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Designing a Sustainable Supply Chain Model to Achieve World Class Based on Critical Conditions Information Systems with a Fuzzy Hybrid Approach

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ABSTRACT

The research aims to design a sustainable supply chain model to achieve world class with a fuzzy hybrid approach based on critical situation information systems. This research is developmental-applicative in terms of its purpose, and the method used is a combined method that includes historical method (gathering information) and survey method (questionnaire distribution). The statistical population of this research consists of experts in the handwoven carpet industry and professors in the field of world-class production. The sampling method is purposive and model fitting was done with Dematel techniques and interpretive structural model. Based on the literature, 15 indicators were identified, which are: lean production (elimination of redundant activities), cost of materials and transportation, reduction of time to reach the market and waiting, technology and machinery and software Design tools, supply chain agility, applying honest principles in hiring local people, increasing consumer awareness to consume sustainable products, focusing on social/community welfare, insurance and pension guarantee, creating strong legal facilities to take care of industries in times of Corona, compatible production processes With environment and green distribution, ISO 14001, reverse logistics and recycling, green packaging and distribution and creating sustainable procurement strategies. The results show that based on the designed interpretative structural model, the low-level components of applying honest principles in hiring local people, focusing on the social/personal welfare of employees and issuing, creating strong legal facilities in times of Corona and environmentally friendly production processes and Green distribution has the most influence on the whole model. **©authors**

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1. Introduction

In recent decades, supply chain management has emerged as one of the most critical elements in the performance of organizations (Seddigh et al., 2023). With the expansion of business activities globally and the increasing complexity of supply chain networks, the need to create a sustainable supply chain model using critical information systems has been increasing (Voigt et al., 2023). Today, sustainable supply is emerging as a fundamental goal for organizations in the modern world. Maintaining a balance between economic, social, and environmental factors in the supply chain has become very important and is known as one of the components of world-class (Bagheri et al., 2023). This importance increases especially when faced with the evolution of supply chain networks and the communication between their different levels increases (Rafigh et al., 2022; Hettiarachchi et al., 2022). Information systems are introduced as key tools in the development and improvement of the supply chain. These systems provide the ability to collect, analyze data and information related to the supply chain, which allows managers to make better decisions about managing and optimizing processes (Tseng et al., 2018; Yousefi et al., 2022). In critical situations, the importance of supply chain management becomes clear. Critical situation information systems help organizations to choose the best strategies to manage vulnerabilities and risks by improving the ability to make decisions and predict in unexpected situations (Kot, 2018; Venegas and Ventura, 2018). According to researchers, sustainable supply chain practices in terms of government regulations, customer expectations, and buyer pressures for sustainable products have been global concerns (Golan et al., 2020; Marcus et al., 2017; Vieira et al., 2020). In world-class production, knowledge and information play a vital role.

These two fundamental elements are continuously developed and improved, playing a crucial role in determining the position and establishment of a country or company at the forefront globally (Saeed and Kersten, 2019; Moktadir et al., 2018; Tirkolaee et al., 2021). The environmental and green aspects of sustainability emphasize ensuring the preservation of the environment, reducing the use of natural resources, developing environmentally friendly products, and decreasing the emission of harmful gases and liquids (Quaid Aminiharuni et al., 2023). Sustainable supply chain management involves creating a coordinated supply chain by voluntarily integrating economic, social, and environmental assessments with key internal information systems to effectively and efficiently manage materials, information, and cash flow associated with the procurement, production, and distribution of products or services. This is done to meet the requests of shareholders and enhance the profitability, competitiveness, and flexibility of the organization in the short and long term (Wang & Dai, 2018; Stodder, 2015). The role of knowledge and information in world-class production is paramount. In today's rapidly changing global economy, metropolises are central to this process as the primary hubs of production and services. Knowledge and information serve as essential tools in technology development, process improvement, and economic productivity enhancement. Businesses and industries achieve world-class production through strategic planning based on knowledge and information (Yadav et al., 2022; Vishwakarma et al., 2022).

In world-class production, information plays a crucial role as a strategic resource in decision-making processes and from an economic perspective. Businesses can identify opportunities and challenges through detailed analysis of market information, competitors, and customer needs. This knowledge enables them to respond with innovative and flexible

strategies to market fluctuations and to navigate global competition (Raut et al., 2017; Shaharudin et al., 2023). Moreover, world-class production necessitates the utilization of current knowledge and new technology. Key components of this process include investing in research and development, providing training and upskilling for employees, and establishing technological infrastructure. Therefore, having access to current information and new knowledge is pivotal, enabling businesses to progress towards world-class production through transformation and continuous improvement (Xiao, 2019; Sharma et al., 2022). According to the International Labor Organization, the pandemic has resulted in a 2.7% reduction in working hours for over 125 million full-time workers in the Asia-Pacific region alone (International Labor Organization (ILO), 2020). Consequently, it has had significant adverse effects on financial aspects, time management, customer relations, and production performance, necessitating the recovery and revitalization of supply chains. Challenges such as the SARS outbreak in 2003 have highlighted the importance of considering supply chain resilience and continuity (Haren and Simchi, 2020; Yook et al., 2018). The current study has proposed fuzzy hybrid solutions for designing a sustainable supply chain model to achieve world-class status. This approach enhances the ability to address uncertainty and complexity in supply chain management decisions, effectively tackling economic and environmental challenges in today's business landscape. Therefore, the study aims to answer the question: What is the sustainable supply chain model for achieving world-class status based on critical situation information systems using a fuzzy hybrid approach?

2. Literature Review

Sustainable supply chain

In the last 20 years, most of the research in the field of sustainable supply chain has focused on its green aspect (Ahi & Searcy, 2015). The environment has been one of the key elements of the triple policy of sustainability and a mediator for issues such as climate change and energy price increase (Qassemi, 2014). From the point of view of researchers and research that has been done in recent years, the sustainable supply chain covers two basic dimensions, which include 1- environmental aspects that refer to the impact of supply chain activities on the natural environment and issues related to energy consumption, waste minimization , it covers resource conservation and pollution reduction. 2- Social or human aspect which mainly focuses on physical, financial and mental. Koberg & Longoni (2019), among their studies; Sustainable supply chain considers material, information and capital flows as well as cooperation between companies in the supply chain with a focus on the three dimensions of sustainable development (environmental, social and economic) derived from customers and stakeholders. Sustainable supply chain management helps to link development and environmental issues and create political and economic changes at the national, local and global levels (Oelze et al, 2018). World class production In explaining the concept of world-class production as an economic term, it should be recognized using the literature of international economic knowledge, which has been defined by many different people (de Sousa Jabbour et al., 2020). Schoenberger is the first person who introduced the concept of world-class production to everyone (Dubey et al, 2015). According to him, the production in Clais Global is "a broad agreement on the continuous improvement of quality, cost, waiting time and customer service". According to this researcher, flexibility is also listed as the primary goal, a part of the world-class production system (Schonberger & Manufacturing, 1986). Rubrich considers world-class production to include the application of a number of productivity concepts and believes that the concepts of just-in-time production, Total quality management and employee involvement

must be properly combined in world-class manufacturing. By accepting the six characteristics of quality, price, customer service, delivery speed, flexibility and responsiveness as important indicators in the definitions of experts in this field, and then explaining them with the literature of international economic knowledge, it is possible to distinguish which elements of global indicators each one is based on. It emphasizes (Farsijani, 2013). Information system in world-class production Information system plays a vital and very important role in world class production. These systems are a collection of processes, equipment, software, and people that, through improved collaboration, enable the collection, storage, analysis, and communication of information. In a world-class manufacturing environment, these systems help businesses make the most of their information resources. At the level of analysis and decision-making, information systems enable businesses to respond more accurately to the needs and preferences of customers by analyzing market, customer, and competitor data and information. This information facilitates better decision making and business strategies. Also, these systems enable active communication between different business units. In addition, information systems play a role in facilitating operational processes. Among their duties are supply chain management, inventory management, and optimization of production and service processes. These systems use new technologies such as the Internet of Things (IoT) and artificial intelligence (AI) to improve the productivity and efficiency of businesses in world-class production. In general, information systems play a vital role in facilitating the information needed to make decisions and execute business operations towards world-class production.

3. Method

The purpose of the research is developmental-applicative, and the researcher aims to provide a model for the development of a sustainable supply chain to achieve a world-class level using a combined approach of interpretive structural modeling and fuzzy modeling. The method used in this research is a combination of historical methods (information gathering) and survey methods (questionnaire distribution). Additionally, to gather and compile the theoretical foundations of the research, the researcher utilized articles, books, and reliable sources. The society and statistical sample of this research consist of experts in the handwoven carpet industry, as well as professors and researchers in the field of world-class production. The sampling method is purposeful. The methods employed in this research are Dimtel techniques and interpretive structural modeling. The software used includes EXCEL and MICMAC. The statistical population of this research comprises two groups of specialists with executive expertise in evaluating the performance of sustainable supply chains and conducting studies on world-class status. They also collaborate with companies active in the handwoven carpet industry in Fars province. The specialists in the second group were selected from individuals with at least five years of relevant work experience in the investigated companies, meeting one of the following criteria:

1- Having executive experience in the handwoven carpet industry and supply chain related to the studied industry

2- Having educational experience in organizations related to training human resources in the handwoven carpet production industry. The statistical sample includes 21 experimental and theoretical experts. The qualitative part of this study is based on the opinions of 21 experts in the field. In terms of gender distribution, 12 participants are male and 9 are female. Regarding age, all members of the statistical sample were selected from the age of 35 and above (based on experience, knowledge, and work experience of more than 15 years). In terms of education, 15 individuals hold a master's degree, and 3 have a doctorate. The research purposes include:

- Identifying effective indicators in the sustainable supply chain of the handwoven carpet production industry
- Determining the strength of relationships between variables using the fuzzy Dimetal technique
- Establishing relationships between indicators and their effectiveness through the combined approach of interpretive structural modeling.

4. Findings

Dimetal technique The Dmittel technique is a technique used to identify the pattern of causal relationships between a set of variables. Table 3 shows the spectrum used in this technique.

Table 3. *Spectrum used in Dimetal technique*

Very high impact	high impact	low impact	Very little impact	Effectless
4	3	2	1	0

Based on the investigations, the identified components of the world-class sustainable supply chain model are presented in Table 4.

Table 4*. Symbol of identified indicators*

symbol	Indicator
D01	Lean production (elimination of redundant activities)
D02	Cost of materials and transportation
D03	Reducing the time to reach the market and waiting
D04	Using design software
D05	The agility of the supply chain during the corona outbreak
D06	Up-to-date production technology and machinery
D07	New product design and world class quality
D08	Applying honest principles in hiring local people
D09	Increasing consumer awareness to consume sustainable products
D10	Focusing on social/personal welfare of employees and issuing insurance and pension guarantee
D11	Creating strong legal facilities to take care of industries during the outbreak of Corona
D12	ISO14001
D13	Environmentally friendly production processes and green distribution
D14	Reverse logistics and recycling
D15	Creating sustainable procurement strategies in light of Covid-19
D16	World class sustainable supply chain

Calculation of direct correlation matrix ($\widetilde{X}$)

After collecting the opinions of the experts, if the relationships of n criteria are examined by k experts, the initial matrix of examining the relationships of n criteria from the point of view of k experts will be as follows:

Relationship 1

$$\begin{bmatrix} 0 & \tilde{X}_{12}^{(k)} & \cdots & \tilde{X}_{1n}^{(k)} \\ \tilde{X}_{21}^{(k)} & 0 & \cdots & \tilde{X}_{2n}^{(k)} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{X}_{n1}^{(k)} & \tilde{X}_{n2}^{(k)} & \cdots & 0 \end{bmatrix}$$

Table 5. *Calculation of direct correlation matrix*

	D01	D02	D03	D04	D05	D06	D07	D08	D09	D10	D11	D12	D13	D14	D15	D16
D01	0	0.25	0.25	0.25	0.25	0.25	0.25	0.25	1	0.25	0.25	0.75	0.25	0.75	0.75	0.75
D02	0.75	0	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.25	0.25	1	0.75	0.75	0.75	0.75
D03	1	1	0	0.75	0.75	0.75	0.75	0.75	0.75	0.25	0.25	1	0.75	0.75	0.75	0.75
D04	1	0.25	0.25	0	0.25	0.75	0.75	0.75	0.75	0.25	0.25	0.75	0.25	0.75	0.75	0.75
D05	1	1	1	1	0	0.75	0.75	0.75	0.75	0.25	0.25	1	0.75	0.75	0.75	0.75
D06	1	0.25	0.25	1	0.25	0	0	0	0.75	0.25	0.25	0.75	0.25	0.75	0.75	0.75
D07	1	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.5
D08	0.75	1	1	1	1	1	1	1	1	1	1	1	0.75	0.75	1	1
D09	1	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0	0.25	0.25	0.75	0.25	0.75	0.75	0.75
D10	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1
D11	1	1	1	0.75	1	1	1	1	1	1	0	1	1	1	1	0.75
D12	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0	0.25	0.25	0.75	0.75
D13	1	1	1	1	1	1	1	1	1	0.75	1	1	0	1	1	1
D14	0.75	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.75	0.25	0.25	1	0.25	0	0.75	0.75
D15	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0	0.75
D16	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0

Calculation of normal direct correlation matrix

For normalization, first, the sum of all rows and columns of the direct correlation matrix is calculated. The largest number of the sum of rows and columns will be displayed with k. For normalization, each row of the direct correlation matrix must be divided by k.

$$k = max\left\{max\sum_{j=1}^{n} x_{ij}, \sum_{i=1}^{n} x_{ij}\right\}$$

$$N = \frac{1}{k} * X$$

Table 6. *Calculation of normal direct correlation matrix*

SSIM	D01	D02	D03	D04	D05	D06	D07	D08	D09	D10	D11	D12	D13	D14	D15	D16
D01	0.000	0.065	0.065	0.061	0.065	0.056	0.075	0.056	0.075	0.056	0.075	0.075	0.075	0.075	0.056	0.070
D02	0.019	0.000	0.075	0.075	0.075	0.056	0.065	0.075	0.061	0.075	0.061	0.056	0.065	0.065	0.075	0.061
D03	0.019	0.075	0.000	0.056	0.075	0.056	0.075	0.070	0.056	0.075	0.056	0.075	0.056	0.075	0.075	0.075
D04	0.019	0.075	0.075	0.000	0.075	0.056	0.075	0.065	0.075	0.065	0.075	0.056	0.075	0.075	0.056	0.075
D05	0.019	0.019	0.019	0.019	0.000	0.056	0.056	0.075	0.056	0.056	0.070	0.075	0.075	0.056	0.056	0.056
D06	0.019	0.019	0.019	0.019	0.075	0.000	0.075	0.075	0.065	0.056	0.061	0.056	0.075	0.056	0.056	0.056
D07	0.019	0.023	0.033	0.019	0.019	0.019	0.000	0.056	0.056	0.075	0.075	0.075	0.075	0.056	0.075	0.056
D08	0.037	0.037	0.037	0.019	0.019	0.037	0.075	0.000	0.033	0.061	0.075	0.075	0.056	0.056	0.056	0.065
D09	0.037	0.019	0.019	0.037	0.037	0.019	0.019	0.019	0.000	0.023	0.075	0.056	0.056	0.070	0.075	0.070
D10	0.037	0.037	0.019	0.037	0.019	0.019	0.019	0.019	0.037	0.000	0.019	0.056	0.056	0.075	0.061	0.065
D11	0.037	0.019	0.023	0.037	0.019	0.019	0.037	0.037	0.037	0.075	0.000	0.061	0.075	0.056	0.075	0.065
D12	0.037	0.019	0.019	0.019	0.037	0.037	0.019	0.019	0.019	0.019	0.019	0.000	0.070	0.061	0.075	0.061
D13	0.019	0.019	0.037	0.019	0.037	0.019	0.019	0.028	0.019	0.037	0.019	0.065	0.000	0.075	0.056	0.075
D14	0.019	0.033	0.023	0.037	0.019	0.037	0.019	0.019	0.019	0.019	0.019	0.065	0.075	0.000	0.056	0.056
D15	0.019	0.037	0.019	0.023	0.037	0.019	0.028	0.028	0.019	0.019	0.019	0.033	0.019	0.037	0.000	0.042
D16	0.037	0.019	0.019	0.019	0.019	0.019	0.019	0.028	0.033	0.028	0.019	0.019	0.019	0.019	0.019	0.000

Calculation of the complete correlation matrix

To calculate the complete correlation matrix, we first form an identical n×n matrix. Then we subtract this same matrix from the normal matrix and invert the resulting matrix. The normal matrix is multiplied by the product matrix to obtain the complete correlation matrix.

$$\mathrm{T} = \mathrm{N} \times (I - N)^{-1}$$

The obtained matrix is the same as the complete correlation matrix and it can be used to calculate the pattern of causal relationships.

Table 7. *Complete correlation matrix (definitive)*

SSIM	D01	D02	D03	D04	D05	D06	D07	D08	D09	D10	D11	D12	D13	D14	D15	D16
D01	0.002	0.006	0.006	0.006	0.006	0.006	0.016	0.006	0.02	0.006	0.006	0.016	0.006	0.015	0.016	0.016
D02	0.017	0.002	0.016	0.016	0.016	0.016	0.017	0.006	0.016	0.006	0.006	0.021	0.016	0.016	0.017	0.017
D03	0.022	0.02	0.002	0.016	0.016	0.016	0.017	0.006	0.017	0.006	0.006	0.022	0.016	0.016	0.017	0.017
D04	0.021	0.006	0.006	0.002	0.006	0.015	0.016	0.006	0.016	0.006	0.006	0.016	0.006	0.016	0.016	0.016
D05	0.022	0.021	0.02	0.021	0.002	0.016	0.017	0.006	0.017	0.006	0.006	0.022	0.016	0.017	0.017	0.017
D06	0.021	0.006	0.006	0.02	0.006	0.002	0.016	0.006	0.016	0.006	0.006	0.016	0.006	0.016	0.016	0.016

D07	0.02	0.006	0.006	0.006	0.006	0.006	0.001	0.005	0.006	0.005	0.005	0.006	0.005	0.006	0.006	0.011
D08	0.018	0.022	0.021	0.022	0.021	0.022	0.023	0.002	0.022	0.021	0.021	0.023	0.017	0.018	0.023	0.023
D09	0.02	0.006	0.006	0.006	0.006	0.006	0.02	0.006	0.002	0.006	0.006	0.016	0.006	0.015	0.016	0.016
D10	0.023	0.022	0.022	0.022	0.021	0.022	0.018	0.021	0.023	0.002	0.021	0.023	0.021	0.022	0.023	0.023
D11	0.023	0.022	0.022	0.017	0.021	0.022	0.023	0.021	0.023	0.021	0.002	0.023	0.021	0.022	0.023	0.018
D12	0.006	0.006	0.006	0.006	0.006	0.006	0.02	0.005	0.006	0.005	0.005	0.001	0.006	0.006	0.015	0.015
D13	0.023	0.022	0.021	0.022	0.021	0.022	0.023	0.021	0.023	0.016	0.021	0.023	0.003	0.022	0.023	0.023
D14	0.016	0.006	0.006	0.006	0.006	0.006	0.016	0.006	0.015	0.006	0.006	0.02	0.006	0.002	0.016	0.016
D15	0.006	0.006	0.006	0.006	0.005	0.006	0.006	0.005	0.006	0.005	0.005	0.006	0.005	0.006	0.001	0.015
D16	0.006	0.005	0.005	0.006	0.005	0.006	0.006	0.005	0.006	0.005	0.005	0.006	0.005	0.006	0.006	0.001

Display the map of network relations

A threshold value must be calculated to determine the Network Relationship Map (NRM). With this method, partial relationships can be ignored and the network of significant relationships can be drawn. Only relations whose values in matrix T are greater than the threshold value will be displayed in NRM. To calculate the relationship threshold value, it is enough to calculate the average values of the T matrix (threshold intensity is calculated as 0.013). After the intensity of the threshold is determined, all the values of the T matrix that are smaller than the threshold are zeroed, that is, the causal relationship is not considered. According to the pattern of relationships, it is possible to determine the set of effects and effects:

Table 8. *Complete de-fuzzified (deterministic) correlation matrix*

D-R	D+R	R	D	
0.114	0.419	0.153	0.266	D01
0.044	0.484	0.22	0.264	D02
0.016	0.478	0.231	0.247	D03
0.051	0.4	0.174	0.226	D04
-0.021	0.464	0.242	0.222	D05
0.042	0.401	0.18	0.222	D06
0.116	0.327	0.106	0.221	D07
-0.094	0.541	0.318	0.223	D08
0.068	0.383	0.158	0.226	D09
-0.104	0.554	0.329	0.225	D10
-0.103	0.544	0.324	0.22	D11
0.097	0.338	0.12	0.218	D12
-0.093	0.563	0.328	0.235	D13
0.082	0.387	0.152	0.235	D14
0.124	0.314	0.095	0.219	D15
0.151	0.321	0.085	0.236	D16

- The sum of the elements of each row (D) indicates the influence of that factor on other factors of the system. It is clear that lean production (elimination of redundant activities) has the greatest impact on other elements of the system.

- The sum of the elements of the column (R) for each factor indicates the influence of that factor on other factors of the system.

- The horizontal vector (D+R) is the degree of influence of the desired factor in the system.

- The vertical vector (D-R) shows the influence of each factor. In general, if D-R is positive, the variable is considered a causal variable, and if it is negative, it is considered an effect. Based on the degree of inconsistency of 0.088, the reliability is confirmed

The combined ISM-DEMATEL method is an approach to modeling the criteria relationships based on the interpretation paradigm that uses the DEMATEL capability as an input. Interpretive-structural modeling (ISM) method has many capabilities for modeling. On the other hand, the input of this method is only in the form of zero and one, which limits the experts to express the relationships between the variables. On the other hand, in the DEMATEL method, a wider range can be used to gather and represent the opinions of experts.

The combined ISM-DEMATEL method is a systematic and scientific approach that is suitable for designing exploratory models in management and social sciences. This method is based on interpretive paradigm and research in soft operations, so it is highly efficient in management studies. In this method, the advantages of Dimtel method and structural-interpretive modeling can be used simultaneously. The combination of these two methods was first introduced by Zhu in 2004 and soon became popular among researchers. In the country, management doctoral students use

this method a lot to complete their doctoral thesis. Therefore, I felt it necessary to describe this method. I also published a scientific-research article with the same title so that students and researchers can use it to advance their research.

Interpretive structural model

The first step in structural-interpretive modeling is to calculate the internal relationships of indicators (Azer et al., 2018). Experts' point of view is used to reflect the internal relationships between indicators. The matrix obtained in this step shows which variables a variable affects and from which variables it is affected. Conventionally, symbols like Table 9 are used to identify the relationship pattern of elements.

Table 9. *Modes and signs used in expressing the relationship of research indicators*

O	X	A	V
Absence of relationship	Two-way relationship	Variable j affects i	Variable i affects j

The structural self-interaction matrix consists of the dimensions and indicators of study and their comparison using four modes of conceptual relations. The resulting information is formed based on the summation interpretive structural modeling method and the final structural self-interaction matrix. According to the signs listed in Table 9, the structural self-interaction matrix will be as Table 10.

Table 10. *Structural autocorrelation matrix of SSIM*

D16	D15	D14	D13	D12	D11	D10	D09	D08	D07	D06	D05	D04	D03	D02	D01	SSIM
V	V	X	A	V	A	A	X	A	V	A	A	A	A	A		D01
V	V	V	A	V	A	A	V	A	V	V	X	V	X			D02
V	V	V	A	V	A	A	V	A	V	V	X	V				D03
V	V	V	A	V	A	A	V	A	V	X	A					D04
V	V	V	A	V	A	A	V	A	V	V						D05
V	V	V	A	V	A	A	V	A	V							D06
V	A	A	A	A	A	A	A	A								D07
V	V	V	X	V	X	X	V									D08
V	V	X	A	V	A	A										D09
V	V	V	X	V	X											D10
V	V	V	X	V												D11
V	V	A	A													D12
V	V	V														D13
A	A															D14
V																D15
																D16

Formation of the received matrix

The received matrix is obtained by transforming the structural self-interaction matrix into a two-valued matrix of zero and one. In the received matrix, the dimensions of the main diameter are equal to one. The matrix is presented in Table 11.

Table 11. *Received matrix of identified indicators*

D16	D15	D14	D13	D12	D11	D10	D09	D08	D07	D06	D05	D04	D03	D02	D01	SSIM
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	D01
1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	D02
1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	D03
1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	D04
1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	D05
1	1	1	1	1	1	1	1	1	1	0	1	0	0	0	0	D06
1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	D07
1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	D08
1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	D09
1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	D10
1	1	1	1	1	0	1	0	0	0	0	0	0	0	0	0	D11
1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	D12
1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	D13
1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	D14
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	D15
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	D16

Create the final access matrix

After the initial access matrix is obtained, the final access matrix is obtained by entering transferability in the relations of the variables. The final access matrix of sustainable supply chain indicators is presented in Table 12:

Table 12. *The final access matrix of indicators*

D16	D15	D14	D13	D12	D11	D10	D09	D08	D07	D06	D05	D04	D03	D02	D01	SSIM
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	D01
1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	D02
1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	D03
1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	D04
1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	D05
1	1	1	1	1	1	1	1	1	1	0	1	0	0	0	0	D06
1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	D07
1	1	1	1	1	1	1	1	0	0	1	0	0	0	0	0	D08
1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	D09
1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	D10
1	1	1	1	1	0	1	0	0	0	0	0	0	0	0	0	D11
1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	D12
1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	D13
1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	D14
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	D15
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	D16

Determining relationships and leveling dimensions and indicators

To determine the relationships and leveling of the criteria, the set of outputs and the set of inputs for each criterion should be extracted from the received

matrix. The set of outputs includes the criterion itself and the criteria that are affected by it. The set of inputs includes the criterion itself and the criteria that affect it, and then the set of two-way relations of the criteria is determined. For the C_i variable, the access set (output or effects) includes the variables that can be reached through the C_i variable. The prerequisite set (inputs or effects) includes the variables through which the variable C_i can be reached.

Table 13. *Set of inputs and outputs of each variable and stratification*

Variables	Number of columns	Number of rows
Lean production (elimination of redundant activities)	6	11
The cost of materials and transportation	10	6
Reducing time to reach the market and waiting	11	6
Using design software	8	8
The agility of the supply chain during the corona epidemic	11	6
Up-to-date production technology and machinery	8	8
New product design and world class quality	1	14
Applying honest principles in hiring local people	15	3
Increasing consumer awareness to consume sustainable products	6	11
Focusing on the social/personal welfare of employees and issuing insurance and retirement guarantee	15	3
Creating strong legal facilities to take care of industries during the spread of Corona	15	3
ISO 14001	3	12
Environmentally friendly production processes and green distribution	15	3
Reverse logistics and recycling	4	13
Creating sustainable procurement strategies according to Covid-19	3	12
World class sustainable supply chain	1	13
Total	132	132

After determining the achievement set and the prerequisite set, the subscription of the two sets is calculated. The first variable for which the commonality of the two sets equals the attainable set (outputs) will be the first level. Therefore, the elements of the first level will have the most influence in the model. After determining the level, the criterion whose level is known is removed from the whole set and the set of inputs and outputs is formed again and the next variable level is obtained.

Table 14. *Determining the level in the ISM hierarchy*

Symbol	Research variables	level
D01	Lean production (elimination of redundant activities)	4
D02	Cost of materials and transportation	6
D03	Reducing the time to reach the market and waiting	6
D04	Using design software	5
D05	The agility of the supply chain during the corona outbreak	6
D06	Up-to-date production technology and machinery	5
D07	New product design and world class quality	7
D08	Applying honest principles in hiring local people	2
D09	Increasing consumer awareness to consume sustainable products	4
D10	Focusing on social/personal welfare of employees and issuing insurance and pension guarantee	7
D11	Creating strong legal facilities to take care of industries during the outbreak of Corona	7
D12	ISO14001	3
D13	Environmentally friendly production processes and green distribution	7
D14	Reverse logistics and recycling	4
D15	Creating sustainable procurement strategies in light of Covid-19	3
D16	World class sustainable supply chain	1

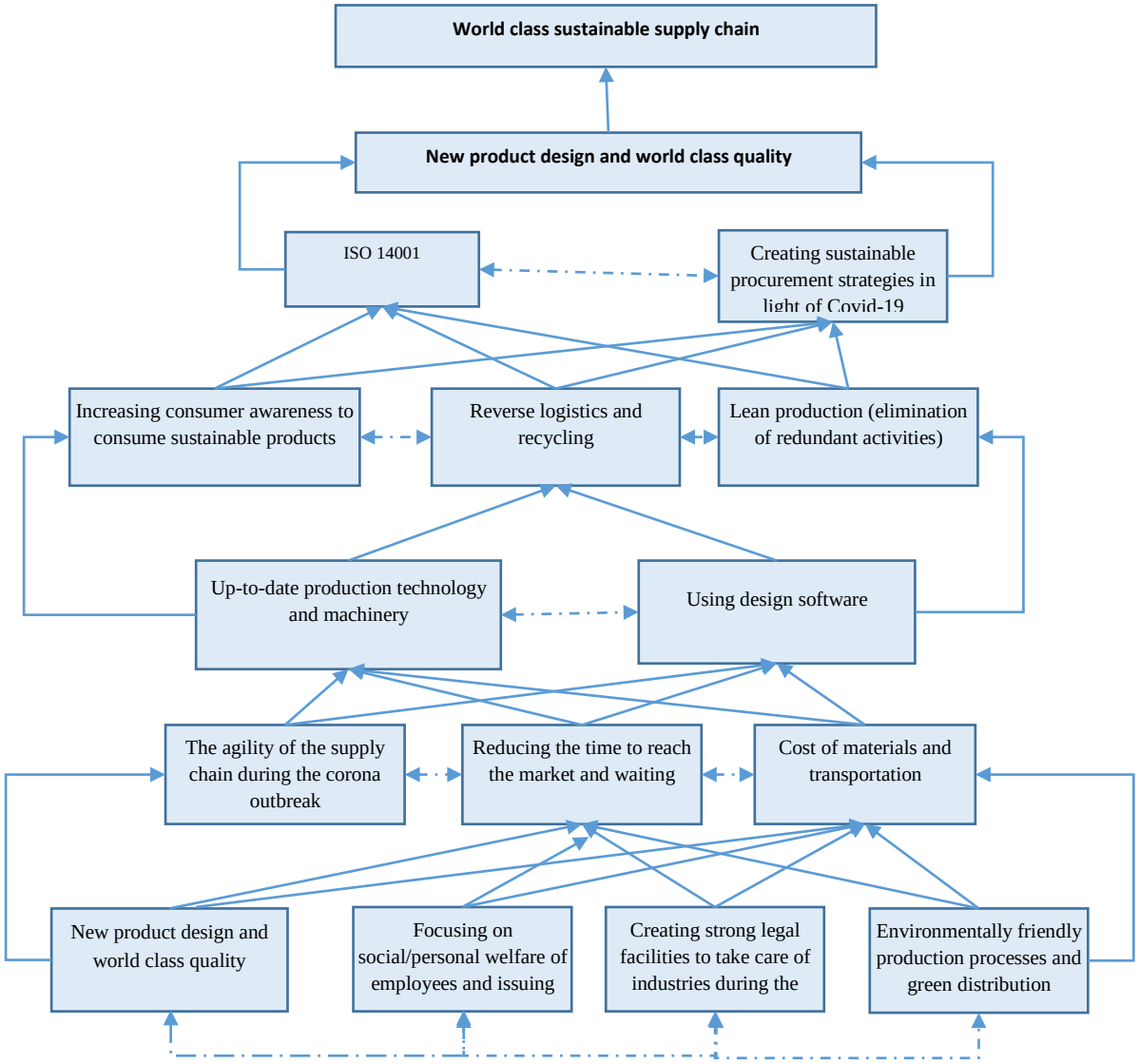

Figure1. *The basic model developed by the ISM method*

5. Discussion

After identifying the variables of the first level, these variables are removed and the set of inputs and outputs is calculated without considering the variables of the first level. The common set of identification and the variables whose commonality is equal to the set of inputs are selected as the second level variables. The final pattern of the levels of the identified variables is shown in the figure. In this diagram, only the meaningful relationships of the elements of each level on the elements of the lower level, as well as the meaningful internal relationships of the elements of each row, are considered. Figure 2 shows the basic model developed by the ISM method. Discuss The focus of the research has been designing a sustainable supply chain model to achieve world class based on critical information systems with a fuzzy hybrid approach. The 15 identified components are lean production (elimination of redundant activities), cost of materials and transportation, reduction of time to market and waiting, use of design software, agility of the supply chain during the outbreak of Corona, up-to-date technology and production machinery. New product design and world-class quality, applying honest principles in hiring local people, increasing consumer awareness to consume sustainable products, focusing on social/personal welfare of employees and issuing insurance and pension guarantee, creating strong legal facilities to take care

of industries in time Corona outbreak, ISO 14001, environmentally friendly production processes and green distribution, reverse logistics and recycling, creating sustainable procurement strategies in light of Covid-19. To achieve a world-class sustainable supply chain model, strong legal facilities are among the critical priorities. It is vital to have strict laws and regulations that help and protect industries in critical situations, such as the outbreak of Corona. Creating sustainable procurement strategies can also be effective considering the conditions caused by Covid-19. This includes increased disruption in the supply chain, raw materials and sustainable transportation, which helps reduce costs and increase efficiency. Also, paying attention to reverse logistics and recycling can help preserve the environment and reuse resources. In the following, agile solutions of the supply chain during the outbreak of Corona should also be taken into consideration. This includes the use of advanced design software, up-to-date technology and machinery, and new design of world-class quality products. Also, applying honest principles in hiring local people in order to improve the social and personal welfare of employees is also very important. Finally, increasing the awareness of consumers about sustainable products can help to achieve the goal of creating a sustainable and world-class supply chain in critical conditions. Studies have been conducted and economic reports in the country show that Iran's handwoven carpet plays a significant role in the gross national product and employment creation, and the export of this product has always been one of the most important items of non-oil exports. So that for many years, it has been the first and most valuable item in non-oil exports and has allocated about 7% of the country's total employment (Siavoshi et al., 2017; Alfat et al., 2014). Examining the different dimensions of this industry in the country shows that Iran's carpet has gone through a period of fragile decline and stagnation in the field of global competition and has been placed in inappropriate conditions (Vermarziari et al., 2017). The share of Iran's handwoven carpets in the world market has been decreasing, while at the same time the share of countries such as Turkey, China, and India has experienced an appropriate growth (Razwani et al., 2013).

6. Conclusion

As a result, designing a sustainable supply chain model with a focus on achieving world class and using information systems in critical situations is very important. By identifying 15 key components, including lean production, cost reduction, agility in the supply chain, and creating sustainable procurement strategies, this model aims to reduce the negative effects of critical conditions, improve efficiency, and increase reliability in the supply chain system. In this model, paying attention to technology and advanced design software, creating environmentally friendly production processes, and reverse logistics and recycling can help solve problems related to critical conditions and create a sustainable and world-class supply chain structure. Paying attention to increasing consumer awareness about sustainable products can play an important role in the success of this model. With the increasing demand for sustainable products, manufacturers will be encouraged to provide high-quality products and sustainable supply chain management, which will ultimately contribute effectively to achieving world-class supply chain and information in critical situations. Based on the sustainable supply chain model in critical conditions with a focus on information systems and achieving world class, the following suggestions are provided: Creating an integrated information system that collects and manages all activities and information related to the supply chain in one platform. This system should benefit from advanced technologies such as cloud, Internet of Things (IoT) and artificial intelligence. Creating inventory monitoring and forecasting systems using artificial

intelligence algorithms and data analysis. These systems can help in optimal inventory management in critical situations and sudden market changes. Integrating information systems to monitor and improve product quality and ensure supply chain stability in weather conditions or natural disasters. Using technology to prevent quality problems or disruptions in the supply chain. Using advanced data analysis techniques and algorithms to identify patterns and problems in the supply chain. These analyzes can quickly provide an understanding of the current and future situation and facilitate better decision making. Creating an electronic supply network that facilitates communication between supply chain members. Using Internet-based technologies to improve communication and coordination among all supply chain partners. Training employees on risk management and using information systems in critical situations. Awareness of possible risks in the supply chain and how to manage them optimally is of particular importance.

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