without structure in delivering and packing
Safe use of product	2	4	4	4	1	1	Unsafe use of product
Marketing	2	4	4	4	2	2	Traditional marketing
Separability of product components	2	5	5	3	1	2	One part structure of product
National and international standards for product	2	5	5	4	1	2	Without standard for product
Labeling and notices	2	4	4	4	1	2	Without noticing to customer

(Contd...)

Table 4: ***(Continued)***

Elements of repertory grid of interviewee							
Newly found pole of structure (appropriate)	**Situation of production structure in the company**	**Position of structure in establishing competitive production (technical and economic approach)**	**Position of structure on establishing pure production (legal and systematic approach)**	**Position of structure on establishing green production (environmental approach)**	**Position of structure on establishing sustainable production (human and philanthropically approach)**	**Importance of structure in sustainable and ideal production in the company**	**Figurative pole of structure (inappropriate)**
Sustainable design	2	4	3	3	1	1	Without structure in design
Lifecycle analysis	3	3	4	2	1	1	Focused on selling time
Innovation on product	3	3	4	3	1	1	Without innovation on product
Aesthetics of product	2	5	4	4	1	1	Stability in design of product
Variety and custom made production	2	5	5	4	1	2	Identical and repetitive production
Favorite financial performance	2	4	3	3	1	1	Irregular financial system
Management of costs	2	4	4	4	1	2	Without structure in budgeting
Productivity and sustainable profitability	2	4	4	4	1	1	Short term profitability
Intangible investing and brand management	2	4	3	3	1	1	Lack of investing on hidden assets
Applying high tech in production	3	4	3	3	1	2	Applying old tech in production
Knowledge management	2	5	4	4	1	2	Without structure in knowledge management
Quality engineering	2	4	3	4	1	1	Supervising and troubleshooting
Research and development	3	4	3	4	1	2	Without structure in research and development
Applying information technology and communication	3	4	3	3	1	1	Lack of applying information technology and communication
Common cooperation with large companies	2	5	4	3	2	2	Focused on itself
Social welfare	3	5	5	4	2	2	Lack of cooperation in social welfare
Welfare of customers	2	2	3	4	1	1	Lack of cooperation in welfare of customers
Regular tax payment	1	5	5	5	1	1	Tax fraud
Social investment	3	5	5	4	2	3	Without regarding social investment
Industrial legacy and returning materials to the nature	3	6	5	3	2	2	Without structure in deficit environment

(Contd...)

Table 4: ***(Continued)***

Elements of repertory grid of interviewee							
Newly found pole of structure (appropriate)	**Situation of production structure in the company**	**Position of structure in establishing competitive production (technical and economic approach)**	**Position of structure on establishing pure production (legal and systematic approach)**	**Position of structure on establishing green production (environmental approach)**	**Position of structure on establishing sustainable production (human and philanthropically approach)**	**Importance of structure in sustainable and ideal production in the company**	**Figurative pole of structure (inappropriate)**
Localization of technology	3	5	4	4	2	2	Technology consumer
Management and reducing the accidents leading to injury or death	3	5	4	5	1	1	Without structure in reducing injury or death
Exports	3	4	4	4	1	2	Lack of exports
Science production	4	5	5	4	3	3	Science consumption
Cultural effectiveness on the environment	3	6	6	4	3	3	Without cultural structure
Formulating and calculating green tax	3	5	4	2	1	2	Regardless to economic losses of environmental concerns
6R measures	3	5	5	3	2	2	Without approach on wastage chain
Green accounting	4	5	5	2	1	2	Without structure in green accounting
Buying sewage and wastage	4	6	5	3	2	2	Buying final product
Selling sewage and wastage	3	5	5	3	1	1	Wasting sewage and wastage
Benefits and satisfaction of stakeholders	2	4	4	3	2	2	Lack of satisfaction in stakeholders

1: very high importance – 7: non-significant

6. ANALYSIS OF PRINCIPAL COMPONENTS OF COMBINED REPERTORY GRID

In order to analyze the principal components, descriptive characteristics of investigated variables on combined repertory grid are firstly studied and then, in order to determine the principal components using PCA method, statistical software SPSS 22 is used. The applied information in this section is including a qualitative variable named as the element (6 elements) and 87 quantitative variables named as the structures. The symmetrical correlation matric of structures and subscription of each variable (structure) are calculated as shown in Tables 5 and 6.

Table 7 summarizes general characteristics of factors (components) before and after rotation including eigenvalues, variance percentage corresponding to each factor and accumulative variance percentage of each factor.

In the first set (eigenvalues), the first and second components are explained 87.3 and 8.1%, respectively, and totally 95.4% of variance between structures and have eigenvalue more than 5. Information of two first components before rotation and after rotation are listed in the second and third parts of Table 7, respectively. It should be noted that eigenvalues are closer to each other than non-rotated values and it shows that the variances of factors after rotation are more close to each other. However, both sets totally measure 95.4% of variance and total variance of both factors is not changed.

Tables 8 and 9 are listed the component (factor) matric based on two determined factors.

After rotation, two factors of final component matric (Table 9) can be obtained. These rotated factors can be conceptually interpreted. Against non-rotated component matric, this analysis leads to distribution of highest load among 2 components.

Hence, the first component which is responsible for about 90% effectiveness on elements with total variance of 87.32% is including poles that are listed in first three columns of Table 9 (summarized in Table 10) while the second factor is including poles that are listed in two last columns of Table 9 (summarized in Table 11).

Table 5: Correlation matric of structures

Structures	Structure 1	Structure 2	Structure 3	Structure 85	Structure 86	Structure 87
Structure 1	1.000	0.780	0.924	0.937	0.969	0.984
Structure 2	0.780	1.000	0.744	0.766	0.755	0.679
Structure 3	0.924	0.744	1.000	0.942	0.955	0.913
Structure 85	0.937	0.766	0.942	1.000	0.992	0.930
Structure 86	0.969	0.755	0.955	0.992	1.000	0.969
Structure 87	0.984	0.679	0.913	0.930	0.969	1.000

Table 6: Subscriptions of each variable (structure)

Variable	Participation	Variable	Participation	Variable	Participation	Variable	Participation
Structure 1	0.987	Structure 23	0.892	Structure 45	0.965	Structure 67	0.999
Structure 2	0.659	Structure 24	0.951	Structure 46	0.940	Structure 68	0.924
Structure 3	0.950	Structure 25	0.883	Structure 47	0.956	Structure 69	0.951
Structure 4	0.910	Structure 26	0.899	Structure 48	0.975	Structure 70	0.807
Structure 5	0.997	Structure 27	0.989	Structure 49	0.857	Structure 71	0.954
Structure 6	0.963	Structure 28	0.978	Structure 50	0.977	Structure 72	0.982
Structure 7	0.930	Structure 29	0.884	Structure 51	0.977	Structure 73	0.916
Structure 8	0.972	Structure 30	0.978	Structure 52	0.998	Structure 74	0.957
Structure 9	0.996	Structure 31	0.985	Structure 53	0.929	Structure 75	0.976
Structure 10	0.947	Structure 32	0.978	Structure 54	0.930	Structure 76	0.952
Structure 11	0.973	Structure 33	0.983	Structure 55	0.974	Structure 77	0.993
Structure 12	0.992	Structure 34	0.990	Structure 56	0.970	Structure 78	0.979
Structure 13	0.982	Structure 35	0.993	Structure 57	0.998	Structure 79	0.921
Structure 14	0.989	Structure 36	0.987	Structure 58	0.821	Structure 80	0.989
Structure 15	0.967	Structure 37	0.997	Structure 59	0.829	Structure 81	0.941
Structure 16	0.838	Structure 38	0.936	Structure 60	0.994	Structure 82	0.965
Structure 17	0.979	Structure 39	0.997	Structure 61	0.994	Structure 83	0.962
Structure 18	0.961	Structure 40	0.995	Structure 62	0.937	Structure 84	0.968
Structure 19	0.993	Structure 41	0.946	Structure 63	0.955	Structure 85	0.989
Structure 20	0.987	Structure 42	0.942	Structure 64	0.989	Structure 86	0.988
Structure 21	1.000	Structure 43	0.982	Structure 65	0.971	Structure 87	0.949
Structure 22	0.910	Structure 44	0.995	Structure 66	0.931		

Table 7: Descriptive statistics of produced principal components

Component	Primary eigenvalues			Eigenvalues of extracted factors before rotation			Eigenvalues of extracted factors after rotation		
	Eigenvalue	Variance (%)	Accumulative variance (%)	Eigenvalue	Variance (%)	Accumulative variance (%)	Eigenvalue	Variance (%)	Accumulative variance (%)
1	75.965	87.32	87.32	75.965	87.32	87.32	51.147	58.79	58.79
2	7.006	8.05	95.37	7.006	8.05	95.37	31.823	36.58	95.37
3	2.206	2.54	97.90						
4	1.533	1,76	99.67						

If variables and components indicate as Xi and Ci, respectively, the relationship between variables and components can be written as the following using Table 9:

X73=0.955*C1−0.062*C2
X43=0.950*C1+0.281*C2
X32=0.942*C1+0.301*C2
……
X7=0.680*C1+0.684*C2
X16+0.618*C1+0.675*C2

As can be seen in Table 7, two components are responsible for more than 95% of total variance. If we pay attention to effective structures listed in Tables 9-11, it can be said that two factors are clear in the subject of research:

First factor: Economic, human and social issues

Second factor: Environmental issues and industrial ecology.

7. DISCUSSION AND CONCLUSIONS

Change is the secret of surviving and many people and hence, many societies, institutes and organizations are always tried to change themselves and to reconcile their conditions with the surrounding world. The conditions that may have not been affect by them. Reviewing the history of companies with high old year shows this fact that they are continually try to survive and to more reconcile with their surrounding world and it seems that the sustainability and persistence is related to applying gradual, arbitrary changes to reconcile with mandatory changes. However, regarding the fast changes in technology and working processes in the current competitive world, it seems that sustainable production processes and even in higher level, sustainable businesses are really necessary. Hence, the aspects of sustainable production were determined in the current paper. Moreover, comparing the results of the current research with previous results, the identified structures were more widely than

Table 8: Component (factor) matric

Variable	Component loads before rotation		Variable	Component loads before rotation		Variable	Component loads before rotation		Variable	Component loads before rotation	
	1	2		1	2		1	2		1	2
Structure 5	0.999	0.017	Pole 64	0.974	–0.197	Pole 47	0.952	–0.233	Pole 21	0.915	0.403
Structure 57	0.997	0.058	Pole 87	0.974	–0.024	Pole 83	0.952	0.238	Pole 49	0.907	–0.185
Structure 37	0.997	–0.047	Pole 48	0.973	–0.169	Pole 54	0.950	0.165	Pole 53	0.901	–0.342
Pole 40	0.997	0.029	Pole 72	0.973	–0.191	Pole 85	0.949	0.298	Pole 16	0.899	0.169
Pole 35	0.996	–0.046	Pole 6	0.972	0.136	Pole 42	0.949	–0.204	Pole 59	0.899	–0.144
Pole 80	0.995	–0.009	Pole 41	0.972	–0.041	Pole 63	0.947	–0.240	Pole 70	0.898	–0.004
Pole 27	0.995	–0.007	Pole 36	0.972	–0.208	Pole 62	0.947	–0.202	Pole 22	0.894	0.334
Pole 44	0.995	–0.078	Pole 69	0.970	–0.105	Pole 28	0.946	–0.287	Pole 14	0.892	0.439
Pole 9	0.994	0.090	Pole 81	0.969	–0.053	Pole 46	0.946	–0.213	Pole 25	0.868	0.359
Pole 1	0.993	–0.045	Pole 78	0.968	–0.208	Pole 51	0.944	–0.292	Pole 12	0.855	0.510
Pole 60	0.987	–0.139	Pole 61	0.967	–0.240	Pole 79	0.944	–0.175	Pole 17	0.827	0.544
Pole 11	0.986	0.026	Pole 76	0.965	0.142	Pole 68	0.942	–0.191	Pole 2	0.812	0
Pole 39	0.986	–0.156	Pole 45	0.965	–0.183	Pole 55	0.941	–0.296	Pole 24	0.809	0.544
Pole 67	0.985	–0.170	Pole 10	0.965	0.125	Pole 38	0.941	–0.226	Pole 58	0.798	0.430
Pole 30	0.983	–0.107	Pole 50	0.965	–0.216	Pole 20	0.935	0.334	Pole 19	0.792	0.605
Pole 34	0.982	–0.162	Pole 77	0.963	–0.255	Pole 74	0.935	–0.286	Pole 82	0.786	0.589
Pole 8	0.978	0.122	Pole 56	0.963	–0.209	Pole 32	0.934	–0.324	Pole 84	0.777	0.604
Pole 65	0.978	–0.122	Pole 66	0.960	–0.099	Pole 4	0.934	0.194	Structure 18	0.753	0.628
Pole 31	0.977	–0.176	Pole 3	0.956	0.191	Pole 26	0.933	0.168	Structure 15	0.740	0.648
Pole 86	0.976	0.188	Pole 75	0.955	–0.252	Pole 43	0.929	–0.345	Structure 73	0.727	–0.623
Pole 71	0.975	–0.056	Pole 7	0.954	0.140	Pole 29	0.918	–0.205	Structure 23	0.666	0.669
Pole 52	0.975	–0.218	Pole 33	0.952	–0.278	Pole 13	0.916	0.377			

Table 9: Final component matric

Variable	Component loads after rotation		Variable	Component loads after rotation		Variable	Component loads after rotation		Variable	Component loads after rotation	
	1	2		1	2		1	2		1	2
Structure 73	0.955	–0.062	Pole 38	0.888	0.383	Pole 71	0.814	0.540	Pole 23	0.132	0.935
Pole 43	0.950	0.281	Pole 31	0.887	0.445	Pole 81	0.807	0.539	Pole 17	0.335	0.931
Pole 32	0.942	0.301	Pole 46	0.885	0.397	Pole 59	0.805	0.424	Pole 12	0.378	0.921
Pole 55	0.931	0.328	Pole 34	0.883	0.459	Pole 41	0.802	0.550	Pole 24	0.320	0.921
Pole 51	0.931	0.333	Pole 39	0.883	0.467	Pole 80	0.801	0.589	Pole 14	0.450	0.887
Pole 28	0.929	0.338	Pole 45	0.882	0.432	Pole 27	0.800	0.591	Pole 21	0.491	0.871
Pole 33	0.928	0.349	Pole 42	0.882	0.406	Pole 87	0.793	0.565	Pole 13	0.507	0.851
Pole 53	0.926	0.267	Pole 48	0.880	0.449	Pole 5	0.789	0.613	Pole 20	0.548	0.829
Pole 77	0.924	0.374	Pole 62	0.879	0.406	Pole 40	0.780	0.622	Pole 58	0.380	0.822
Pole 74	0.920	0.332	Pole 60	0.873	0.481	Pole 11	0.773	0.613	Pole 25	0.479	0.808
Pole 61	0.918	0.388	Pole 68	0.868	0.413	Pole 57	0.763	0.645	Pole 85	0.580	0.808
Pole 75	0.915	0.371	Pole 79	0.860	0.426	Pole 9	0.741	0.668	Pole 22	0.514	0.803
Pole 52	0.910	0.411	Pole 29	0.857	0.386	Pole 70	0.721	0.536	Pole 83	0.619	0.761
Pole 36	0.902	0.416	Pole 65	0.855	0.489	Pole 8	0.710	0.684	Pole 86	0.668	0.736
Pole 63	0.902	0.376	Pole 30	0.851	0.505	Pole 10	0.697	0.679	Pole 3	0.650	0.726
Pole 50	0.901	0.406	Pole 44	0.842	0.535	Pole 6	0.696	0.692	Pole 4	0.631	0.715
Pole 78	0.899	0.414	Pole 69	0.839	0.498	Pole 2	0.650	0.487	Pole 54	0.661	0.702
Pole 64	0.898	0.427	Pole 49	0.837	0.396	Pole 15	0.204	0.692	Pole 26	0.646	0.694
Pole 56	0.896	0.410	Pole 66	0.827	0.496	Pole 19	0.270	0.959	Pole 76	0.687	0.693
Pole 47	0.895	0.392	Pole 37	0.826	0.561	Pole 18	0.226	0.954	Pole 7	0.680	0.684
Pole 72	0.893	0.431	Pole 35	0.824	0.560	Pole 84	0.259	0.949	Structure 16	0.618	0.675
Pole 67	0.890	0.455	Pole 1	0.821	0.560	Pole 82	0.276	0.943			

previous ones while the related structures with development and industrial progress, industrial ecology and industrial coexistence, supply chain, organizational leadership, industrial legacy and products are determined as important and vital basics for achieving sustainable production. Review on the theoretical literature shows that the obtained results in this research is in accordance with the theories related to sustainable production and the importance of these aspects have been reflected in most of theories and researches which indicates external compatibility in addition to internal integrity and comprehensiveness of structures. In addition to good accordance of model aspects with previous researches, the results of the current research have a good accordance with many sustainability reports such as the results of Siemens Vision, 2020 in the field of structures related to personnel, with the results of Nambiar in University of

Table 10: Rotated matric of first factor

Structure No.	Structure Title	First Comp.	Structure No.	Structure title	First Comp.
Structure 73	Social welfare of customers		Pole 60	Aesthetics	
Pole 43	Developing national suppliers		Pole 68	Quality engineering	
Pole 32	Lack of discrimination		Pole 79	Exports	
Pole 55	National and international standards		Pole 29	Structure for team work	
Pole 51	Delivery and packing		Pole 65	Intangible investing and brand management	
Pole 28	Non-compulsory work		Pole 30	Management of workers safety	
Pole 33	Route of job progress		Pole 44	Variety of suppliers	
Pole 53	Marketing		Pole 69	Research and development	
Pole 77	Localization of technology		Pole 49	Planning for organizational resources	
Pole 74	Regular tax payment		Pole 66	Applying high tech in production	
Pole 61	Variety and custom made production		Pole 37	Importance of education for personnel	
Pole 75	Social investment		Pole 35	Satisfaction of personnel	
Pole 52	Safe use of product		Pole 1	Following national and international laws	
Pole 36	Appropriate salary and benefits		Pole 71	Cooperating with large companies	
Pole 63	Cost management		Pole 81	Cultural effectiveness on the environment	
Pole 50	Quality and satisfaction on product		Pole 59	Innovation on product	
Pole 78	Management and reducing injury and death		Pole 41	Education supply chain	
Pole 64	Productivity and sustainable profitability		Pole 80	Science production	
Pole 56	Labeling and notices		Pole 27	Management of physical and mental health	
Pole 47	Outsourcing		Pole 87	Benefits and satisfaction of stakeholders	
Pole 72	Social welfare		Pole 5	Risk management	
Pole 67	Knowledge management		Pole 40	Reducing harmful factors in production space	
Pole 38	Solving residence problems of personnel		Pole 11	Anti-corruption system	
Pole 31	Presence of structure for workers union		Pole 57	Sustainable design	
Pole 46	High and low investment on supply chain		Pole 9	Passive defense and crisis management	
Pole 34	Applying appropriate human resources		Pole 70	Applying information technology and communication	
Pole 39	Personnel welfare and commitment to minimum laws		Pole 8	Futurism	
Pole 45	Assessment of suppliers		Pole 10	Project management	
Pole 42	Establishing and committing principles, laws and ethics for trade		Pole 6	Membership in technical institutes and organizations	
Pole 48	Transportation of materials and products		Pole 2	Management of operation	
Pole 62	Favorite financial performance				

Table 11: Rotated matric of second factor

Structure No.	Structure title	First Comp.
Pole 15	Moving towards clean energies	
Pole 19	Measuring and monitoring gas distribution	
Pole 18	Measuring and monitoring biological efficiency	
Pole 84	Green accounting	
Pole 82	Formulating and calculating green tax	
Pole 23	Measuring and monitoring soil pollution	
Pole 17	Resource recovery	
Pole 12	Correct and managed use of water	
Pole 24	Effects of production on animal/plants life	
Pole 14	Measuring and monitoring the efficiency of facilities	
Pole 21	Management of reducing water pollution	
Pole 13	Correct and managed use of raw materials	
Pole 20	Measuring and monitoring the efficiency of production	
Pole 58	Lifecycle analysis	
Pole 25	Management, separation and reduction of wastage	
Pole 85	Buying sewage and wastage	
Pole 22	Measuring and monitoring air pollution	
Pole 83	R6 measures	
Pole 86	Selling sewage and wastage	
Pole 3	Establishing management systems	
Pole 4	Commitment to values and ethics	
Pole 54	Separability of product components	
Pole 26	Reducing disturbances resulted from production	
Pole 76	Industrial legacy and returning the materials to the nature	
Pole 7	Gaining authentications and cheers	
Structure 16	Planning for correct use of land	

California in the field of structures related to the product and supply chain issues (Nambiar, 2010. p. 3), with the research of Feng and Joung in the field of product and organizational leadership (Feng and Joung, 2009. p. 2), with the researches of Loures in the field of structures related to affect the future and industrial legacy (Loures, 2008. p. 687), with the research of Chiarini in the field of structures related to industrial development (Chiarini, 2014. p. 226), with the research of Erkman in the field of industrial ecology and industrial legacy (Erkman, 1997. p. 2), with the research of Chatterjee in the field of products, environment and resource usage (Chatterjee et al., 2012. p. 261), with the research of Bhattacharya et al. in the field of environment, resource usage and some primary structures of products and industrial ecology (Bhattacharya et al., 2011. p. 7), and with the researches of Hamner (1996) in the field of structures related to the environment and ecology which used the relationships between the key environmental concepts entitled as "stairs". Further, the results obtained from principal component analysis indicates the importance of environmental issues along with economic, human and social issues in achieving sustainable production. In this analysis, the first factor including economic, human and social structures is determined as the first set of operational plans in establishing sustainable production and the second factor including environmental and ecological structures is determined as the second set of operational plans in establishing sustainable production which is in good agreement with previous researches as well as validated models in the field of sustainable production (Joung et al., 2012. p. 148) in which, environmental concerns are of great important.

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