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Machines Tool Operation Optimization Considering the Effective Criteria for Reliability in Industry 4.0

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Abstract
Industry 4.0 includes an important regeneration of production and management systems within manufacturing, where the majority of the procedures will be entirely or partially automated. However, there are insufficient research studies related to machines tool operation optimization considering the effective criteria for reliability in industry 4.0 to enable plants to measure their own conditions and to make future strategies for their activities in this field. Thus, this article proposes a decision-making model using a combination of DEMATEL, ANP and Shannon Entropy, and VIKOR methods with fuzzy features in cellular production systems, considering the effective criteria for reliability in Industry 4.0. Use of fuzzy features aims to bring the problem closer to the real world in this study. The efficiency of proposed model has been validated in a large automotive parts manufacturing plant as a case study. Based on the results, the most critical machine in the category of automatic lathe machines is Machine3, and the ordinary lathe machines is Machine31. Sensitivity analysis shows that changing the weights of criteria affects the individual prioritization of machines but does not have any impact on their overall prioritization. This prioritization has a high level of alignment in terms of priority and accuracy with the perspectives of experts and decision-making teams. The selected critical machine is a sensitive machine in plant and cannot be replaced throughout its equipment lifetime. Finally, practical recommendations for Machines Tool Operation Optimization have been provided in Industry 4.0.

Keywords: *Machine Tool, Operation, Optimization, Reliability, Industry 4.0.*

Introduction

The term reliability was first used in the 1800s to calculate human life insurance, while later this term was used mostly for machine products (mechanical, electrical, electronic, and structural) and not for humans themselves. Applying the term reliability to humans is usually more complicated due to the complexity of biological organisms compared to machine products, but it cannot be said that it is not measurable. Reliability is a quantitative measure of the correct functioning of parts, devices, and systems in general. These systems can be machine, human-machine, or human. Although they are usually used for mechanical systems or engineering or man-made products and artifacts. In the past decades, reliability has been discussed in industries such as military, communications, oil, and gas production. With the accelerating globalization of the economy, competition among manufacturing industries has increasingly intensified. Automotive manufacturing has always been an important investment and development industry in various countries (Yue et al., 2021).

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An automotive company provides quality assurance services to customers based on two criteria, including time and distance traveled to ensure the quality of its products for them and to remind customers of their credibility (Lee et al., 2021). The factors of time and distance driven are referred to as two-dimensional quality assurance areas, and if a minor error or accident occurs during this time, the automotive company offers a parts warranty that incurs quality assurance costs. For this reason, countless automotive manufacturers are increasing their scope of quality assurance in specific markets (Rajaguru & Matanda, 2013).

Meanwhile, sales are continuously increasing rapidly, with companies subsequently paying tens of billions of dollars in after-sales parts warranties (Schumacher et al., 2016). As a result, identifying the durability of automotive parts and systems, along with determining the appropriate level of quality assurance and quality management, significantly affects the competitiveness of an automotive company (Lee et al., 2021).

Hence, if the possibility of failure in terms of quality assurance can be determined by identifying poor machining processes, it will be easy to manage each part and reduce the cost of quality assurance. To support the reliability of automotive parts, machines are prioritized based on the reliability and manufacturing of intact and defective parts in various ways that can determine the reliability of using equipment. Therefore, one of the most challenging tasks in today's automotive industry is product quality control across the automotive supply chain (Chehade et al., 2022). The automotive industry is becoming customer-oriented and needs faster response times to cope with automotive accidents (Lee et al., 2021).

Paying attention to the reliability of complex products is a serious challenge for most manufacturers. Numerous factors affect reliability and increase complexity [9]. Challenges that may jeopardize the reliability of automotive parts generally fall into two categories: First, the lifespan of the parts is different from each other because drivers act differently from each other and high-risk drivers can always cause unexpected accidents. Second, automobiles have a huge volume of parts and a relatively long warranty period compared to other products, which is a more difficult problem because many parts require prediction and the prediction of parts also takes a long time (Zhan & Xiao, 2022).

The Fourth Industrial Revolution is a general concept that refers to a period of technological advancements in industry and production systems. This revolution is based on the integration of devices and systems into internet networks, artificial intelligence, cloud computing, and data analytics to improve performance and optimize production processes (Schumacher et al., 2016).

In the automotive industry, the Fourth Industrial Revolution plays a crucial role. These innovative technologies and concepts enhance production efficiency and quality, reduce production time and costs, increase flexibility and reliability in the production line, and improve the customer experience. For example, the use of smart systems and connecting production devices to the internet network can lead to the collection and analysis of big data to improve the performance of production lines, predict market needs, enhance quality supervision and control, and monitor system maintenance and repairs (Butollo et al., 2019).

Additionally, the implementation of technologies such as artificial intelligence, robotics, the Internet of Things, and augmented reality in the automotive industry can result in increased automation of production processes, improved accuracy and speed of production, reduced errors and work-related accidents, enhanced security and productivity, and the creation of innovation and development opportunities in this industry. Therefore, the Fourth Industrial Revolution in the automotive industry, by harnessing advanced technologies, improves efficiency, optimizes processes, reduces costs, and brings about significant

transformations in this industry (Jafari-Asl et al., 2022).

To address these challenges, a machine prioritization approach based on reliability factors to realize the goals of the fourth industrial revolution in the field of operation optimization seems essential. In this case, changes need to be managed to identify failures. In other words, the main goal of prioritizing auto parts manufacturing machines based on reliability enables us to obtain the probability of failures among machines and to decide on the process of using the future type of auto parts machining. Data related to the machining process, including Machine operation time, The total number of manufacturing parts, Number of non-defective parts, Planned manufacturing quantity, Machine availability, Efficiency, Overall Equipment Effectiveness(OEE), and Percentage of non-defective parts, index are required to identify the probability of failures(Butollo et al., 2019).

In this research, the information recorded from the archived documents of a large automotive spare parts plant is used, which is known as a field claim to determine the parts manufactured by each machine, the operation time of machines, etc. The reason for using this data is that it gives us feedback on the expected life of the product. Because providing appropriate manufacturing products with optimal reliability for customers of auto parts manufacturing units to ensure proper operation of the product during its lifetime is considered by logistics, supply, and supply chain experts.

Based on the above, the most important objectives of this research are as follows:

1- Providing a decision-making model that, in addition to identifying the effect of criteria on reliability to realize the goals of the fourth industrial revolution in the field of operation optimization can determine the prioritization of machines using it.

2- Applying the fuzzy property to bring the problem closer to the real world.

3- Determining Cause-and-effect relationships between criteria affecting the reliability of machines, as well as determining the importance of criteria and prioritizing machines in groups.

The rest of the paper is organized as below. The second section provides a literature review of past studies on the main research topic. In the third section, the proposed research method is provided. In the fourth section, the computational results are implemented in a real case study. Finally, in the fifth section, a general conclusion is provided along with suggestions for future research.

Literature Review

Jafari-Asl et al, in their paper, proposed a new framework for accurate reliability analysis based on the improvement of directional simulation using meta-heuristic algorithms. To apply the proposed framework is first tested on five highly nonlinear criterion functions and then applied to solve four engineering problems with high dimensions. The performance of the six simulation-based reliability analysis methods and the first-order reliability method are compared with the proposed method. Furthermore, the feasibility of other meta-heuristic algorithms is investigated. The results show the high-performance capabilities of the improved version of the directional simulation to solve highly nonlinear engineering problems.

Manouchehrinia et al, proposed an evaluation of reliability based on failure to measure random vibration loads due to unexpected loads in different road conditions. Because random loads have been identified as the main cause of failure in reliability analysis. Acceleration signals were measured during road tests conducted on rural and highway road surfaces. The signals were taken from an accelerometer mounted on the suspension system of an urban sedan automobile. The results of this study showed that failure prediction is not affected by cases of dynamic behavior in components in the time domain.

Huang et al, considered warranties for electronics with failure processes. In this study, the failures include minor failure,

excessive failure, and catastrophic failure. Also, a dynamic planning approach is designed to provide reliability to obtain optimal solutions for periodic planning. Mi et al, conducted a comprehensive evidence-based network study to analyse the reliability of complex systems with continuously caused failures and complex uncertainties. In addition, two layers, namely a decomposed event layer and a paired layer, are embedded in the system evidence network, resulting in a hierarchical structure of system reliability. As a result, the importance and sensitivity of different components and their effect on system reliability are identified.

Xiao et al. proposed a new learning function with a parallel processing strategy for selecting new training samples for complex systems using Surrogate models. Using the proposed parallel learning strategy for system reliability problems performed through the Cracking surrogate model, one or more new instructional samples can be selected in each iteration to modify the built surrogate models. Three numerical examples were examined to show the validity of the proposed method. The results show that this method has high applicability and accuracy for complex reliability problems. Wang et al. proposed a new reliability analysis method that is a combination of the improved Cracking method for the possibility of small failures. For this purpose, a new strategy for parallel learning is proposed to enable parallel computing and further reduce overall computational time. The proposed method can be applied to a system with low failure probability, multiple failure regions, high nonlinearity, and implicit functions. Finally, the efficiency and accuracy of the proposed method were demonstrated using four numerical examples and compared with the five competing methods reported.

Lee et al. developed a failure and reliability prediction model for auto parts using the initial 6-month field claim. This paper proposes different deep learning methods and compares the work with different methods such as the parametric method, time series method, and machine learning. By conducting experiments, they confirmed that the proposed deep learning model is superior to the existing relevant study, therefore, it is suggested that the deep learning method can maximize performance compared to other existing methods. Soares et al. developed a method to support maintenance management to identify and analyse equipment reliability in a manufacturing factory. This method involves using Laplace test to identify equipment whose reliability decreases over a given period. Then, they carried out an analysis to identify the critical components and related failure factors.

Abolghasemian et al, presented a new framework for prioritizing time in the construction process using an analytical method based on a mathematical model and simulation. For this purpose, the rework parameter and the variables of frequency, duration, and time of call-back have been considered. Also, the effects of these parameters on tangible performance criteria have been investigated.

Ghazi and Pourghader, using fuzzy logic, tried to predict the reliability of passenger automotive tires using machine learning. Thus, they first identified the key criteria affecting the tire reliability, and then, using the opinions of experts, designed and considered rules for training the network. Finally, to validate the model in the best and worst conditions, the validity of the model was measured to investigate the effect of input variables on the output of the model. Hey et al, developed a two-stage supply chain for automotive logistics services. The computational results of the research show that if reliability increases, the optimal order quantity of logistics capability, purchase price, and all expected profits will decrease. Teymouri and Farahani , proposed a model that in addition to the reliability of the part, well investigates the environmental factors affecting the failure rate. Furthermore, since the consumption of many parts is due to their relationship with other parts and the existence of a concept called part failure interaction, these factors are also included in the model as another group of factors

affecting demand. The model proposed in this paper, using reliability models and the renewal process, predicts the consumption of spare parts by considering the reliability, factors in the operational environment, and failure interaction.

Tortorella and Fettermann, assessed the development of Industry 4.0 in Brazilian manufacturing companies. They utilized a multivariate analysis to analyze the lean production (LP) practices of 110 companies which were collected by means of a questionnaire form. They found the implementation of the LP and Industry 4.0 technologies has led to larger performance improvements in Brazilian companies. Skrzeszewska et al, assessed the effectiveness of Manufacturing Execution Systems (MES) for production management in Industry 4.0. They analyzed the readiness level of two companies in three levels of management: operational, tactical and strategic. Sadeghi-Niaraki, developed a comprehensive framework to assess the countries' readiness level in Industry4.0 development. The research conducted in several steps. First, the main required clusters and their criteria of Industry 4.0 development assessment such as technological, social, economic, political and environmental clusters determined. Second, the importance of the clusters and their criteria specified using the Fuzzy DEMATLE and Fuzzy ANP techniques. Third, the countries ranked using the VIKOR technique.

According to literature review, machine learning, parametric, and deep learning methods have been considered in the studies to ensure reliability. However, a decision-based model has not been investigated in Industry 4.0. Therefore, the proposed model in this research enables manufacturing companies to decrease huge costs by prioritizing the machines in Cellular Manufacturing Systems in Industry 4.0, with ensuring reliability, taking into account the exact number of future failures of each automotive part. Table 1, shows the literature review.

Table 1.
Literature review

Author	**Year**	**Goal**	**Tools**	**Solution approach**
Sadeghi-Niaraki	2020	Evaluation countries' readiness level in Industry 4.0 development	Decision making	Fuzzy DEMATLE - Fuzzy ANP and VIKOR
Soares et al	(2021)	Support maintenance management to identify and analyse equipment reliability	Experimental	Laplace test
Lee et al	(2021)	Predicting the failure and reliability of automotive parts	Statistical	Time series
Jafari- Asl, et al	(2022)	Calculate reliability analysis based on the improvement of directional simulation	Simulation	Meta-Heuristic
Manouchehrinia, et al	(2022)	Calculate an evaluation of reliability based on failure	Experimental	-
Huang et al	(2022)	Evaluation warranties reliability for electronics with failure processes	Experimental	-
Mi et al	(2022)	Conducted a comprehensive evidence-based network study to analyse the reliability of complex systems	Experimental	-
Xiao et al	(2022)	Studied reliability using a surrogate model	Surrogate model	Cracking

Author	Year	Goal	Tools	Solution approach
Wang et al	(2022)	Analysis reliability using a surrogate model	Surrogate model	Machine learning
This research	(2024)	To prioritize and select the most critical machine in cellular manufacturing systems using effective criteria for reliability in Industry 4.0	Decision making	A Fuzzy Hybrid Method of DEMATEL-ANP- Shannon Entropy/VIKOR

Methodology

The proposed framework of this research includes four basic pillars as follows: 1- Determining the complete relationship between criteria, 2- Determining the importance of criteria, 3- Prioritizing the critical machines to determine the most critical machine in manufacturing halls, and 4- Sensitivity Analysis.To carry out this research, a hybrid decision-making framework using DEMATEL (Decision-Making Trial and Evaluation) method is used to determine the complete relationships between criteria and ANP-Shannon Entropy method is used to calculate weight of criteria. Because, the most significant constraint in using decision-making methods is considering the mental importance of criteria, which may lead to different results by changing its value compared to what has been calculated. To overcome this limitation, this article uses combined weights obtained from Shannon Entropy and ANP methods. Finally, using VIKOR (Vlse Kriterijumsk Optimizacija Kompromisno Resenje) method, the prioritization of machines is determined according to the importance determined for the criteria and their criticality. Figure 1 shows the research implementation framework.

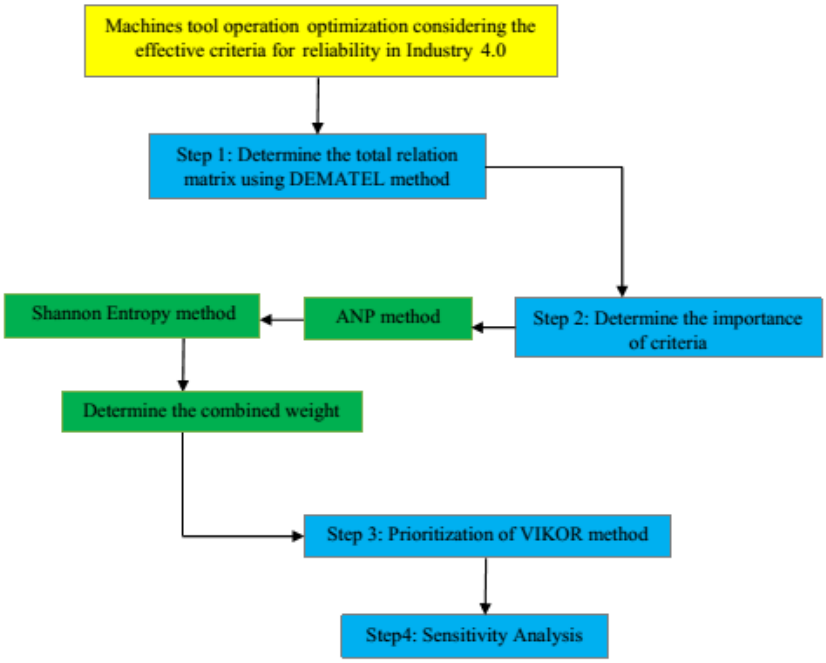

Figure 1. Research method framework

DEMATEL Method

Using DEMATEL method, the effect of criteria on each other is addressed. The steps of this method are:

Step 1: Forming the initial relation matrix

The values of each column and row represent the opinion of experts for the criteria. This matrix shows how each factor affects the other factors of the study. Any criterion that does not affect the similar criterion, its value is considered zero.

(1)$A = \begin{bmatrix} 0 & \cdots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{n1} & \cdots & 0 \end{bmatrix}$

Step 2: Normalizing the initial relation matrix

The normal matrix for the initial relations based on Equation 2 can be calculated as follows:

(2) $X = {}^{1}/_{\max \sum_{j=1}^{n} a_{ij}}$

(3) $N = X.A$

Where X is the normalized value of each factor and A is the initial relation matrix.

Step 3: Total relation matrix

The total relation matrix Y can be calculated using the normalized matrix N as follows.

$$Y = N(I - N)^{-1}$$

(5) $I_n = \begin{bmatrix} 1 & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & 1 \end{bmatrix}$

Step 4: Calculating sum of the rows and columns in the total relation matrix

In this step, the column matrix $R_{n\times 1}$ is calculated using sum of the rows of the total relation matrix, and the row matrix $C_{1\times n}$ is calculated using sum of columns of the total relation matrix as follows:

(6) $R = [\sum_{j-1}^{n} m_{ij}]$

(7) $C = [\sum_{i-1}^{n} m_{ij}]$

Step 5: Drawing the degree of influence cause and effect criteria diagram

In this step, by calculating $(R_i + C_i)$ and $(R_i - C_i)$ the degree of influence cause and effect criteria diagram is drawn to show the effect of factors on each other.

ANP Method

The steps of ANP method are follows:

Step 1: Building a model and turning the problem into a network structure

In this stage, the problem needs to be turned into a logical system like a network. The network structure can be obtained by brainstorming, nominal group, or any other suitable method. In this research, the relationship between the criteria is obtained using DEMATEL method.

Step 2: Forming a pairwise comparison matrix and determining relative weights vector

The decision elements in each cluster should be compared two by two based on their importance in the equation to the control criteria. Clusters are also compared two by two according to their role and influence in achieving the goal. Also, due to the interdependencies between the elements of a cluster, pairwise comparisons should be made between them.

Step 3: Forming a super matrix and converting it to a limit super matrix

To achieve the final weights in the network, the relative weight vectors are inserted into the appropriate columns of a matrix. The result is a super matrix, each part of which represents the relationship between two clusters in a system.

Step 4: Selecting the top option

The overall priority of the options is obtained from the options column in the normalized limit super matrix.

Shannon Entropy Method

In this step, using Shannon Entropy method, the importance of each of considered criteria for critical equipment prioritizing is determined. To determine the weight, it is necessary to calculate the entropy uncertainty criterion by a certain probability distribution such as p_i in Equation 8:

(8) $E_j = -k \sum_{i=1}^{m} p_j \ln(p_j)$

Therefore, value of d_j or the degree of deviation is calculated, which shows how much useful information the relevant *j* index provides to the decision maker. The closer measured values are to each other, it shows that the other options are not much different from each other in terms of the index.

(9) $d_j = 1 - E_j$

Finally, the weight of W_j is calculated as follow:

(10) $W_j = \frac{d_j}{\sum_{j=1}^{n} d_j}$

In this research, it is suggested that the weight of criteria be determined using the combined ANP-Entropy method. If the calculated weight of ANP method for considered factors is assumed to be equal to δ_j and the calculated weight of criteria using Shannon

Entropy method is assumed to be equal to γ_j, then the combined weight will be equal to:

(11) $$W_j = \frac{\delta_j \gamma_j}{\sum_{j=1}^{n} \delta_j \gamma_j}$$

VIKOR Prioritization Method

The steps of VIKOR method are:

Step 1: Calculating f_j^* and f_j^- of criteria: for each of criteria $j = 1, \dots, n$, the best f_{ij} is specified as f_j^*, and the worst f_{ij} is specified as f_j^-. The values of f_j^* and f_j^- for positive criteria, are determined from Equation 12.

(12) $$f_j^* = \max f_{ij}\,;\; f_j^- = \min f_{ij}$$

Also, values f_j^* and f_j^- for negative criteria are determined from Equation 13.

(13) $$f_j^* = \min f_{ij}\,;\; f_j^- = \max f_{ij}$$

Step 2: Calculating S_i and R_i according to Equations 14 and 15:

(14) $$S_i = \sum_{j=1}^{n} w_j \frac{(f_j^* - f_{ij})}{(f_j^* - f_j^-)}$$

(15) $$R_i = \max[w_j \frac{(f_j^* - f_{ij})}{(f_j^* - f_j^-)}]$$

Therefore, $S^* = \min S_i\,;\; S^- = \max S_i\,;\; R^* = \min R_i\,;\; R^- = \max R_i$.

Step 3: Calculating value of VIKOR index for each option according to Equation 16:

(16) $$Q_i = v \times \left[\frac{S_i - S^*}{S^- - S^*}\right] + (1 - v) \times [\frac{R_i - R^*}{R^- - R^*}]$$

It is assumed that v is a strategic weight and often consider equal to 0.5.

Results

The results of this research have been implemented in alarge automotive spare parts plant. This plant produces aluminum automotive parts, which is considered the main engine parts manufacturer for automotive manufacturers. In the following, the applied results are shown step by step until the results are obtained to determine the critical machines.

The Effect of criteria on each other

By collecting information from the designed questionnaire based on DEMATEL method, considering the scale in Table 2, the decision matrix shown in Table 3 is completed. Table 3 shows direct relation matrix, which is based on the arithmetic mean of the opinions of the experts participating in the research based on DEMATEL scale.

Table 2.
DEMATEL method scale

Verbal phrase	Corresponding value
Much more important	500
Important	400
Intermediate	300
Less important	200
Much less important	100

The triangular fuzzy numbers corresponding to the 5-point Likert spectrum are shown in Table 3. In this table, the certain value corresponding to each verbal value, fuzzy value, and triangular number is written. Fuzzy numbers are converted to crisp numbers using Minkowski formula according to $x = m + {}^{u-l}/_{4}$. In this relation, m is the center of the interval, u is the upper bound, and l is the lower bound of the interval.

Table 3.
Fuzzy numbers of 5-degree Likert spectrum

Verbal variable	Fuzzy value	Triangular fuzzy numbers	Crisp value
Much more Important	$\tilde{1}$	(0,0,0.25)	0.0625
Important	$\tilde{2}$	(0,0.25,0.25)	0.3125
Intermediate	$\tilde{3}$	(0.25,0.5,0.25)	0.625
Less important	$\tilde{4}$	(0.5,0.75,1)	0.875
Much less important	$\tilde{5}$	(0.75,1,1)	1.0625

Table 4.
Direct relation matrix of DEMATEL method

Direct relation matrix	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8
C_1	0.000	0.763	0.786	0.768	0.603	0.705	0.714	0.781
C_2	0.777	0.000	0.781	0.741	0.585	0.723	0.737	0.719
C_3	0.723	0.759	0.000	0.696	0.473	0.763	0.830	0.777
C_4	0.808	0.643	0.540	0.000	0.576	0.705	0.799	0.862
C_5	0.625	0.692	0.464	0.496	0.000	0.364	0.531	0.879
C_6	0.790	0.571	0.786	0.670	0.371	0.000	0.763	0.781
C_7	0.808	0.826	0.737	0.741	0.509	0.835	0.000	0.821
C_8	0.692	0.710	0.656	0.817	0.817	0.728	0.786	0.000

To normalize Table 4, it is necessary to specify the sum of rows and columns in the table of the total relation matrix and to divide each of the numbers in this table by the maximum value of these sums. Table 5 shows the sum of the rows and columns of the total relation matrix to determine the maximum value.

Table 5.
Sum of rows and columns

Sum of rows	**Sum of columns**
5.120	5.223
5.062	4.964
5.022	4.75
4.933	4.928
4.051	3.933
4.731	4.823
5.276	5.160
5.205	5.620

According to table 5, maximum value for rows is 5.276 and maximum value for columns is 5.620. Therefore, maximum value is set to 5.620, which is calculated by dividing values of total relation matrix by this value of normal matrix according to Table 6.

Table 6.
Normal matrix

Normal matrix	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8
C_1	0.000	0.136	0.140	0.137	0.107	0.125	0.127	0.139
C_2	0.138	0.000	0.139	0.132	0.104	0.129	0.131	0.128
C_3	0.129	0.135	0.000	0.124	0.084	0.136	0.148	0.138
C_4	0.144	0.114	0.096	0.000	0.102	0.125	0.142	0.153
C_5	0.111	0.123	0.083	0.088	0.000	0.065	0.095	0.156
C_6	0.141	0.102	0.140	0.119	0.066	0.000	0.136	0.139
C_7	0.144	0.147	0.131	0.132	0.091	0.149	0.000	0.146
C_8	0.123	0.126	0.117	0.145	0.145	0.129	0.140	0.000

According to tables 7 and 8, using normal matrix and performing necessary operations the total relation matrix $N \times (I - N)^{-1}$ is calculated. For this purpose, first, the inverse matrix obtained by subtracting the identity matrix from the normalized matrix. Then, product of normal matrix in the inverse matrix is obtained as the total relation matrix. In Table 7, the matrix $(I - N)^{-1}$ is calculated.

Table 7.
Matrix $(I - N)^{-1}$

$(\boldsymbol{I - N})^{-1}$	$\boldsymbol{C_1}$	$\boldsymbol{C_2}$	$\boldsymbol{C_3}$	$\boldsymbol{C_4}$	$\boldsymbol{C_5}$	$\boldsymbol{C_6}$	$\boldsymbol{C_7}$	$\boldsymbol{C_8}$
C_1	1.849	0.928	0.907	0.932	0.701	0.91	0.956	1.019
C_2	0.918	1.758	0.859	0.879	0.608	0.866	0.908	0.954
C_3	0.953	0.917	1.776	0.912	0.674	0.91	0.962	1.007
C_4	0.948	0.885	0.848	1.786	0.679	0.885	0.941	1.002
C_5	0.786	0.765	0.712	0.739	1.492	0.709	0.769	0.862
C_6	0.923	0.854	0.862	0.871	0.633	1.754	0.914	0.966
C_7	1.001	0.961	0.952	0.954	0.706	0.954	1.87	1.052
C_8	0.965	0.927	0.895	0.944	0.737	0.918	0.972	1.905

Table 8.
Total relation matrix

$N \times (I - N)^{-1}$	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8
C_1	0.849	0.928	0.911	0.932	0.701	0.91	0.965	1.019
C_2	0.968	0.807	0.908	0.926	0.704	0.911	0.957	1.009
C_3	0.953	0.917	0.78	0.912	0.674	0.91	0.962	1.007
C_4	0.948	0.885	0.852	0.786	0.679	0.885	0.94	1.002
C_5	0.786	0.765	0.714	0.739	0.491	0.709	0.769	0.862
C_6	0.923	0.854	0.866	0.871	0.633	0.753	0.914	0.966
C_7	1.001	0.961	0.925	0.953	0.706	0.954	0.869	1.052
C_8	0.965	0.927	0.898	0.944	0.737	0.918	0.972	0.906

According to table 9, by calculating sum of each row and column, value of D and R are obtained, respectively.

Table 9.
Values of R, D, (D+R) and (D-R)

Criteria	D	R	D-R	D+R
C_1	7.215	7.393	-0.178	14.608
C_2	7.19	7.044	0.146	14.234
C_3	7.115	6.854	0.261	13.962
C_4	6.977	7.063	-0.086	14.04
C_5	5.835	5.325	0.51	11.16
C_6	6.78	6.95	-0.17	13.73
C_7	7.421	7.348	0.073	14.769
C_8	7.267	7.823	-0.556	15.09

By calculating value of D+R and D-R, it is possible to show the degree of influence cause and effect criteria on each other. In this way, the position of each criterion is determined by a point with coordinates (D+R, D-R) in system. Diagram 1 shows the degree of influence cause and effect criteria based on value of D+R and D-R.

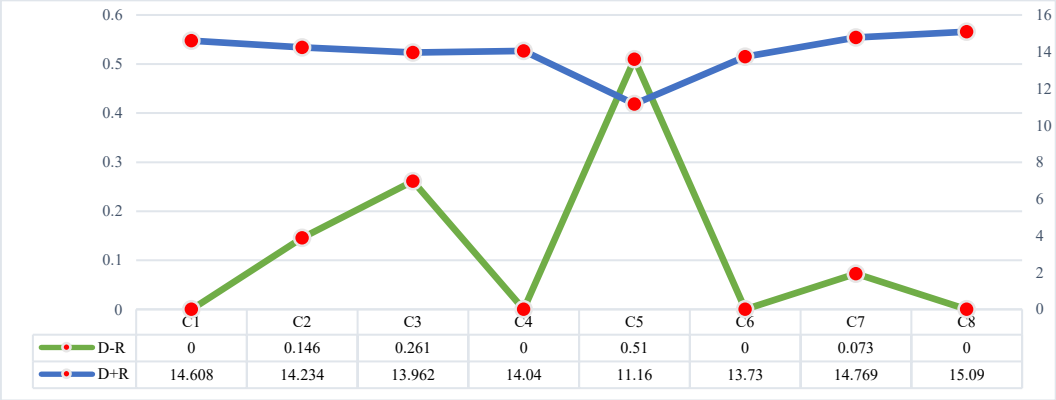

Diagram 1. *The degree of influence cause and effect criteria*

Cause-and-effect variables are also determined using DEMATEL method. Accordingly, Machine operation time, Planned manufacturing quantity, Percentage of non-defective parts, and OEE are causal factors, while Total number of manufactured parts, Number of non-defective parts, Machine availability, and Efficiency are effect factors in this research.

In general, sum of the elements of each row (D) for each factor indicates the degree of influence of that factor on other factors of system. If amount of this variable is more, it means that the factor has more influence. Therefore, Efficiency has the most influence and Machine availability has the least influence on machinery reliability planning. On the other hand, sum of the column elements(R) for each factor indicates the degree of influence of that factor on other factors of system. If value of this variable is higher, it means that the factor is more effective. Based on the results, OEE has the

most impact and Machine availability is the least impact.

Based on the above, the horizontal vector (D+R) is how much the intended factor affect in system. In other words, the higher D+R factor, the more it interacts with other system factors. Based on the results, OEE has the most interaction with other criteria and Machine availability has the least interaction. In contrast, the vertical vector (D-R) indicates the effect of each factor. If D-R is positive, factor is a cause variable, and if it is negative, it is an effect.

Accordingly, Machine operation time, Planned manufacturing quantity, Percentage of non-defective parts, and OEE are the criteria of cause, and Total number of manufactured parts, Number of non-defective parts, Machine availability, and Efficiency are the criteria of effect in this research.

Calculation of initial weight using ANP method

To get the initial weight for eight considered criteria, first a network is drawn. The main points of this network as figure 3 are:

Objective: To determine the importance of criteria

Criteria: The eight main criteria are:

Machine operation time (C1).

Total number of manufactured parts (C2),

Number of non-defective parts (C_3),

Planned manufacturing quantity (C4),

Machine availability (C5),

Percentage of non-defective parts (C6),

Efficiency (C7),

OEE (C8).

Options: 33 machines are considered as options.

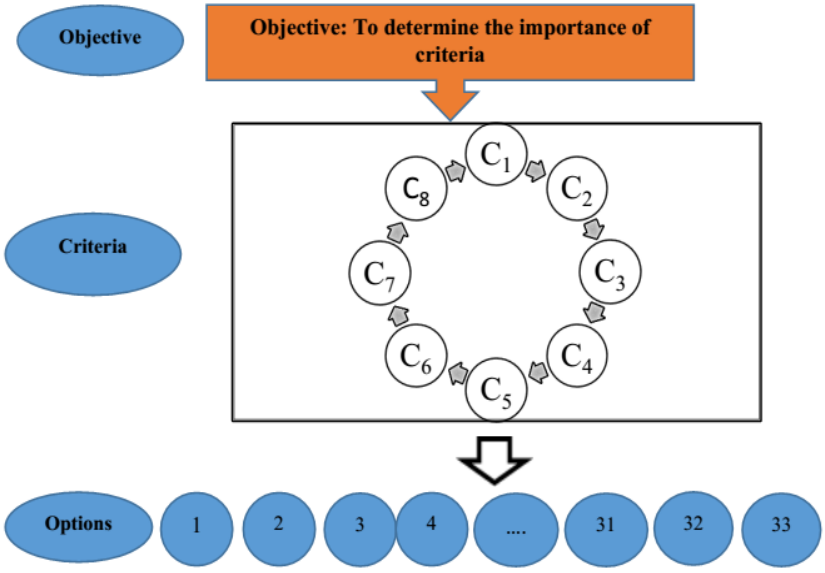

Figure 2. Relationship network of objective, criteria and options

In this stage using ANP method, initial importance of the considered criteria is determined using Super Decision software. For this purpose, the total relation matrix of DEMATEL method is considered as input to pairwise comparison matrix of criteria in ANP method. For the intended pairwise comparison, the incompatibility rate and the importance of criteria are collected.

It is noteworthy that the software has been designed to perform network calculations that focus on ANP method. Therefore, after establishing connections between nodes, it automatically considers the desired network and performs its calculations based on criteria dependencies. Then, by specifying the network relationships in Super Decision software, the pairwise comparison matrix in ANP is obtained that shows in table 10.

Table 10.
ANP pairwise comparison matrix

$N \times (I - N)^{-1}$	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8
C_1	0.849	0.928	0.911	0.932	0.701	0.91	0.965	1.019
C_2	0.968	0.807	0.908	0.926	0.704	0.911	0.957	1.009
C_3			0.78	0.912	0.674	0.91	0.962	1.007
C_4				0.786	0.679	0.885	0.94	1.002
C_5					0.491	0.709	0.769	0.862
C_6						0.753	0.914	0.966
C_7							0.869	1.052
C_8								0.906

By determining the matrix of pairwise comparisons, the importance of each criteria and the incompatibility rate of pairwise comparison of criteria are calculated. Table 11 shows the importance of all criteria. Given that the incompatibility rate for calculated pairwise comparison is 0.004 and it is less than 0.1, the results of pairwise comparison are acceptable.

Table 11.
Incompatibility rate of criteria

Criteria Number	Value	Criteria Number	Value
C_1	0.109	C_5	0.119
C_2	0.126	C_6	0.117
C_3	0.135	C_7	0.101
C_4	0.139	C_8	0.151

Calculating combined weight

According to table 12, combined weight of criteria is determined using Shannon Entropy method and weights of ANP method.

Table 12.
Calculations of Shannon Entropy method

Machine Number	**C_1**	**C_2**	**C_3**	**C_4**	**C_5**	**C_6**	**C_7**	**C_8**
Machine1	0.0278	0.0350	0.0351	0.0352	0.0032	0.0031	0.0029	0.0309
Machine2	0.0190	0.0321	0.0323	0.0328	0.0022	0.0031	0.0029	0.0209
Machine3	0.0278	0.0633	0.0637	0.0642	0.0032	0.0031	0.0029	0.0307
Machine4	0.0243	0.0058	0.0058	0.0059	0.0028	0.0031	0.0029	0.0268
Machine5	0.0379	0.0449	0.0451	0.0456	0.0029	0.0031	0.0029	0.0279
Machine6	0.0422	0.0383	0.0376	0.0380	0.0032	0.0030	0.0030	0.0310
Machine7	0.0358	0.0366	0.0368	0.0373	0.0027	0.0031	0.0029	0.0263
Machine8	0.0379	0.0261	0.0262	0.0266	0.0029	0.0031	0.0029	0.0277
Machine9	0.0278	0.0592	0.0596	0.0604	0.0032	0.0031	0.0029	0.0306
Machine10	0.0293	0.0310	0.0312	0.0314	0.0033	0.0031	0.0029	0.0324
Machine11	0.0376	0.0184	0.0183	0.0069	0.0029	0.0018	0.0133	0.0739
Machine12	0.0379	0.0218	0.0209	0.0214	0.0029	0.0030	0.0030	0.0275
Machine13	0.0385	0.0375	0.0377	0.0380	0.0029	0.0031	0.0029	0.0284
Machine14	0.0464	0.0413	0.0413	0.0421	0.0035	0.0031	0.0029	0.0339
Machine15	0.0271	0.0279	0.0281	0.0283	0.0031	0.0031	0.0029	0.0299
Machine16	0.0248	0.0738	0.0742	0.0749	0.0028	0.0031	0.0029	0.0273
Machine17	0.0403	0.0321	0.0323	0.0328	0.0031	0.0031	0.0029	0.0295
Machine18	0.0263	0.0343	0.0345	0.0345	0.0030	0.0031	0.0029	0.0294
Machine19	0.0225	0.0259	0.0260	0.0262	0.0026	0.0031	0.0029	0.0249
Machine20	0.0190	0.0364	0.0366	0.0369	0.0022	0.0031	0.0029	0.0210
Machine16	0.0248	0.0738	0.0742	0.0749	0.0028	0.0031	0.0029	0.0273

Machine Number	**C_1**	**C_2**	**C_3**	**C_4**	**C_5**	**C_6**	**C_7**	**C_8**
Machine17	0.0403	0.0321	0.0323	0.0328	0.0031	0.0031	0.0029	0.0295
Machine18	0.0263	0.0343	0.0345	0.0345	0.0030	0.0031	0.0029	0.0294
Machine19	0.0225	0.0259	0.0260	0.0262	0.0026	0.0031	0.0029	0.0249
Machine20	0.0190	0.0364	0.0366	0.0369	0.0022	0.0031	0.0029	0.0210
Machine21	0.0420	0.0415	0.0408	0.0414	0.0032	0.0030	0.0030	0.0307
Machine22	0.0286	0.0345	0.0347	0.0352	0.0033	0.0031	0.0029	0.0314
Machine23	0.0278	0.0319	0.0321	0.0325	0.0032	0.0031	0.0029	0.0307
Machine24	0.0278	0.0308	0.0310	0.0311	0.0032	0.0031	0.0029	0.0309
Machine25	0.0293	0.0348	0.0350	0.0356	0.0033	0.0031	0.0029	0.0321
Machine26	0.0247	0.0087	0.0087	0.0086	0.0028	0.0031	0.0030	0.0278
Machine27	0.0278	0.0064	0.0064	0.0069	0.0032	0.0031	0.0027	0.0287
Machine28	0.0266	0.0096	0.0097	0.0097	0.0030	0.0031	0.0029	0.0297
Machine29	0.0231	0.0113	0.0114	0.0114	0.0026	0.0031	0.0029	0.0257
Machine30	0.0299	0.0034	0.0033	0.0033	0.0034	0.0031	0.0030	0.0336
Machine31	0.0285	0.0273	0.0260	0.0263	0.3117	0.2928	0.3111	0.0301
Machine32	0.0266	0.0226	0.0223	0.0226	0.2935	0.3080	0.2955	0.0284
Machine33	0.0269	0.0157	0.0152	0.0158	0.3051	0.3072	0.2954	0.0294
E_j	0.1052	0.1016	0.1015	0.1012	0.0487	0.0490	0.0496	0.1051
d_j	0.8948	0.8984	0.8985	0.8988	0.9513	0.9510	0.9504	0.8949
w_j	0.1219	0.1224	0.1224	0.1225	0.1296	0.1296	0.1295	0.1220
λ_j	0.1090	0.1260	0.1350	0.1390	0.1190	0.1170	0.1010	0.1510
$w_j * \lambda_j$	0.0133	0.0154	0.0165	0.0170	0.0154	0.0152	0.0131	0.0184
W_j	0.1069	0.1240	0.1329	0.1369	0.1241	0.1219	0.1052	0.1481

VIKOR ranking

Table 13 shows the decision matrix in VIKOR method. This table has been compiled based on the classified information contained in the archived documents of a large automotive spare parts plant in the period from April 2020 to April 2022. In this table, Machine operation time is a negative criteria and other criteria are positive.

Table 13.
Decision matrix in VIKOR method

Machine Number	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8
Machine1	18960	10308	10289	10200	73.15	99.80	101.10	73.79
Machine2	12960	9461	9461	9500	50.00	100.00	99.60	49.79
Machine3	18920	18658	18651	18600	72.99	100.00	100.30	73.19
Machine4	16560	1704	1704	1700	63.89	100.00	100.20	64.04
Machine5	25860	13225	13197	13200	66.51	99.80	100.20	66.5
Machine6	28746	11294	11007	11000	73.94	97.50	102.70	73.98
Machine7	24425	10781	10773	10800	62.82	99.90	99.82	62.66
Machine8	25800	7682	7669	7700	66.36	99.80	99.80	66.09
Machine9	18960	17464	17464	17500	73.15	100.00	99.80	73
Machine10	19960	9129	9129	9100	77.01	100.00	100.30	77.25
Machine11	25620	5424	5357	2000	65.90	58.70	456.50	176.5
Machine12	25860	6414	6124	6200	66.51	95.50	103.50	65.7
Machine13	26215	11055	11041	11000	67.43	99.90	100.50	67.68
Machine14	31650	12175	12111	12200	81.40	99.50	99.80	80.81
Machine15	18480	8217	8217	8200	71.30	100.00	100.20	71.44
Machine16	16880	21759	21736	21700	65.12	99.90	100.30	65.23
Machine17	27500	9470	9470	9500	70.73	100.00	99.70	70.51
Machine18	17960	10117	10117	10000	69.29	100.00	101.20	70.1
Machine19	15360	7630	7630	7600	59.26	100.00	100.40	59.49
Machine20	12960	10729	10729	10700	50.00	100.00	100.30	50.14
Machine21	28620	12247	11949	12000	73.61	97.60	102.10	73.3
Machine22	19480	10167	10162	10200	75.15	100.00	99.70	74.87

Machine Number	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8
Machine23	18960	9413	9413	9400	73.15	100.00	100.10	73.25
Machine24	18960	9087	9081	9000	73.15	99.90	101.00	73.81
Machine25	19960	10260	10260	10300	77.01	100.00	99.60	76.71
Machine26	16840	2554	2553	2500	64.97	100.00	102.20	66.35
Machine27	18960	1875	1875	2000	73.15	100.00	93.80	68.58
Machine28	18160	2832	2829	2800	70.06	99.90	101.10	70.79
Machine29	15760	3329	3329	3300	60.80	100.00	100.90	61.34
Machine30	20400	989	969	950	78.70	98.00	104.10	80.28
Machine31	19422.00	8054.33	7613.00	7616.67	71.80	93.73	107.00	71.77
Machine32	18109.17	6652.00	6541.17	6533.33	67.62	98.57	101.63	67.71
Machine33	18344.17	4630.33	4461.33	4583.33	70.27	98.32	101.60	70.12

According to table 14, S_i and R_i criteria are calculated using VIKOR method.

Table 14.
Values of S_i and R_i

Machine Number	S_i	R_i	Machine Number	S_i	R_i
Machine1	0.7603	0.1237	Machine18	0.7740	0.1243
Machine2	0.8381	0.1481	Machine19	0.8480	0.1367
Machine3	0.6024	0.1237	Machine20	0.8140	0.1477
Machine4	0.9480	0.1320	Machine21	0.6716	0.1236
Machine5	0.6737	0.1285	Machine22	0.7577	0.1236
Machine6	0.6884	0.1236	Machine23	0.7772	0.1237
Machine7	0.7324	0.1330	Machine24	0.7832	0.1237
Machine8	0.7793	0.1290	Machine25	0.7509	0.1236
Machine9	0.6244	0.1237	Machine26	0.9279	0.1287
Machine10	0.7722	0.1236	Machine27	0.9248	0.1300
Machine11	0.7142	0.1300	Machine28	0.9097	0.1247
Machine12	0.8068	0.1295	Machine29	0.9251	0.1346
Machine13	0.7115	0.1272	Machine30	0.9207	0.1369
Machine14	0.6434	0.1235	Machine31	0.4635	0.1224
Machine15	0.8048	0.1237	Machine32	0.5047	0.1271
Machine16	0.5648	0.1300	Machine33	0.5345	0.1243
Machine17	0.7302	0.1239			

According to Table 15 and consider value of $S^* = 0.463$, $S^- = 0.948$, $R^* = 0.122$, and $R^- = 0.1$, VIKOR index Q_i is calculated.

Table 15.
VIKOR index Q_i

Machine Number	Q_i	**Machine Number**	Q_i
Machine1	0.3308	Machine18	0.3584
Machine2	0.8865	Machine19	0.6762
Machine3	0.1680	Machine20	0.8538
Machine4	0.6863	Machine21	0.2391
Machine5	0.3368	Machine22	0.3275
Machine6	0.2563	Machine23	0.3482
Machine7	0.4847	Machine24	0.3545
Machine8	0.4551	Machine25	0.3199
Machine9	0.1906	Machine26	0.6025
Machine10	0.3418	Machine27	0.6238
Machine11	0.4064	Machine28	0.5054
Machine12	0.4923	Machine29	0.7136
Machine13	0.3490	Machine30	0.7544
Machine14	0.2074	Machine31	0.0000
Machine15	0.3774	Machine32	0.1349
Machine16	0.2533	Machine33	0.1108
Machine17	0.3039		

According to table 16 and VIKOR index, general and separate prioritization is determined for each of machines.

Table 16.
Prioritization of machines

Machine Number	Q_i	General priority	Separate Priority	Machine Number	Q_i	General priority	Separate Priority
Machine1	0.3308	13	10	Machine18	0.3584	19	16
Machine2	0.8865	33	30	Machine19	0.6762	28	25
Machine3	0.1680	4	1	Machine20	0.8538	32	29
Machine4	0.6863	29	26	Machine21	0.2391	7	4
Machine5	0.3368	14	11	Machine22	0.3275	12	9
Machine6	0.2563	9	6	Machine23	0.3482	17	14
Machine7	0.4847	23	20	Machine24	0.3545	18	15
Machine8	0.4551	22	19	Machine25	0.3199	11	8
Machine9	0.1906	5	2	Machine26	0.6025	26	23
Machine10	0.3418	15	12	Machine27	0.6238	27	24
Machine11	0.4064	21	18	Machine28	0.5054	25	22
Machine12	0.4923	24	21	Machine29	0.7136	30	27
Machine13	0.3490	16	13	Machine30	0.7544	31	28
Machine14	0.2074	6	3	Machine31	0.0000	1	1
Machine15	0.3774	20	17	Machine32	0.1349	3	3
Machine16	0.2533	8	5	Machine33	0.1108	2	2
Machine17	0.3039	10	7				

According to prioritization, the most critical machine in the category of automatic lathe machines is Machine3, and the ordinary lathe machines is Machine31. Based on the results obtained, this prioritization has a high level of conformity with the views of experts and the decision-making team because, in practice, the selected critical machine is one of the sensitive and expensive machines in the plant, and replacing it is impossible to sustain the production process. This underscores the importance of selecting optimal maintenance and repair strategies for the equipment of this plant.

Sensitivity Analysis

By changing value of weight parameter of criteria the alternatives are re-prioritized. For this purpose, the obtained combined weight is replaced by calculated weights of ANP and Shannon Entropy method. Therefore, by using each of the weights for criteria, a separate prioritization has been determined using VIKOR method. Finally, the overall ranking is calculated using the average ranks. It should be noted that the alternative that has the lowest average in the ranks is given higher priority. Based on this, Machine31, Machine33, and Machine32 are placed in the first, second, and third priorities respectively. According to table 17 and diagram 2, the change in the weight of criteria affects the individual prioritization of machines and does not affect the overall prioritization.

Table 17.
Changing the criteria weights and re-prioritization of machines

Machine Number	**Q_i**			**Rank**				
	Hybrid	**ANP**	**Shannon Entropy**	**Hybrid**	**ANP**	**Shannon Entropy**	**Rank average**	**Final Ranking**
Machine1	0.330838	0.358668	0.82506	13	13	17	14.33333	14
Machine2	0.886533	0.882092	0.902838	33	33	26	30.66667	33
Machine3	0.167972	0.200148	0.682204	4	3	5	4	4
Machine4	0.686265	0.738937	0.996903	29	29	33	30.33333	30
Machine5	0.33677	0.399044	0.737927	14	17	9	13.33333	12
Machine6	0.256325	0.27768	0.748194	9	8	10	9	9
Machine7	0.484705	0.532482	0.792393	23	23	14	20	21
Machine8	0.455076	0.519949	0.833708	22	22	18	20.66667	22
Machine9	0.190602	0.227232	0.702177	5	6	6	5.666667	6
Machine10	0.341812	0.312218	0.835296	15	11	19	15	15

Machine Number	Q_i			Rank				
	Hybrid	ANP	Shannon Entropy	Hybrid	ANP	Shannon Entropy	Rank average	Final Ranking
Machine11	0.406396	0.455636	0.78975	21	21	13	18.33333	19
Machine12	0.492311	0.556606	0.857623	24	24	23	23.66667	24
Machine13	0.348982	0.418048	0.771873	17	18	11	15.33333	16
Machine14	0.207403	0.17247	0.705653	6	2	7	5	5
Machine15	0.377362	0.449498	0.865835	20	20	24	21.33333	23
Machine16	0.253334	0.305677	0.64952	8	10	4	7.333333	7
Machine17	0.303916	0.386249	0.787875	10	15	12	12.33333	11
Machine18	0.358379	0.440973	0.838116	19	19	20	19.33333	20
Machine19	0.676158	0.714979	0.907322	28	28	27	27.66667	26
Machine20	0.853781	0.849885	0.881102	32	32	25	29.66667	29
Machine21	0.239107	0.272113	0.733184	7	7	8	7.333333	7
Machine22	0.327474	0.336069	0.822566	12	12	16	13.33333	12
Machine23	0.348246	0.386676	0.840514	16	16	21	17.66667	17
Machine24	0.354489	0.382909	0.845851	18	14	22	18	18
Machine25	0.319858	0.295071	0.816126	11	9	15	11.66667	10
Machine26	0.602522	0.674987	0.978187	26	26	32	28	27
Machine27	0.623771	0.682375	0.975043	27	27	30	28	27
Machine28	0.505416	0.583759	0.960936	25	25	28	26	25
Machine29	0.713644	0.76386	0.976613	30	30	31	30.33333	30
Machine30	0.754432	0.786056	0.968877	31	31	29	30.33333	30
Machine31	0	0.097321	0	1	1	1	1	1
Machine32	0.134885	0.215618	0.107977	3	5	3	3.666667	3
Machine33	0.110838	0.203723	0.09424	2	4	2	2.666667	2

The results of sensitivity analysis implementation is shown in diagram 2.

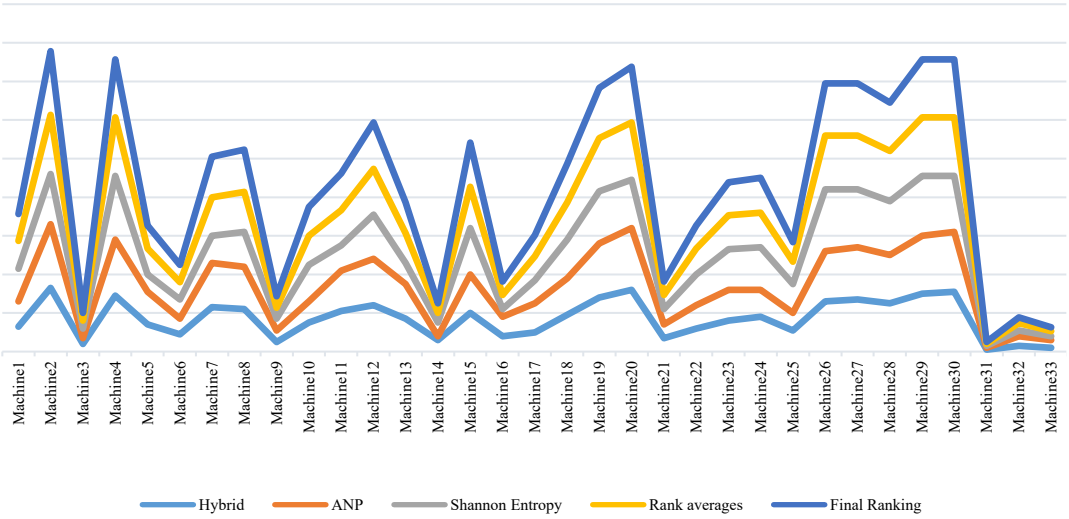

Diagram 2. *The results of sensitivity analysis*

Conclusion

The Industry 4.0 refers to a new concept of industrial and technological advancements in the modern world. Ensuring system safety and reliability is increasingly becoming a fundamental issue in the digital transformation paradigm, also known as Industry 4.0, with the introduction of new technologies and the growth of system complexity. In fact, the concern about reliability and safety is developing in various industries, which plays an important role in meeting demand and increasing productivity and availability at the lowest possible cost and with the least unexpected breakdowns. In order to identify and mitigate process bottlenecks, proactive approaches to reliability and safety analysis are critical in

high-risk sectors. As part of the efforts to development of operational strategies in the fourth industrial revolution is prioritization of machinery based on comprehensive analysis of maintenance risks and operational repairs. Based on this, in this paper, a combination of DEMATEL, ANP and Shannon entropy and VIKOR methods with fuzzy features in cellular production systems is presented, considering effective criteria for reliability in Industry 4.0. Based on the results, the implementation of this method can contain valuable knowledge for continuous improvement of maintenance, productivity, increasing the level of equipment availability and increasing efficiency by monitoring equipment performance for maintenance managers. The presented method provides additional information for decision-making, enabling the most critical machine selection in Cellular Manufacturing Systems. As suggestions for future research to optimize machine performance in Industry 4.0, determining critical machine failures, prioritizing critical machine failures, identifying the most critical failures, and investigating the causes of these failures can be considered. Also, solutions can be explored to reduce or eliminate identified critical machine failures.

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RESEARCH ARTICLE **Open Access**

Future Trends and Challenges in Sales and Operations Planning (S&OP): A Systematic Literature Review

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Abstract
Effective supply chain management (SCM) enhances organizational performance by optimizing resource allocation, reducing costs, and increasing customer satisfaction through streamlined operations and cross-functional collaboration. This leads to improved inventory management, higher service levels, and a competitive edge. Sales and operations planning (S&OP) plays a vital role in aligning demand forecasts with supply capabilities, fostering visibility and proactive decision-making. This minimizes inventory costs and improves responsiveness to market changes, supporting strategic goals and long-term success. Despite its importance, a gap remains in systematic literature reviews that categorize trends and challenges in S&OP. Addressing this gap aids supply chain managers in identifying and understanding current challenges and trends, facilitating informed decision-making. This study conducted a comprehensive systematic literature review, examining 295 studies and selecting 66 relevant articles published between 2012 and 2023 using screening methods coupled with TOPSIS and ANP techniques. The results reveal that most studies focus on optimization models for S&OP, employing optimization techniques, simulation, heuristic methods, artificial intelligence, machine learning, statistical approaches, and qualitative models. The research identified key S&OP planning issues and various models for addressing them. It also highlights emerging trends, such as the increasing use of machine learning and artificial intelligence to improve demand forecasting and decision support systems. Additionally, the growing focus on sustainability in supply chains, including reducing carbon emissions and minimizing waste, is being integrated into S&OP models. However, challenges persist, including dependence on accurate and reliable data, data quality issues, and organizational resistance to change. The complexity of S&OP processes also presents obstacles. This review provides insights into S&OP models, trends, and challenges, and offers future research directions, emphasizing AI integration, sustainability, and hybrid modeling approaches. Addressing these challenges can enhance alignment between sales, production, and inventory, ultimately improving business performance.
Keywords: *Sales and Operations Planning, Supply Chain Management, Machine Learning, Artificial Intelligence, Sustainability*

Introduction

The Sales and Operations Planning (S&OP) process plays a critical role in boosting organizational performance by forming a vital link between sales, production, and inventory management functions. This alignment is essential as it fosters the efficient coordination of material, financial, and informational flows, enabling businesses to effectively meet customer demand while maximizing their supply capabilities (Almeida et al., 2021). The S&OP process has evolved from a tactical tool into a strategic advantage for organizations seeking to enhance their market positions through resource-based and market-driven

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approaches to supply chain management. Research has shown that successful S&OP implementation fosters greater cooperation among business units, increases operational transparency, optimizes inventory management, improves sales and forecasting accuracy, elevates service levels, and enhances capacity utilization (Hung & Eldridge, 2019; Matsebatlela & Mpofu, 2015; Farias et al., 2017). These operational improvements not only translate into tangible financial gains but also facilitate the achievement of broader organizational visions and goals.

The historical roots of S&OP can be traced back to the early 1960s, where large corporations like General Motors and Procter & Gamble recognized the necessity for an integrated approach to sales and production, initially termed "Sales and Production Planning." During this formative era, organizations focused primarily on optimizing resource utilization and reducing operational costs (Krajewski & Ritzman, 2012). As the business environment became more complex, S&OP transitioned into a comprehensive management process, particularly refined during the 1980s by companies such as IBM and Hewlett-Packard. These firms expanded the S&OP framework beyond merely coordinating sales and production to include a variety of functions like marketing, supply chain management, and inventory controls (Farris et al., 2017).

The technological advancements of the 1990s represented a pivotal period for S&OP processes. The adoption of sophisticated information systems and management software—including Supply Chain Management (SCM) and Enterprise Resource Planning (ERP) systems—facilitated more efficient and accurate data collection and analysis (Chopra & Meindl, 2013). This technological evolution laid the foundation for contemporary S&OP practices, empowering organizations to respond more quickly to customer needs and market fluctuations.

Advancements in technology, particularly the rise of artificial intelligence (AI), have further transformed S&OP processes (Martínez-Lopez & Casillas, 2013; Jarrahi, 2018). AI applications are instrumental in optimizing processes across various sectors, including supply chain management. The multifaceted S&OP process involves crucial functions such as demand forecasting, supply planning, inventory management, and performance evaluation, all of which require significant collaboration and coordination across multiple stakeholders (Hübl & Fischer, 2017). The integration of AI and machine learning allows organizations to effectively process large volumes of data, thereby enabling more informed decision-making and operational success.

Despite these advancements, practical challenges persist in implementing S&OP models. Issues such as data quality, availability, and the integration of technology pose significant barriers to successful implementation. Additionally, resistance to change within organizations often hinders the adoption of optimized S&OP processes that necessitate substantial operational adjustments. The inherent complexity of S&OP processes requires a strategic approach that adequately captures the various factors influencing decision-making, calling for a deeper understanding of current research trends, models, and operational challenges.

The necessity of this research is evident. Optimizing S&OP processes is not solely beneficial for individual organizations; it also has broader implications for supply chain efficiency and market competitiveness. If these issues remain unaddressed, organizations risk facing persistent inefficiencies, suboptimal resource allocation, elevated operational costs, and reduced responsiveness to changing customer demands. This study aims to illuminate these challenges by developing a structured framework to assist organizations in navigating the complexities of S&OP, thus enhancing theoretical understanding as well as practical applications.

A comprehensive review of existing literature reveals a significant gap in analyses that effectively connect theoretical models with practical applications within the S&OP framework. While there has been substantial exploration concerning demand forecasting techniques and inventory optimization strategies, many studies indicate a disconnection between these theoretical constructs and their practical applicability in real-world scenarios. This research aims to bridge this gap by offering insights into how existing S&OP models can be leveraged effectively in practice. The study plans to examine current trends in S&OP optimization models and identify key variables influencing theireffectiveness.

To accomplish these objectives, the research will focus on clearly delineated goals:

Analyze Current Models: Investigate existing S&OP optimization models across various industries to assess their effectiveness and applicability.

Identify Key Features: Explore the key features, variables, and frameworks underpinning these models, evaluating both their strengths and areas for improvement.

Examine Trends and Challenges: Evaluate current trends in forecasting methodologies related to S&OP planning while identifying associated challenges that practitioners encounter.

By addressing these objectives systematically, this research seeks to improve understanding of S&OP and offer valuable insights that can bolster organizational performance through enhanced decision-making capabilities.

Moreover, the concept of professionalism within organizations, highlighted in contexts such as the Shiraz University of Medical Sciences, serves as a significant backdrop for understanding S&OP effectiveness. As a leading scientific institution in the Middle East, Shiraz University attracts a diverse student body and plays a vital role in health education and service delivery. This institution embodies principles of professionalism that include adherence to ethical standards, prioritizing societal well-being, and fostering the continuous development of knowledge and skills (Zao, 2018). Emphasizing professionalism in healthcare and education can enrich the implementation of S&OP processes by establishing a culture of collaboration, accountability, and high performance.

In conclusion, integrating effective S&OP processes is crucial for organizations striving for enhanced operational efficiency and a competitive edge. While technological advancements and innovative methodologies in S&OP present opportunities for improvement, enduring challenges like data quality issues, organizational resistance to change, and practical implementation hurdles continue to obstruct optimal performance. This research is essential for clarifying these challenges, articulating the need for optimized S&OP, and furnishing a structured framework to assist organizations in overcoming existing impediments. By emphasizing both theoretical insights and practical applications, this study aspires to make a significant contribution to enhancing organizational performance through improved decision-making and strategic alignment in S&OP practices.

Methodology

The method of conducting a systematic literature review of models, trends, and challenges in optimizing sales and operations planning (S&OP) processes follows the guidelines outlined in the Sage Organizational Research Methods Handbook (Denier and Turnfield, 2009), shown in Figure 1.

The first step in conducting a systematic literature review is to clearly define the research question and the scope of the review, as outlined in Table 1. This step establishes the focus and direction for subsequent literature searches and analyses.
In this review of S&OP optimization models and trends, the main research question is articulated as: “What are the models, trends, and challenges in optimizing sales and operations planning (S&OP) processes?”

This question focuses specifically on optimization models and trends related to S&OP processes and examines the challenges associated with their optimization. Furthermore, three sub-questions are presented:

- What models are used for S&OP planning? (RQ1)
- What features, variables, solutions, and paradigms are utilized in these models? (RQ2)
- What are the trends and challenges in forecasting S&OP planning? (RQ3).

To facilitate the search process, the scope of the review must be clearly defined. Studies published between 2012 and 2023 will be included, providing a reasonable timeframe for capturing current research and advancements in S&OP optimization models. Specifying this time range also makes the search process more manageable.

Moreover, this review encompasses a diverse range of industries, including food manufacturing, retail, healthcare, and more. Rather than concentrating solely on industry-specific issues, this approach aims to highlight generalizable optimization models and trends applicable across various supply chain contexts.

Clearly defining the research question and scope is crucial for guiding the objectives and influential parameters of the literature review. This foundational step ensures that the review is organized and systematically addresses the topic of interest. Additionally, a well-defined domain enhances the efficiency of text searching by providing specific and relevant criteria. Overall, this process lays the groundwork for creating a comprehensive systematic review of the S&OP planning literature.

As part of this initial step, a pilot search will be conducted to better understand the context under investigation and the existing literature. Utilizing the defined parameters, a targeted search will be performed in the electronic databases of various publishers to identify relevant sources for the literature review.

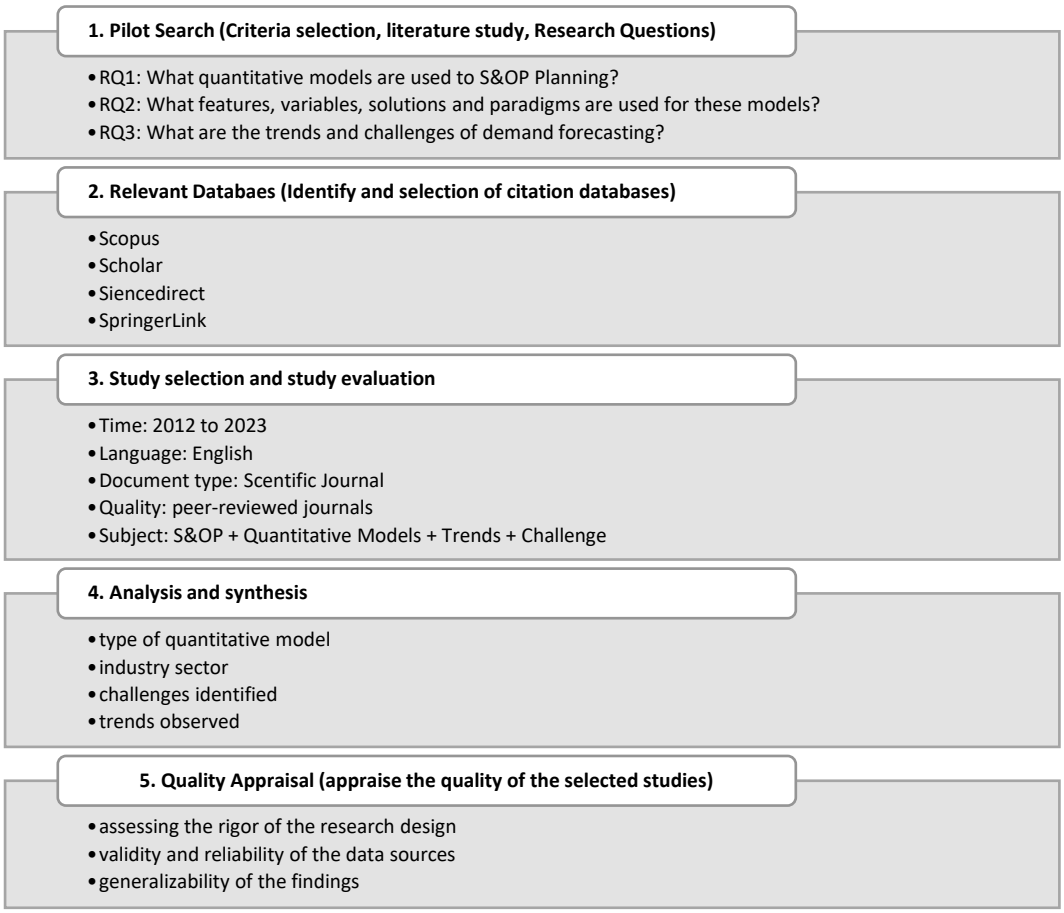

Figure 1. *Systematic literature review process*

Table 1.
Search protocol for selected literature databases

Database	Section	Field	Search string	Time
Scopus Scholar Science direct Springer Link	Title, Abstract, Keywords	Business, Management and Accounting	"S&OP" AND " Models" AND "Challenges" AND "Trends"	2012 - 2023

Table 2.
Search results based on databases and search terms.

Search string	Scholar	Science direct	Scopus	Springer Link	Total
“S&OP Planning” AND “Challenge”	2	10	18	4	34
“S&OP Planning” AND “ Model”	141	14	49	41	245
“S&OP Planning” AND “Trend”	1	7	5	3	16
Total	144	31	72	48	295

Search databases

To conduct the search, this study utilized several relevant databases, including ScienceDirect, SpringerLink, Scopus, and Google Scholar, employing expert opinion scoring to evaluate relevance. These databases were selected due to their comprehensive coverage of the literature pertaining to the subject matter. By using multiple databases, the study aims to ensure the identification of all pertinent studies, thereby minimizing the risk of overlooking significant research.

Key terms employed in this study include "sales and operations planning," "S&OP," "models," "challenges," and "trends." These search terms were carefully chosen based on the research questions and objectives, which focus on identifying and analyzing models, trends, and challenges in optimizing S&OP processes. Utilizing these specific key terms allows the study to focus the search on the most relevant literature, enhancing the validity and reliability of the findings.

The search was restricted to articles published in English. This limitation was based on the predominance of English-language publications and the peer-reviewed nature of the articles selected from these databases. By confining the search to reviewed articles, the study ensures the inclusion of high-quality research that adheres to established standards.

The search process was executed by two independent researchers to ensure comprehensiveness and impartiality. Any discrepancies between the researchers were resolved through discussion and consensus. Additionally, the authors maintained an archive of all identified studies during the search process, contributing to the transparency and reproducibility of the study.

Selection and evaluation of studies

The selection and evaluation of studies for a systematic literature review (SLR) on Sales and Operations Planning (S&OP) is a critical phase that significantly impacts the depth, quality, and reliability of the resulting analysis. By focusing on studies that specifically address S&OP processes, models, and challenges, we aim to construct a comprehensive and focused survey of this research field.

Our research began with an extensive search of relevant databases, leading to the identification of 295 articles. To ensure the integrity of our study, a rigorous screening process was implemented. This involved removing duplicate articles, applying quality ranking criteria for journals, and evaluating abstracts and full articles. As a result, we were able to narrow our selection to 66 high-quality articles that formed the core of our analysis.

However, ensuring the robustness and reliability of the selection process required the use of structured decision-making tools. For this purpose, we employed two powerful multi-criteria decision-making (MCDM) methods: ANP (Analytic Network Process) and TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution).

Analytic Network Process (ANP)

ANP is an advanced decision-making method that extends the traditional Analytic Hierarchy Process (AHP) by incorporating complex interdependencies between decision criteria. In contrast to AHP, which assumes that criteria are independent of one another, ANP allows for the interaction and feedback between criteria, making it particularly useful in evaluating research articles where multiple factors—such as publication quality, relevance, and author reputation—may influence each other. In our study, we used ANP to build a network model that captured these interrelationships between various criteria used to evaluate the articles. The key criteria included:

- The scientific ranking of the journal in which the article was published.
- The clarity and relevance of the article's title and abstract.
- The reputation of the authors and their expertise in the S&OP domain.

By structuring these criteria into a network, we assigned relative weights to each criterion, reflecting their importance within the overall evaluation framework. This weighting process helped ensure that all relevant factors were taken into account in a balanced manner during the article evaluation.

Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS)

After the ANP was used to establish a set of weighted criteria, we applied the TOPSIS method to rank the articles based on their proximity to an "ideal" solution. TOPSIS is particularly effective in decision-making

scenarios where alternatives (in this case, articles) need to be ranked based on multiple criteria.

In TOPSIS, each article was evaluated by comparing its performance against both an ideal solution (the best possible score) and a negative-ideal solution (the worst possible score). The distance from these two reference points was calculated, and articles were ranked based on their geometric closeness to the ideal solution. Articles that scored closer to the ideal were ranked higher, while those closer to the negative ideal were ranked lower. For our screening process, each article was scored on a scale of 1 to 5 using the SuperDecision software, based on the following criteria:

- Scientific ranking of the publication – Higher-ranked journals contributed to better scores.
- Quality of the title and abstract – Clarity and relevance of the content were crucial.
- Reputation of the authors – Renowned experts in the field were rated more favorably.

Articles with a score below 3 were eliminated, as they were deemed not to meet the quality standards required for inclusion in the systematic literature review.

Outcomes of the Evaluation Process

The combined application of ANP and TOPSIS allowed us to refine our selection process with precision. Initially, 295 studies were identified. After removing duplicates, 223 unique articles remained. The application of quality-ranking criteria led to the exclusion of 130 articles, and abstract evaluations removed an additional 8. A detailed review of the full texts of the remaining articles resulted in the exclusion of 20 more, leaving a final selection of 66 high-quality studies.

These 66 articles form the foundation of our literature review. By leveraging ANP and TOPSIS, we ensured that the final selection was not only comprehensive but also highly relevant and of the highest quality. This systematic approach enabled us to highlight emerging trends, best practices, and critical challenges within S&OP, providing actionable insights and a thorough understanding of the field. The use of ANP and TOPSIS in this systematic literature review was not simply a procedural step but a critical method to ensure the robustness and validity of the research findings. Through these methods, we were able to objectively evaluate and rank articles, ensuring that only the most relevant and high-quality studies were included in our analysis. This structured approach significantly enhanced the quality and focus of the review, aligning it with the primary objectives of our research.

As previously mentioned, the selection and evaluation processes are not merely procedural requirements but essential steps in ensuring the accuracy, relevance, and validity of research findings. The systematic approach adopted in screening studies plays a fundamental role in shaping the study's presentation, allowing us to deliver a detailed review based on empirical evidence and scientific discourse.

The review and screening of articles using effective criteria are crucial for analyzing studies conducted in S&OP (Sales and Operations Planning). By focusing on articles that directly address key aspects of S&OP, we highlight emerging trends, best practices, and challenges within the field. This targeted approach enables us to transform complex information into actionable insights and provide a comprehensive understanding of the research topic's dynamics.

Therefore, it can be asserted that the selection and evaluation of studies for a systematic literature review on this research topic is not only necessary for conducting the research process but also vital for validating the research findings. Through a systematic approach, we assembled a collection of research that aligns with the study's main objectives and offers valuable insights for the literature review.

Table 3 below outlines the specific process undertaken to conduct the research literature review. It details the number of articles identified at each stage of the screening process. Initially, 295 studies were identified

through database searches. After removing 72 duplicate articles, 223 unique articles remained. The researchers then applied a quality ranking review, resulting in the exclusion of 130 articles that did not meet the desired quality criteria. Examining the abstracts and frameworks of the remaining studies led to the exclusion of 8 more articles, reducing the total to 86 studies. The final step involved thoroughly reading the full texts of these studies, resulting in the exclusion of an additional 20 articles. Ultimately, a set of 66 high-quality articles remained, which form the foundation of the literature review.

The temporal distribution of the 66 scientific articles included in the systematic literature review on models, trends, and challenges in sales optimization and operations planning (S&OP) has varied over the years. These articles were published between 2012 and 2023, with a notable concentration in recent years, reflecting a growing interest and research focus in this field. The graph shows fluctuations in the number of articles published annually, peaking in 2021 and experiencing a slight decline in 2022. This trend suggests that research into S&OP optimization has significantly accelerated over the past decade.

Analysis of studies

This stage is crucial for combining and analyzing data, discovering patterns, and identifying themes related to research questions and objectives. Data extraction includes various aspects of the studies, such as model type, industrial application, identified challenges, and observed trends. These data were selected based on the objectives of the study, as well as trends and challenges within the S&OP process.

The data extraction process was conducted by two independent researchers to ensure accuracy and reliability. Any discrepancies between the researchers were resolved through discussions, and an archive of the extracted data was created to enhance the transparency and reproducibility of the studies.

Following data extraction, the analysis phase commenced to identify patterns and themes. This step required categorizing the data based on similarities and differences, and identifying recurring key themes across all studies. By employing a combination of inductive and deductive approaches, the authors gained insights aligned with the research questions and objectives of the study.

Table 3.
Search results based on execution and elimination stages

Steps	Springer Link	Science direct	Scholar	Scopus	Total
1. Search in identified Citation Databases	48	31	144	72	295
2. Remove Duplicate	41	14	120	48	223
Exclude	(7)	(17)	(24)	(24)	(72)
3. Journal Ranking Review	33	13	13	33	93
Exclude	(8)	(1)	(107)	(15)	(130)
4. Reading Abstract & Framework	30	13	12	31	86
Exclude	(3)	0	(1)	(2)	(7)
5. Reading Full Text	17	13	11	25	66
Exclude	(13)	0	(1)	(6)	(20)

Table 4.
Distribution of articles by analysis method

Analysis method	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**Total**
Qualitative Study	1	1	3	2	1	1	4	3	2	4	2	1	25
Models		3	2	3			2	1	2	2	3	1	19

Analysis method	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Total
Optimization	1					1		1	2		1		6
Simulation			1			2	1		1		1		6
Statistical	1	1	1				1				1	1	6
AI & ML								1			1	2	4
Total	3	5	7	5	1	4	8	6	7	6	9	5	66

Table 5.
Distribution of articles by category

Category	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Total
Perspectives	2	3	4	1	1	1	6	4	2	2	4	2	32
Challenges		1		1		2	1		2		3	2	12
Best practices	1		3	2				1	2	1	1		11
Case studies		1		1		1	1	1	1	3	1	1	11
plural	**3**	**5**	**7**	**5**	**1**	**4**	**8**	**6**	**7**	**6**	**9**	**5**	**66**

The analysis process was iterative, with interpretations and conclusions continuously reviewed in light of various issues. Additionally, a sensitivity analysis was performed to validate the findings. This involved re-evaluating the data using different criteria and methods to ensure the consistency and reliability of the results.

Fundamentally, the data extraction and analysis stage plays a central role in revealing and explaining the models, trends, and challenges of the S&OP process. Through careful collection and synthesis of data from multiple studies, the researcher's uncovered insights that define the classification of S&OP process studies. The involvement of two researchers and the implementation of a sensitivity analysis bolstered the reliability and validity of the findings, while meticulous documentation of all data extraction and analysis methods increased the transparency and reproducibility of the study.

Table 4 below presents the distribution of the 66 articles included in the systematic literature review on sales and operations planning (S&OP) models, trends, and challenges, classified by their analysis methods. The table indicates that most studies (25 out of 66) employed qualitative research methods, such as case studies and interviews.

The next most common analytical approach involved the development and application of quantitative models, with 19 articles focusing on this aspect. These studies proposed and evaluated various mathematical models to optimize S&OP processes, often incorporating techniques such as optimization, simulation, and statistical analysis.

The table also highlights the growing trend of using artificial intelligence (AI) and machine learning (ML) methods in research, with four papers published in 2021 and 2023 showcasing the potential of these technologies for demand forecasting and decision support. This illustrates that AI and ML are becoming important tools for enhancing S&OP processes.

Table 5 below categorizes the 66 articles included in the systematic literature review on sales optimization and operations planning (S&OP) models, trends, and challenges. The table shows that most of the articles (32 out of 66) are focused on presenting S&OP perspectives and approaches, such as conceptual frameworks, mathematical models, and decision support systems. These studies aim to provide new insights and methodologies to strengthen S&OP processes.

The second category was studies that discussed challenges and opportunities in

implementing S&OP, with 12 articles examining issues such as data quality, organizational resistance to change, and complexity of S&OP integration. Understanding these challenges is critical for organizations looking to adopt and optimize their S&OP practices.

The table also shows that 11 articles are each categorized as best practices and case studies. Best practices articles discuss successful strategies and techniques for implementing effective S&OP, while case studies provide in-depth analyzes of how specific organizations are using S&OP to improve their supply chain performance.

Results

One of the critical aspects of the literature review on this research topic is the results obtained from the study. The distribution of results in the systematic literature review provides an overview of the types of analyses utilized in the sales and operations planning (S&OP) process. The findings from the studies, categorized by significant issues in sales planning and operations and the solutions proposed by researchers during the study period, are presented in the following tables.

Table 6.
Sales and operation planning issues

Category	Sales and operations planning issues	Quantity	Percentage
Prediction accuracy	Incorrect demand forecasts lead to mismatches in supply and demand	13	20
Customer satisfaction	Decrease in customer satisfaction due to lack of supply and demand balance management	10	15
Inventory management	High inventory or inventory costs due to poor planning	10	15
cooperation	Lack of coordination between departments leads to inefficiency	7	10
Cost management	High costs associated with inefficiencies in the S&OP process	7	10
Supply chain flexibility	Vulnerability to supply chain disruptions	7	10
Market fluctuations	Inflexibility in plans to adapt to market changes or disruptions	3	5
Performance criteria	KPIs in capturing the effectiveness of S&OP processes	3	5
Process integration	Silent processes that cause communication delays and disruptions	3	5
Acceptance of technology	Resistance to adoption of new S&OP technologies	3	5
Total		**66**	**100**

Table 7.
Methods of solving sales and operation planning problems

Category	Problem solving method	Quantity	percentage
Mathematical modeling	Advanced statistical methods, inventory optimization models, safety stock calculations, scenario analysis	14	22
Simulation	System dynamics, digital twins	5	8
exploratory models	Lean manufacturing principles, just-in-time practices (JIT), balanced scorecards, change management strategies , continuous improvement measures	11	16
Artificial intelligence and machine learning	AI (artificial intelligence), machine learning algorithms, predictive analytics, artificial intelligence, big data analytics	10	15
Statistical models	Advanced statistical methods	8	12

Category	Problem solving method	Quantity	percentage
Qualitative and structural models	Collaborative forecasting, cross-functional teams, customer relationship management (CRM) ,advanced service level agreements SLA ,ERP systems , collaborative platforms, cost optimization tools, supplier base diversification, integrated business planning IBP ,Internet of Things (IoT) Index Key performance indicators KPIs ,(risk management frameworks , stakeholder engagement initiatives, process mapping, supply chain risk management	18	27
Total		**66**	**100**

As shown in Table 6, the main issues in sales and operations planning identified from the selected studies include forecasting accuracy, process coordination, inventory management, customer satisfaction, and process integration. These have emerged as the most critical concerns in recent years. Several important challenges have been highlighted: incorrect demand forecasts that lead to mismatches between supply and demand, decreased customer satisfaction due to inadequate management of supply-demand balance, high inventory costs or stock shortages resulting from poor planning, elevated costs associated with inefficiencies in the S&OP process, and a lack of coordination between departments leading to further inefficiencies and increased vulnerability to supply chain disruptions.

On the other hand, researchers have proposed various methods to address these problems. The most prominent solutions include collaborative forecasting, advanced statistical methods, cross-functional teams, comprehensive organizational planning systems, and machine learning, among others. These solutions, along with their respective categories, are detailed in Table 7.

Discussion

To address the main research question, we have formulated three specific research questions aimed at providing an accurate and comprehensive answer. This section addresses each of these questions in detail:

What are the models, trends, and challenges in optimizing Sales and Operations Planning (S&OP) processes?

This question focuses on the optimization models and current trends related to S&OP processes. It also examines the challenges associated with optimizing S&OP. In addition, there are three sub-questions:

- What models are used for S&OP planning? (RQ1)
- What features, variables, solutions, and paradigms are used in these models? (RQ2)
- What are the trends and challenges in forecasting S&OP planning? (RQ3)

We will delve into these questions in the next section.

Importance of Models in S&OP Planning

Models provide a systematic and structured approach to S&OP planning and enable organizations to make informed decisions based on data and analytics. They are widely used in S&OP planning to:

Optimize production and inventory levels.

Model uncertain and imprecise information.

Evaluate the impact of demand forecasting errors.

Optimize conflicting objectives.

Determine optimal production and inventory policies under demand uncertainty.

In the following sections, we will answer the specific research questions and elaborate on the importance of these models in S&OP processes.

Linear programming models

Linear programming models are among the most popular for S&OP planning, as they consider various constraints such as capacity, inventory, and labor to determine the optimal production schedule. For example, Almeida et al. (2021) proposed an optimal S&OP model for integrated steel industries focusing on minimizing production costs, inventory holding costs, and back orders, while

maximizing customer satisfaction. Nemati et al. (2018) introduced a fuzzy bi-objective mixed integer linear programming (MILP) approach for integrating sales, production, distribution, and logistics planning in a fast-moving consumer goods (FMCG) supply chain, aiming to minimize total costs and maximize customer satisfaction under uncertain supply and demand conditions. Albrecht & Steinrücke (2019) developed a continuous scheduling model for production, distribution, and sales in supply chains with reduced prices. Hassanzadeh et al. (2017) proposed a mixed integer nonlinear programming model addressing the order acceptance problem in customized manufacturing systems, focusing on maximizing total expected profit while considering capacity constraints and uncertain demand. Wang et al. (2012) presented an advanced S&OP framework incorporating multiple levels of planning and optimization techniques to improve supply chain performance, demonstrated through a case study of a manufacturing company in Slovenia. Yang et al. (2020) proposed an integrated S&OP model for multiple products, optimizing the number and timing of advertising and production decisions, illustrated with a case study of a Chinese company.

While linear programming models are widely used, other models have also been applied in S&OP planning. Markov Decision Process (MDP) models handle S&OP planning decisions under uncertainty. Discrete event simulation models evaluate the performance of S&OP planning systems under different scenarios. Multi-objective optimization models aim to optimize conflicting objectives, such as balancing production costs and customer service levels. Fuzzy logic models manage uncertain and imprecise information in S&OP planning.

Recent trends in S&OP research include the increasing use of data analytics and machine learning techniques, which are revolutionizing S&OP planning. Additionally, there is a growing focus on minimizing carbon emissions in the supply chain as part of S&OP planning. Despite these advancements, several challenges remain. The lack of data integration and collaboration across organizational processes makes it difficult to manage uncertainty and fluctuating demand effectively. Uncertainty in demand can lead to either insufficient or excess inventory, resulting in lost sales or increased costs. To address these challenges, organizations should invest in data integration and enterprise process collaboration tools to enhance the efficiency and effectiveness of their S&OP processes.

Simulation models

There has been growing interest in using simulation-based optimization models to enhance S&OP processes. This section discusses some recent studies employing simulation techniques to optimize these processes. Tliba et al. (2022) proposed a dual digital dynamic scheduling method for a manufacturing plant and evaluated its effectiveness through simulation, comparing it with other scheduling methods. Al-Hafsi et al. (2018) introduced a simulation-optimization framework for S&OP in a co-production context, aiming to explore new product opportunities. This framework combined a multi-period mixed integer linear programming model with a discrete event simulation model, demonstrating its effectiveness in a case study.

Lim and Kim (2014) utilized advanced planning and scheduling systems (APS) in S&OP planning, employing simulation to test various production scenarios and analyze the results. Dravai et al. (2017) presented a simulation-based business scenario, comparing different logistics and production scenarios using S&OP planning and analyzing the learning outcomes. Zendieh et al. (2020) proposed an optimization model based on stochastic multi-objective simulation for S&OP planning in a make-to-order and outsourcing context. They applied the model to a case study of an Iranian company, comparing it to traditional S&OP models. In the automotive industry, Zhang and Wang (2017) developed a simulation

optimization approach for S&OP planning in make-to-order environments, combining demand forecasting, capacity planning, and production scheduling, and tested it through a case study.

Simulation-based optimization models offer several advantages over traditional optimization models in S&OP planning. They enable the analysis of complex systems with various sources of uncertainty such as demand and time variability. Simulation can also provide valuable insights into system dynamics, crucial for understanding the impact of different decisions on overall system performance.

Despite these benefits, challenges remain in using simulation-based optimization models for S&OP planning. The complexity of simulation models can make interpreting results and effectively communicating them to decision-makers difficult. Additionally, the accuracy of these models heavily relies on the quality of input data, which can be challenging to obtain in real-world settings.

In conclusion, literature shows that simulation-based optimization models are increasingly used to optimize S&OP processes. The studies reviewed demonstrate the effectiveness of simulation in enhancing S&OP planning across various contexts. However, there are challenges, primarily the need for comprehensive data input and the development of accurate representations of real-world supply chain dynamics.

Artificial intelligence and machine learning models

The use of artificial intelligence (AI) and machine learning (ML) techniques to optimize S&OP processes has been gaining significant attention. This section discusses several recent studies that have employed these techniques to enhance S&OP processes.

Effat et al. (2022) proposed a deep learning model using Hybrid Adaptive Trend Estimation Series (HATES) for sales modeling and forecasting. The HATES method combines the strengths of adaptive filtering and trend estimation to improve the accuracy of sales forecasting. The authors evaluated the performance of the HATES model using real sales data from a supermarket chain in Bangladesh. Hossein Nia and Ebrahimi (2022) conducted a systematic literature review of deep learning applications in supply chain management (SCM), focusing on identifying current research trends and gaps, and providing a framework for future research. This review covers various SCM areas, such as demand forecasting, inventory management, production planning, and logistics, and discusses the benefits and challenges of using deep learning in each area.

Shakeri et al (2020) explores how contracts can effectively coordinate a two-tier supply chain under competitive conditions, particularly focusing on managing the uncertainties in demand for perishable goods. Alavi et al (2020) develops a mathematical model that utilizes the Bee Algorithm for selecting production suppliers, demonstrating its effectiveness compared to traditional Genetic Algorithms in optimizing supplier selection processes within supply chains.

Kim et al. (2019) proposed a machine learning-based demand forecasting model for mass customization in smart manufacturing. The authors demonstrated the model's effectiveness through a case study of a South Korean manufacturing company. Ferreira et al. (2023) presented a case study on the redesign, intelligent, and digital activation of S&OP processes in a home appliance manufacturing company. Using a qualitative research approach, the authors analyzed the impact of the redesign on the S&OP process.

AI and ML techniques offer several advantages over traditional optimization models in S&OP planning. These techniques can handle large and complex datasets, identify patterns and trends in the data, and make accurate predictions. The use of AI and ML can improve the accuracy of demand forecasting, reduce inventory costs, and increase customer service levels.

However, despite these benefits, challenges remain in using AI and ML

techniques for S&OP planning. The accuracy of the models heavily relies on the quality of the input data, which can be challenging to obtain in real-world settings. Additionally, the complexity of these models can make the results difficult to interpret and effectively present to decision-makers.

In summary, the literature review indicates that AI and ML techniques are increasingly being used to optimize S&OP processes. While these techniques have shown promise in the discussed studies, their implementation can be problematic due to issues related to data availability and quality, as well as the expertise required to develop and maintain these complex models.

Heuristic models

The importance of heuristic models in optimizing S&OP processes has been increasingly recognized. This section discusses some of the recent studies that have utilized these models to enhance S&OP processes.

Jansen et al. (2013) propose a waiting time forecasting (LTA) method for supply chain operations planning (SCOP) that improves planning accuracy by considering waiting time variation and its impact on inventory performance and service levels. The LTA method involves estimating the delivery time distribution and adjusting the reserve stock and order quantities in the SCOP model. Wolfshornd et al. (2020) investigated the use of an advanced planning system (APS) as a support tool for sales and operations planning (S&OP) in a Brazilian automotive company, analyzing the implementation process, benefits, limitations, and the importance of organizational culture and communication for successful APS and S&OP implementation.

Oliveira et al. (2022) conducted a study to address the challenges of implementing S&OP in a medium-sized auto parts company. They identified key barriers such as lack of communication, resistance to change, and data quality issues, providing solutions to overcome these challenges. Prasad (2021) investigated the impact of smart ERP on supply chain agility and the use of graph theory for adaptation in the Indian automotive industry.

Erat & Ferreira (2015) proposed an inventory management framework (IMF) to minimize supply and demand mismatch in a manufacturing organization, examining S&OP and inventory management while considering holding costs and inventory levels. Havaldsen et al. (2015) analyzed the use of complex production planning (MPS) techniques to improve performance in manufacturing organizations through a case study.

Boyer and Verma (2014) suggested the use of Internet-based tools to enhance S&OP and supply chain integration, discussing benefits, challenges, and implementation recommendations. Galán-Ordax et al. (2018) recommended using S&OP to enhance tactical planning in food retailing, identifying challenges and providing effective implementation recommendations.

Sitorus & Womsiwor (2022) presented a case study on an explosives company's implementation of S&OP and an economic order quantity (EOQ) model to improve effectiveness, describing the process and benefits. García Arca et al. (2021) proposed a predictive S&OP approach based on statistical demand forecasting to increase supply chain efficiency, demonstrating its effectiveness through simulation and comparison with traditional S&OP approaches.

Shafiq et al. (2020) discussed the use of big data analytics to enable integrated business planning through S&OP, describing the implementation process and benefits in a manufacturing company. Moras and Nagai (2014) proposed a method for adjusting reserve stock in manufacturing systems with S&OP, using a simulation model to evaluate its effectiveness.

Machuca & Rodríguez (2013) provided an overview of the evolution of operations planning and control (OPC) from manufacturing to supply chain, analyzing main concepts, models, and tools, and

discussing future research challenges and opportunities.

In conclusion, the systematic literature review shows that heuristic models are increasingly used to optimize S&OP processes. The studies discussed demonstrate the effectiveness of these models in improving S&OP planning across various fields. The main challenge in using heuristic models is balancing simplicity with the ability to capture the nuances of the S&OP process.

Statistical models

Statistical models are still being used to optimize S&OP processes. This section discusses several studies that have utilized statistical models to enhance S&OP processes.

Das et al. (2018) examined the role of multitasking teams and social identity theory in S&OP performance. Their study was based on a survey of S&OP teams in manufacturing organizations. Garcia and C. Changko (2013) investigated the impact of S&OP on manufacturing operational performance by conducting a survey among manufacturing companies in the Philippines.

Lee et al. (2022) proposed a sustainable S&OP process involving stakeholder engagement to address sustainability issues in the supply chain. They discussed key challenges and provided recommendations for effective stakeholder engagement. Huang et al. (2022) analyzed the relationship between sales culture and S&OP, as well as supply chain performance. They examined the mediating effects of five coordination mechanisms: information sharing, decision synchronization, resource allocation, incentive alignment, and communication management, using survey data from Chinese manufacturing companies.

Sosa and Ferreira (2014) studied the impact of different S&OP methods on manufacturing operational performance, collecting data through surveys and employing structural equation modeling in Portuguese manufacturing companies. Zhang et al. (2012) proposed a decision model for a make-to-order supply chain, considering uncertainty in demand and delivery time. They developed and tested the model using stochastic programming.

In conclusion, the systematic literature review indicates that statistical models are being increasingly used to optimize S&OP processes. The studies discussed demonstrate the effectiveness of these models in improving S&OP planning across various fields. The main challenges in using statistical models for S&OP optimization include the availability and quality of historical data, as well as the ability to incorporate external factors that may affect demand.

Qualitative and structural models

Qualitative and structural models are still being used to optimize S&OP processes across a wide range of applications. These models enhance decision-making capabilities, reduce costs, increase efficiency, and improve customer satisfaction. This section discusses several qualitative and structural models that have been employed to optimize S&OP processes.

Crowther et al. (2021) provide a comprehensive review of the S&OP literature from both empirical and theoretical perspectives. This review covers various topics related to S&OP, including its definition, goals, benefits, challenges, and success factors. The authors discuss diverse models and methods used in S&OP, concluding that there is no one-size-fits-all approach, and organizations should tailor their strategies to their specific contexts.

Monksgaard et al. (2014) propose a value-based approach to supply chain innovation and identify key success factors. They conclude that organizations should focus on creating customer value while ensuring efficient and effective supply chain operations. The authors propose a framework integrating customer value, supply chain capabilities, and financial performance to guide supply chain innovation.

Holby et al. (2015) investigated the flexibility of a dairy company's supply chain

in Norway, identifying factors affecting flexibility, such as demand diversity, capacity utilization, and production complexity. They propose a model to help organizations improve flexibility by addressing these factors.

Ehsani et al (2020) presents a framework that identifies and assesses various factors influencing organizational performance within supply chains, emphasizing the need for systematic evaluation to enhance efficiency and effectiveness. Pereira (2020) reviews the literature on decision-making models and proposes a comprehensive framework for S&OP. The author argues that S&OP should be viewed as a strategic process integrating finance, marketing, and operations. The proposed framework includes four key elements: demand planning, supply planning, financial planning, and scenario planning.

Rangaswamy et al. (2019) identified emerging trends in the evolution of S&OP towards Integrated Business Planning (IBP). They state that IBP represents the next step in S&OP evolution, involving the integration of business planning processes across all organizational functions. The authors propose a model integrating demand planning, supply planning, and financial planning to guide IBP efforts.

Torabi et al (2021) develops a structured model using Interpretive Structural Modeling (ISM) to identify and analyze the key factors influencing the maturity of technology, aiming to enhance understanding and decision-making in technology management.

Gomez et al. (2020) presented a case study on designing and implementing the S&OP process in a manufacturing company. They found that key success factors include top management commitment, mutual cooperation, and effective communication.

Shafiei et al (2020) identifies key indicators that influence the adoption of management accounting innovations during economic crises, utilizing both qualitative and quantitative methods to develop a structural model that highlights the role of economic indicators, organizational culture, and technology in enhancing management practices.

Tavares Tom et al. (2012) provide a research synthesis of the S&OP literature, suggesting major themes, research trends, and gaps, and future research directions. They highlight the main research topics in S&OP, such as demand management, capacity management, and inventory management. They also identify a need for more research on the role of information technology and the impact of external factors on S&OP.

Wallace and Stahl (2014) provide a framework for aligning organizations with S&OP processes. They argue that successful S&OP requires alignment of people, processes, and systems. Their framework includes defining the S&OP process, aligning the organization, developing the S&OP plan, implementing the plan, and monitoring and improving the process.

Lee et al. (2014) propose a coordination framework for S&OP based on a systematic literature review. This framework consists of four components: organizational structure, decision-making process, information system, and performance measurement. Effective coordination between these components is critical for the success of S&OP.

Wang et al. (2018) provide a literature review of S&OP research from a context-oriented perspective, covering studies published between 2010 and 2018. They identify research gaps and future directions, emphasizing the need for more research on the role of information technology, external factors, and the effectiveness of different S&OP models in various contexts.

Other case studies include implementing S&OP in the industrial food manufacturing sector (Garcia & Sy-Changco, 2015), introducing new products (Reijnders et al., 2022), and using S&OP to improve supply chain performance in a multinational manufacturing company (Sousay et al., 2021). Methodologies for implementing sales forecasting models (González-Rodríguez et al., 2019) and managing

evolutionary paths of S&OP implementation (Brito et al., 2018) are also explored, as well as assessing the maturity level of demand planning (Wikner et al., 2018) and S&OP process performance measurement (Grzybowska-Brzezińska & Kubiak, 2016).

In general, qualitative and structural models demonstrate the effectiveness of these models in improving S&OP planning across various fields. Models help organizations optimize production and sales plans, reduce costs, and enhance efficiency and customer satisfaction. The main challenge in implementing these models lies in overcoming organizational resistance to change and fostering a culture of cooperation and continuous improvement.

Conclusion

To answer the three research questions, this article reviewed articles from the Scopus, Science Direct, Springer, and Google Scholar databases published between 2012 and 2023. Initially, 295 articles were identified. After several filtering stages, including the application of a combined ANP and TOPSIS model, 66 articles were selected and analyzed.

Through the first research question, "What models are used for S&OP planning?", it was found that S&OP planning utilizes various models including mathematical modeling, simulation, artificial intelligence and machine learning models, statistical models, heuristic models, and qualitative and structural models, all of which significantly emphasize optimization techniques.

Addressing the challenges in sales and operations planning (S&OP) necessitates a combination of innovative methods and continuous improvement strategies. The use of artificial intelligence (AI) and big data analysis plays a crucial role in enhancing the accuracy of forecasting and process efficiency. Machine learning algorithms can analyze historical sales data and influential variables such as consumer behavior, market trends, and seasonal variations, helping to identify hidden patterns and trends that improve demand forecasting. Additionally, big data analysis can identify excess or shortage inventory, thereby reducing inventory holding costs through optimization models.

Promoting departmental coordination is another key element. Effective collaboration and coordination among various organizational departments such as production, marketing, finance, and supply chain are critical success factors in S&OP. Collaborative platforms like ERP systems and collaborative software can be very useful in achieving this goal, as they facilitate real-time information sharing between departments. Furthermore, the formation of cross-functional teams comprising representatives from different parts of the organization can enhance interaction, leading to faster and more efficient decision-making.

Resource optimization models also play a significant role in improving resource management and reducing costs. Using mathematical models and simulations to predict and evaluate different scenarios helps organizations make optimal decisions in response to market changes. These models can identify weaknesses in the supply chain and offer effective solutions to improve processes.

In summary, a combination of innovative methods and continuous improvement can help organizations tackle S&OP challenges and enhance their processes.

Limitations

Despite the significant contributions to optimizing Sales and Operations Planning (S&OP) processes, this research has several limitations that may constrain its impact. Below are some of these limitations:

Diversity of Industries: Due to the wide variety of industries and the specific characteristics inherent to each, the results of this research may not be broadly applicable across all fields. The unique conditions and requirements of each industry can influence the effectiveness of the considered models.

Failure to Consider Rapid Market Changes: The study does not specifically investigate sudden changes in market

demand, competition, and economic conditions. These fluctuations can significantly impact S&OP performance and potentially affect the research outcomes.

Limited Evaluation Criteria: The analysis is restricted to certain criteria, and the reviewed results cover only a small portion of the complex aspects of S&OP. Consequently, some key factors may not have been fully considered.

Indirect Review: Many results in this research are based on literature reviews and past studies, indirectly referencing the real experiences of organizations. This approach may lead to inaccuracies in presenting results and operational recommendations.

Insufficient Attention to Organizational Culture: The importance of organizational culture and its impact on S&OP processes is not addressed. Organizational culture can significantly influence the implementation and success of best practices, and ignoring it can limit the understanding of the results.

Acknowledging these limitations can help researchers and experts adopt more comprehensive approaches in future studies on optimizing S&OP processes. Efforts to eliminate or minimize these constraints will enhance the robustness and applicability of the findings.

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RESEARCH ARTICLE **Open Access**

Designing an Entrepreneurial Marketing Model for Brand Life Cycle Management (Qualitative Approach)

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Abstract
The main problem of most companies is the short life of brands. The brand life cycle is used by many business managers and plays a very vital role in determining strategies. Considering propulsions and inhibitors that strengthen or hinder this type of marketing, entrepreneurial marketing (EM) is one of the new topics of the brand life cycle management. An accepted framework for EM and identification of effective factors for brand cycle management is not available. Therefore, the purpose of this article for solving the above mentioned problem is to design an EM model for brand life cycle management. This is how this paper contributes in this regard. The necessity of this research is the short life of brands and the waste of economic and social capital. This current research has qualitative approach and is descriptive-exploratory in data process with conceptual qualitative analysis methodology. The tool applied in this research are interviews |(semi-structured) and the population of this paper includes managers, marketing and brand experts in the field of chemicals, medicine and facilities industries in Eshtehard industrial zone of Tehran, Iran. The target community have been selected by snowball sampling method. Interviews extracted data has been classified by Open, axial and selective codes and were analyzed by Maxqda software. After investigating of codes by experts and eliminating items less than critical amount of 0.62 (according to Lawche formula), finally 166 codes and 23 components as propulsion and 84 codes and 16 components as inhibitors of EM were identified and categorized for brand life cycle management. The conceptual model of this paper has been reached from the review of the research background and interviews with the experts and by the final investigations, we reached to the conclusion that propulsion and inhibitors are affecting on entrepreneurial marketing and consequently on brand life cycle management. The results of this research shows that entrepreneurial marketing is a suitable solution to manage the brand life cycle and prevent the early decline of brands.
Keywords: *Entrepreneurial Marketing, Brand Life Cycle Management, Propulsion and Inhibitors of Entrepreneurial Marketing*

Introduction

In 21st century's competitive markets, brands are always trying to create a favorable image of their products and services in order to create more approving attitudes in customers (Jalalzadeh & Momeni, 2024). Extending the life of brands in the contemporary era is one of the concerns of entrepreneurial businesses. At the same time, brand rejuvenation has a positive effect on the attitudinal and behavioral loyalty of customers. It is the distribution of goods and services that leads to data and ultimately determines the individual and organizational needs of customers (Taghizade, et al.2022). In ambiguity and uncertainty environment,

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the evidence shows that entrepreneurial companies are more effective in managing the life cycle of their brand. One of the strategies used in this regard is entrepreneurial marketing. This type of marketing, as a new strategy, is a theoretical structure to establish a connection between the concepts of marketing and entrepreneurship (Mohabattalab & Rezvan, 2018). In other hand, brands have various ups and downs during their lifetime and usually decline during maturity, which many organizations ignore and lose time and practically witness the death of their brand (Nasimi, 2017). The brand decline reasons are different among industries .The expansion of competitive markets has drawn managers' attention to this category more than ever in recent years. By reviewing all the articles and books between 2010 and 2024, We have noticed that scientific and accepted framework for identifying the propulsion and inhibitors on entrepreneurial marketing and a comprehensive model for brand life cycle management is not available and very few researches have been done about it at the national and international level, so we find the theoretical and practical gap in this field. Therefore, this research seeks to identify the propulsion and inhibitors of entrepreneurial marketing and is followed by the design of an entrepreneurial marketing model to manage the life cycle of the brand in the field of chemicals, medicine and facilities industries.

Research Literature

Entrepreneurial marketing is a key strategy to guide and determine the sustainability of businesses. In most models, the consequences and results of applying entrepreneurial marketing in organizations have been effective in the form of various factors (Taghizade,et al,2022).Entrepreneurial marketing is a connecting concept between two fields of marketing and entrepreneurship. The first case is the role that marketing plays in the field of entrepreneurship and is a vital issue for entrepreneurial businesses. The second case is the role that entrepreneurship can play in the field of marketing, innovation and creative methods that are the subject of entrepreneurship. Entrepreneurial marketing is an action that is defined as effectiveness in facing opportunity, innovation, risk and limited resources and the adaptation of marketing to business needs (Kousegharavi & Safarianhamedani, 2019). Unlike traditional marketing that focuses on the customer, entrepreneurial marketing is equally focused on both the customer and the entrepreneur and is influenced by the values and personal characteristics of the entrepreneur. Entrepreneurial and traditional marketing differ from each other in different aspects such as the approach toward the future, decision-making basis, and the attitude towards risk, the external environment and the unforeseen possibilities. In contemporary times, there is no single international consensus regarding the number and content of entrepreneurial marketing dimensions (Jaberi,et al,2018). The proposed dimensions of entrepreneurial marketing are not independent and have influence on each other, while the dimensions or strategies of entrepreneurial marketing are different from its mix marketing. On the other hand, brands as the main capital of organizations, like living organisms, have beginnings and growth and decline periods and finally death. The reasons for the decline of the brand are very complex and the expansion of competitive markets has drawn the attention of managers to this category more than before (Haig, 2005). Rejuvenation is a way to prevent this decline. Brand rejuvenation is adding value to an existing brand by improving product features and its current image. Therefore, one of the effective strategies to prevent death and change of direction, or in other words to manage the life cycle of the brand, is entrepreneurial marketing (Aghaei,et al, 2021).

Research Background

There has not been a direct study on the presentation of the entrepreneurial marketing model for managing the life cycle of brands

by now, but similar domestic and international studies can be mentioned in this field. Yun Hong et al., (2024) expressed that while many aspects of entrepreneurial marketing fundamentals remain important, distinct factors influence entrepreneurial marketing and decision-making on the online marketplace. The online framework of entrepreneurial marketing can be visualized as trend-oriented, data-oriented, entrepreneur-oriented and innovative-oriented. It has stated that a greater understanding of the concept of entrepreneurial marketing and the impact of dimensions on the company's performance is one of the concerns of many companies, who finally found that the overall performance of companies has a positive effect on the various dimensions of entrepreneurial marketing. This research states that the increasing use of CRM[2] in companies is one of the pillars of technological and social changes in entrepreneurship, which is a clear example of how big data can be useful for society. Feng Wei and Yi Zhang (2021) investigated how the stages of the product life cycle, charismatic leadership, environmental performance and product life cycle affect production. After examining these relationships and collecting information in SME,[3] it was concluded that the charismatic leadership of organizations helps to advance and improve environmental performance and sustainable development by exchanging opinions between shareholders, and ultimately environmental performance improves and economic performance will also be improved to maintain sustainability. Olovasanmiwadgi (2016) in his paper stated, by focusing on application of the product life cycle as a factor determining the strategies of SME in emerging economics, analyzes the relationship between the product life cycle and entrepreneurial marketing decisions, considering the background of the old products and early failure of startups. This study emphasizes the importance of theoretical and practical knowledge of the concept of product life cycle in entrepreneurial marketing activities and also studies benefits such as effective product planning and cost advantage over life cycle stages for young entrepreneurs in emerging countries. Zahra Kazemi et al., (2024) states that startups play an important role in the growth and development of societies in today's world. Startups makes ideas creation, entrepreneurship, industry growth, new diverse businesses and innovative technologies. It is a turning point in the economy that has opened a new window for developed and developing countries so that they can get more benefits from the development in the field of knowledge-based economy. Therefore, in order to help surviving of start-up companies in the dynamic business environment, they need to have key marketing capabilities in the model that fits their life cycle. Startups can use this model as a scientific tool to make decisions and to solve their problems and to use the marketing capabilities in dynamic business environment. So they get to know the important marketing capabilities in different stages, strengthen these capabilities and add them to their previous capabilities. Samiya Abash Loui Aghdam et al., (2024) stated that due to the fact that social network marketing communication has created a new and profound transformation in businesses, retailers should take care of their customers and attract new customers through the introduction and advertising of their products. Pahlavani et al., (2024), suggests that arrangements be made based on knowledge and communication and information, innovations to promote the branding of consumer goods with a social responsibility approach. Hossein Mohammadi et al., (2023) states that a suitable marketing strategy is necessary to increase sales and profitability at different stages of the product life cycle. The results showed that the variables of manager's experience, education, product type, competitiveness, reputation of the brand and

[2] Customer Relationship Management

[3] Small and Medium-sized Enterprise

market share, had a significant impact on the chosen strategy in different stages of the product life cycle. Therefore, the profitability of a company in the market can be improved by implementing a marketing strategy based on the type of product and in relation to the specific stages of the product life cycle. Masood Taghizadeh et al., (2023) states that providing services to customers can be an effective factor in the country's economic growth. Considering the importance of industries and increasing competitiveness among them, entrepreneurial marketing plays a very important role in achieving organizational goals and obtaining the most profitability. The results show that the entrepreneurial marketing model in these industries consists of three categories of contextual, causal, and environmental factors and dimensions, including creativity, risk-taking, innovation, market-orientation, and opportunism. The results showed that all factors are effective in entrepreneurial marketing in service and general industries.

Research Methodology

According to the purpose of the research, it is a Descriptive-Exploratory type. In order to achieve the goals, qualitative content analysis was used. Qualitative content analysis can be a research method for the mental interpretation of the content of textual data through the processes of systematic classification, coding and schematization or design of well-known patterns (Hsiu-Fang & Shannon, 2005). In the content analysis method, by using the analysis of linguistic messages, it is possible to discover meanings, priorities, attitudes, methods of understanding and organization (Wilkininhibitor & Birmingham, 2003). The statistical population of the current study includes managers and marketing experts in the fields of medicine, chemical, food and facilities industries. In order to extract the codes using the theoretical sampling method until theoretical saturation was reached, a total of ten in-depth semi-structured interviews were conducted in order to extract the model and components of entrepreneurial marketing propulsion and inhibitors. Qualitative content analysis has been used in this research. The key questions of these interviews are listed in table I and details of the interviewees are shown in table 2.

Table 1.
List of Interview Questions

1. What is the marketing model in your business?
2. What stage is your brand in according to the brand life cycle?
3. What steps have you taken to rejuvenate your brand during its declining phase?
4. If you have saved your brand from death, what has been your solution?
5. What are the propulsions of your business marketing?
6. What are the inhibitors of your business?
7. Are these factors effective in managing the life cycle of your brand?
8. Have you made any decisions to change this cycle?
9. Do you have any experience with the decline of your brand?
10. What decisions have you made to help grow your brand?
11. Have you experienced the death of your brand?
12. How do you use entrepreneurial marketing to obtain marketing opportunities?

Table 2.
Details of the interviewees

	name,	born,	experience	education	Job position	Field of activity
1	M.Z	1963	25	Management PhD.	CEO	Foods Production
2	B.D	1971	20	Doctor	CEO	Medical Appliance
3	R.M	1974	20	Veterinarian	Business manager	Vaccines importer
4	M.B	1970	22	Civil Eng.	Managing Director	Construction projects
5	H.K	1981	17	Chemical Eng.	Business manager	Industrial Resin Manufacturer
6	A.M	1974	20	agricultural engineering	Managing director.	Distributer of rubber products
7	R.Z	1983	15	Business Management	Business manager	Producer of cast iron boilers
8	H.R	1976	20	Electronic Eng.	CEO	Producer of Electrical Equipment
9	M. R	1975	23	Polymer Eng.	Managing Director	Manufacture of Engineered Material
10	P. h	1974	25	Chemical Eng.	Managing Director	Importer of Chemical Materials

Research Findings

This research has been conducted by using the method of content analysis and in-depth semi-structured interviews with managers and marketing experts and brand specialists in the medical, chemicals, food and facilities and utility industries and consequently by implementing the interviews and coding all the sentences and revisions several times and reviewing the codes by experts and scoring (CVR) according to Lawshe method, removing options less than the critical limit (0.62), we found 164 indicators of entrepreneurial marketing propulsion for brand life cycle management that identified in 23 components. On the other hand, 84 indicators of entrepreneurial marketing inhibitors were identified in 16 components in order to manage the brand life cycle. Coding are shown in tables 3 and 4, and the main components are shown in charts I to 3.

Table 3.
Open and axial coding of entrepreneurial marketing propulsion.

Selective codes	Axial codes
1- Entrepreneurial Perception	1- Correct understanding of customer needs 2- Exercise in understanding 3- Knowing reality and truth 4- Investing in the customer's mind
2- Consumer Perception	5- Recognizing consumer perception 6- Changing consumer perception 7- Improving consumer understanding
3- Pyramidal Communication	8- Wide public relations 9- Continuous communication 10- Effective communication
4- Knowledge Creation	11- Education 12- Presence in specialized markets 13- Training for customers in deprived areas 14- Training by the main company 15- Production of educational contents

Selective codes	Axial codes
5- Market-Oriented	16- Localization of educational content 17- Implication of practical skills 18- Training during the sales process 19- Transferring experience to the customer 20- Participating in conferences and seminars 21- Accompanying industry experts 22- Practical indirect training 23- Market segmentation 24- Proper knowledge of the market 25- Understanding of the current market situation 26- Monitoring new markets 27- Inspection of products
6- Market-Oriented	28- Evaluating the performance of the marketing team 29- Creating a competitive advantage 30- Recognition of competitors 31- Respect for veterans 32- Learning from market experts 33- Communication with market intermediaries
7- Entrepreneurial Insight	34- Policy of managers 35- Managers' vision horizon 36- The productive thinking of the founders 37- Recognition the capacity of managers 38- Improving the visibility of employees 39- Using flexible policies
8- Creative Advertising	40- Recognition the real needs of customers 41- Recognition the real size of the market 42- Using sponsors 43- Using creative techniques 44- Advertising targeting 45- Systematic advertisements
9- Entrepreneurial Analysis	46- Continuous brand analysis 47- Analysis of the current market situation 48- Analysis of competitors and customers 49- Product analysis design 50- Continuous follow-up of customer feedback 51- Recognition the position of the organization 52- Designing a market map 53- Recognition the position of the product 54- Finding product and brand complications 55- Monitoring hidden factors in the market 56- Movement in attractive markets 57- Avoiding marginal markets 58- Responding to customers' verbal comments 59- Incidental pursuits 60- Risk and opportunity management 61- Revision of the organization's processes 62- Analyses personnel performance 63- Evaluation of best-selling brands 64- Analysis of market blind spots
10- Schumpeter Destruction	65- Innovation in quality 66- Innovation in production 67- Creative localization 68- Recognizing hidden needs
11- Schumpeter Destruction	69- Creative negotiations 70- Providing creative promotions 71- Discovery of opportunity windows 72- Creation of new marketing methods 73- Innovative improvement of personnel motivation

Selective codes	Axial codes
12- Creative Promotions	74- Creative research and development 75- Changes in packaging 76- Change in distribution of products 77- Distribution of information required by the customer 78- Intelligent distribution in times of scarcity 79- Creating a smart distribution chain 80- Flexible distribution management 81- Supply during holidays 82- Creative product supply 83- Creating flexible payment terms 84- Recognition the promotions intended
13- Quality Red Line	85- Commitment to the quality of expression 86- Commitment to agreed quality 87- Commitment to of continuous quality improvement 88- Influencing of the national standard 89- Carrying out slogans of the organization 90- Independent and powerful quality control 91- Real after-sales service 92- Quality change with customer comments 93- Preparation of the best raw materials 94- Monitoring the quality of products 95- Revision of quality assurance processes
14- Systemic Thinking	96- systematic design of processes 97- Designing new marketing systems 98- Establishing ISO9001 99- Systematic sales system 100- CRM deployment 101- Using system tools
15- Variety of Product Portfolio	102- Production of categorized products 103- Offering various products 104- Production of by-products of profit 105- Production of single products 106- Quantitative and qualitative development
16- Variety of Product Portfolio	107- Provision of special ancillary services 108- Production according to the capacity 109- Specialized outsourcing
17- Desired Development	110- Increasing the intensity of production and sales 111- Technical development of products 112- Creating infrastructure for development 113- Simulating reference products 114- Domestic production of imported products
18- Constructive Opportunity	115- Turning threats into opportunities 116- Aligning with global policies 117- Using international laws 118- Continuous and constructive changes 119- Government oriented production policies
19- Entrepreneurial Government	120- Laws approved by the legislature 121- Financial policies of the axial bank 122- Incentive policies of the ministry 123- Support of knowledge bases 124- These are useful executive letters 125- Production subsidies
20- Constructive Competition	126- Creating a specific competitive advantage 127- Creating a pricing system 128- Contingent flexibility in selling price
21- Investment Portfolio	129- Investment in parallel markets 130- Entering the new markets of profitable

Selective codes	Axial codes
22- Entrepreneurial Personality	131- Creation of vertical and horizontal markets 132- Entry into global markets 133- Genetic factors 134- Behavioral stability 135- Attitude towards the growth of the senior manager 136- Entrepreneur's risk tolerance 137- Belief in leading the senior manager 138- Humble character 139- Creative character
23- Acceptable Technology	140- Presenting products with modern technology 141- Making products with approved technology 142- Technological production process 143- Quality localization 144- Comprehensive defense of the quality provided
24- Acceptable Technology	145- Producing products with competitive quality 146- Providing classified products 147- Creating a flexible technology system 148- Innovative policies of the organization
25- Creative Mission-Oriented	149- Internal creative policies of the organization 150- Compliance with legal and legal issues 151- Belief in customer-centered health 152- Honoring the loyalty of customers
26- The Miracle of the Brand	153- Increasing brand power 154- Improving brand reputation 155-Brand Durability 156- Continuous improvement of brand reputation 157- Familiarity with all angles of the brand 158- Respecting the trust of customers 159- Creating an effective brand 160- Creating a leading brand
27- Financial Genius	..161- Proper budgeting 162- Use of bank facilities 163- Creative financial management 164- Adequate attraction of capital

Table 4.

Open and axial coding of entrepreneurial marketing inhibitors

	Selective codes	Axial codes
1	Fake standards	1- Weakness of regulatory institutions 2- Old and ineffective reference standards
2	Anti-Market	3- critical situation of the domestic market 4- Lack of accurate knowledge of competitors 5- Disproportionate product distribution 6- Weakness in the marketing system 7- Basket of disproportionate products 8- Disproportionate promotions for customers 9- Distance from the customer 10- Lack of real knowledge of the customer 11- Wrong choice of target market 12- Not using marketing techniques
3	Anti-Market	13- Adoption of domestic unstable policies 14- Production inconsistent with the request 15- Being unavailable to the customer
4	Drop Budget	16- Lack of liquidity 17- Insufficient fixed and circulating capital

	Selective codes	Axial codes
5	Breach of Contract	18- Inability to fulfill financial obligations 19- damage to the organization's reputation 20- Lack of initial obligations 21- Non commitment to implementation plans 22- Lack of commitment to primary goals
6	Bubble Analysis	23- Infeasibility of production and sales 24- Gradual and imperceptible destruction 25- Lack of analysis of the market and competitors 26- Inefficiency of organization analysis tool
7	Destructive Changes	27- Unreasonable change of strategies 28- Resistance against global changes 29- Making wrong managerial decisions 30- Determining incorrect positions in crises
8	Outdated Thinking	31- Unwillingness to improve knowledge 32- Lack of teaching new skills 33- Failure to implement constructive programs 34- Failure to implement creative changes
9	Illusion of Awareness	35- Seniority of decision making managers 36- Not understanding the situation in the market 37- Mismatch of skills with job position 38- Failure to pay attention to subtle changes 39- Failure to pay attention to feedback 40- Failure to pay attention to real potentials 41- Lack of recognition of real capacities 42- Lack of understanding of the target market 43- Lack of accurate knowledge of products
10	Factory Illusion	44- Lack of energy for production 45- Disproportionate production space 46- Variety of raw materials for production 47- Failure to employ skilled manpower 48- Limitations of production infrastructure 49- Lack of production raw materials 50- worn lines of the production line 51- Inability to produce according to the request
11	External Threats	52- Widespread epidemic diseases 53- Unexpected natural factors 54- New international laws
12	External Threats	55- Global sanctions 56- Global political changes 57- Anti productive judicial laws 58- Non transparent tax and insurance laws 59- Complicated customs rules
13	Self-Sanction	60- Contradictory currency policy of the bank 61- Government monopolies 62- Laws against the production of the legislator 63- Contradictory strategies of devastation 64- Disproportionate policies of the Ministries 65- Many government policies 66- Dummy companies
14	Non Destructive Competition	67- competitive prices 68- The pressure of new competitors 69- Decreasing consumer purchasing power 70- Decreasing the organization's profit margin
15	Lack of Quality Commitment	71- Low quality production 72- Increasing guess and error productions
16	Entrepreneurs Personality	73- Managers' limited horizons 74- Managers not focusing on the main core 75- Job diversification 76- Inability to discover opportunities

	Selective codes	Axial codes
17	Lawlessness	77- Weak personality type of managers 78- Lack of decisiveness in decision making 79- Managers' lack of risk taking 80- Failure to comply with legal and requirements 81- Inability to face challenges 82- Lack of brand registration and 83- Unsatisfied employee 84- Nonstandard departure of personality

The conceptual model

The conceptual model of the research resulting from the review of the background of the research and interview with the experts and the final investigations, we reached to the conclusion that propulsion and inhibitors are affecting on entrepreneurial marketing and consequently on brand life cycle management. As a result, the research model is shown in chart I and1 the factors affecting propulsions and inhibitors of entrepreneurial marketing are shown in charts 2 and 3.

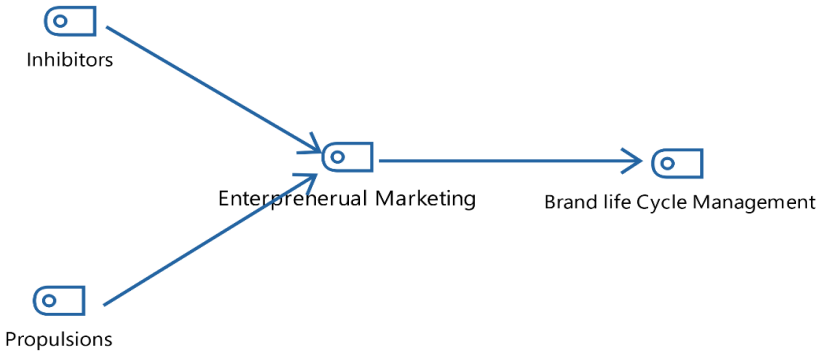

Chart 1. *The Conceptual Model*

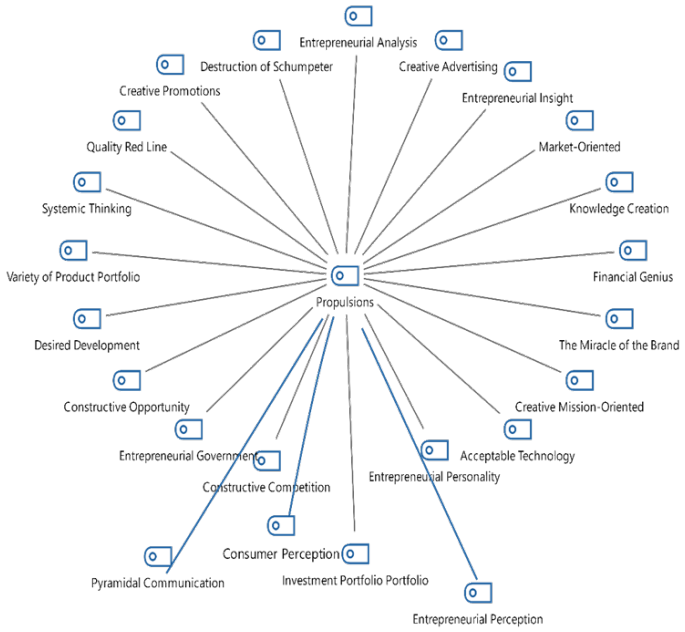

Chart 2. *The Agents of Entrepreneurial Marketing Propulsions*

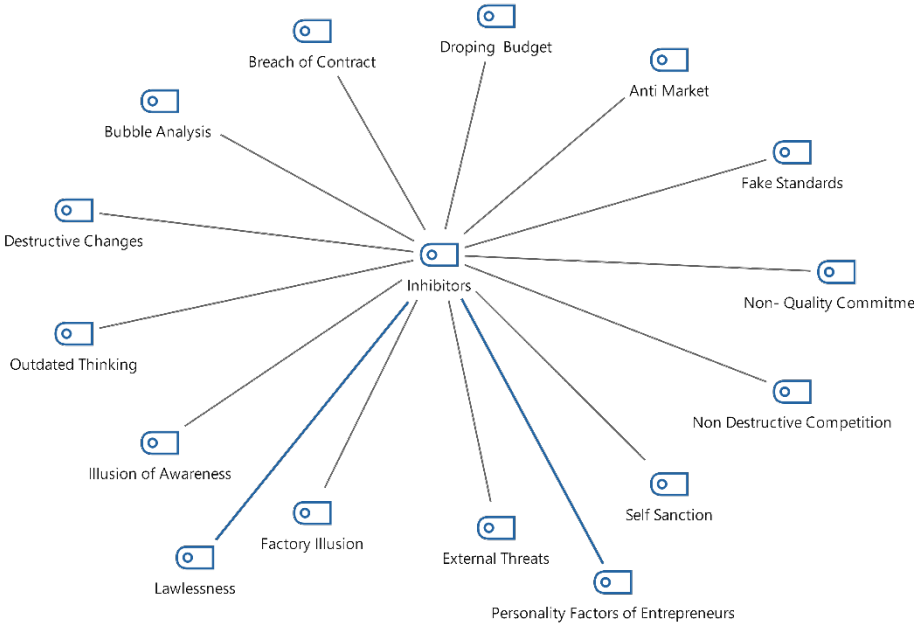

Chart 3. *The Agents of Entrepreneurial Marketing Inhibitors*

Results and Discussion

After the final review, the results show that the effective propulsions of marketing in the direction of brand life cycle management are entrepreneurial perception, real understanding of consumer needs, and practice in understanding perception problems, differentiation in recognizing reality and truth, and investigation in the minds of customers. Understanding the consumer's perception as a very vital issue in the dominance of the consumer's perception in entrepreneurial marketing plays an important role. Entrepreneurial marketers, with extensive, continuous and effective communication and by using training, presence in specialized markets, serving customers in deprived areas, training by parent companies, production of training content, localization of training, transfer of user information, training during sales, transfer experience, participation in conferences and accompanying experts and indirect training always seek to create knowledge, which acts as an effective factor in marketing and changing the life cycle of the brand. The term market-oriented is a word equivalent to entrepreneurship marketers. Entrepreneurs must always have a correct understanding of the market situation by segmented and accurate knowledge, while carefully monitoring the product and new markets and constantly monitoring the marketing personality and distinguishing themselves with exclusive market techniques. They consider the competitors' activities while communicating with the seniors of the market. Entrepreneurial marketing as a type of insight is dependent on the policy, vision and main approach of the funders, which is followed by the promotion and increase of capacity. Meanwhile, by implementing flexible policies, it is possible to understand the market correctly and improve its capacity accordingly. In Entrepreneurial attitude, advertising has been removed from the organization's cost and is a kind of investment to maintain and promote the brand, provided that it uses creative ideas. The use of sponsors leads the organization to effective, systematic and intelligent advertising. Growth always follows analysis, so in order to prevent brand decline, entrepreneurial marketers should always analyze themselves, organization and the market. Analysis takes place with a correct understanding of the product position, customer feedback, profit and loss analysis,

brand life, and hidden factors, recognition of profitable markets, elimination of troublesome markets, risk and opportunity management, evaluation of personality performance, evaluation of mature brands, and analysis of market blind spots Entrepreneurship is synonymous with the innovation. Innovation in quality, manufacturing methods, customer recognition, negotiations, service delivery, marketing methods and realization and development, these are among the most important things that lead marketers towards entrepreneurship and ultimately brand life cycle management. The types of promotions offered to customers have changed recently, therefore organizations should look for changes in packaging, intelligent distribution, timely and creative supply so they should design their promotions according to market needs. Organizations must have a quality standard (red line). The commitment to the company basic slogans are among the basic principles of every organization. Entrepreneurial companies continuously increase quality and upgrade their product standards measures by strong quality control (QC) products, after-sales services and reviewing processes frequently. Ensuring quality and providing standard raw materials and must remain loyal to their original covenant with the customer. Entrepreneurs must always think systematically by designing new marketing processes and systems, establishing various ISO[4] systems, and using tools such as CRM. And this attitude will consequently lead to brand rejuvenation. Marketers are more successful in companies that have a diversified product portfolio, producing classified products, providing effective services, producing profitable side products, creating creative products and developing quantitative and qualitative products, providing special side services. According to the capacity of the organization, they always help the entrepreneurial marketers to promote the brand. Optimum development is one of the necessities of today's society and organizations should look for specialized outsourcing, increase production and sales capacity and technical development of products. They must develop psychological infrastructure of the organization, technical simulation and move towards localization and production in order to maintain and promote their brand. Entrepreneurs should produce imported products step by step and reduce their overhead costs. Organizations are not isolated from the society and are always exposed to changes in policies and laws at the macro and micro level so entrepreneurs can take advantage of present and future opportunities and avoid threats. In addition to external threats, some entrepreneurial governments support them with production-oriented policies, flexible laws and incentive regulations. Organizations must have an attractive competitive advantage and operate with flexible prices in the markets and always compete and be constructive. In today's turbulent environment, organizations must make many investments and discover new and unknown markets and make various investments while using export markets. Along with all the factors affecting marketing, the psychological factors of the entrepreneur have tremendous effects on the organization. Genetic factors, behavioral stability, risk taking, desire for power and being a leader are some of the factors that the policy of organizations depends on. The technology provided by the organization should be in accordance with modern technology, transparent, competitive, defensible, flexible and suitable for the market. These factors are rooted in the main mission of the organization. Keeping and maintaining a brand is as difficult as creating it. Customer loyalty, power, reputation, credibility of the brands, internal policies of managers and believing in the principle of customer health, should be among of main missions of an entrepreneurial organization. The last word is that by using the propulsions

[4] International Standard Organization

and staying away from entrepreneurial marketing inhibitors, it is possible to solve the basic problem of the organization which is the early death of the brand and create a new opportunity in the organization and increase the life of the brand and in some cases with cycle management Change the direction of the brand life, the downward slope.

Limitations and Managerial Suggestions

It seems that the research is sufficient and has achieved its goals but we have faced some limitations in this research such as the lack of full disclosure of information by experts about their brands, the lack of careful analysis of the owners of brands that were declining, and the lack of simultaneous access to marketers and the main owners of businesses .Regarding the entrepreneurial marketing model and the identification of the propulsion and inhibitors of entrepreneurial marketing of the brand life cycle in its different stages, it is suggested that researchers specifically conduct their research in five stages of the brand life cycle. Besides, it is possible to check these factors in service brands and benefit from the extended community of experts.

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Assessment of the Requirements of Smart production Systems in SMEs: Intuitionistic Fuzzy Best-Worst Method and Total Interpretive Structural Modeling Integrated Method

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Abstract
Today, manufacturing companies must address the increasing trend of smart manufacturing (SM) to maintain their competitiveness. Concurrently, small and medium enterprises (SMEs), which constitute the backbone of numerous production economies, are endeavoring to comprehend the complexities associated with implementing this advanced production system. However, many of these enterprises are hesitant to adopt SM due to insufficient human and financial resources. The transformation of a company's existing system into smart production systems, as opposed to implementing smart manufacturing from the outset, necessitates greater financial and temporal investment. Consequently, it is imperative to consider and integrate effective requirements for smart production systems during the design phase. This study aims to identify these requirements, ascertain their significance, and comprehend the contextual relationships among them. To achieve this, a systematic review method is employed to identify the requirements, followed by the Intuitionistic Fuzzy Multiplicative Best-Worst Method (IFMBWM) to determine their weights. Finally, the TISM method is utilized to understand the interrelationships and compare the levels obtained with the results of the best-worst method. The results indicated that the effective requirements can be categorized into eight main criteria. The highest and most fundamental criterion is the requirement for digitalization and real-time data connection. The second criterion is automation, followed by smart communication with beneficiaries as the third. Overall, small and medium-sized enterprises should prioritize information technology and artificial intelligence requirements to advance towards smart production systems.

Keywords: *Smart Manufacturing Systems, Small and Medium-Sized Companies, Intuitionistic Fuzzy Multiplicative Best-Worst Method, Total Interpretative Structural Modeling*

Introduction

The recent advancements in smart production have significantly propelled the industry forward. The successful future of manufacturing hinges on the adoption of smart manufacturing practices. The development of technology, along with the recording and analysis of data in production sectors, enhances productivity, efficiency, process capability, and business sustainability. Manufacturers that fail to adopt smart manufacturing may struggle to compete in the global market and risk becoming obsolete over time (Bello et al., 2024).

In recent years, the industrial environment has undergone significant transformations with the advent of new theoretical models and technologies associated with the fourth industrial revolution, also known as Industry 4.0 (Kagerman et al., 2013; Sandler, 2013; Rauch and Vickery., 2020). Industry 4.0 represents the fourth phase of industrial evolution, driven by smart manufacturing

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(Rauch and Vickery., 2020). Within this revolution, the smart factory is regarded as the ultimate stage of Industry 4.0. Manufacturing companies are striving for advancements in this domain by integrating various advanced technologies to maintain their competitiveness (Jung et al., 2021). Consequently, Industry 4.0 represents a paradigm shift in production systems, emphasizing the creation of value through smart products, procedures, and processes, with the establishment of smart factories being one of its key features (Simetinger and Basl, 2022). Generally, smart manufacturing is a contemporary manufacturing model where machines are fully networked, monitored by sensors, and overseen by computational intelligence designed to enhance system productivity, product quality, and sustainability while reducing costs. The recent advancements in IoT, artificial intelligence, and related technologies provide essential enabling solutions to advance modern manufacturing (Haricha et al., 2023). As a result, smart manufacturing leverages Industry 4.0 technologies to enhance the efficiency, productivity, and flexibility of production systems, processes, and services. Industry 4.0 and smart manufacturing offer several advantages, including improved production efficiency, cost reduction, enhanced product quality, and increased agility in responding to market changes. These benefits provide significant potential for manufacturers to optimize their operations, reduce costs, and remain competitive (Mourtzis, 2024).

On the other hand, SMEs have been recognized as the main sources of employment in developed and developing countries in recent years. These companies play an important role in creating new jobs, innovation, flexibility and economic growth. According to Drucker, to remain competitive in the face of changes in the political, social and economic environment, new; requires innovative strategies. Small and medium-sized enterprises are trying to actualize the principles of Industry 4.0 by implementing specific measures to use its potential and increase their productivity. Meanwhile, companies, particularly SMEs, are endeavoring to actualize the principles of Industry 4.0 by implementing specific measures to harness its potential and enhance their productivity (Rezaei et al., 2021). Meanwhile, companies, particularly SMEs, are endeavoring to actualize the principles of Industry 4.0 by implementing specific measures to harness its potential and enhance their productivity (Matt et al., 2014). However, they often face challenges in understanding how to approach Industry 4.0 or initiate the introduction and implementation of its concepts. According to a survey, many SMEs struggle with increasing product variety and personalization. Price competition, stringent quality requirements, and short delivery times are becoming increasingly significant. Due to their flexibility, entrepreneurial spirit, and smart production capabilities, SMEs have demonstrated greater resilience compared to large and multinational companies (Rauch and Vickery, 2020).

The technologies associated with smart production systems contribute to achieving reliable, flexible, and stable processes. Companies that utilize or plan to transition to smart production systems should consider the features that enable these systems to efficiently perform production processes. These features, which facilitate smart production systems, will also be beneficial for the development of the technologies employed (Kılıç and Erkayman, 2023). The requirements of smart manufacturing systems have evolved into a complex field of requirement engineering, encompassing not only technical aspects but also the realization of multifaceted sustainable value. The list of requirements for smart manufacturing systems includes fundamental sustainable value streams among related stakeholders, key stakeholders, and achievement pathways for smart manufacturing systems. However, systematic analyses of these requirements remain relatively scarce (Qu et al., 2023). Conversely, classifying, examining relationships, and determining the

importance of each requirement or facilitating feature will assist companies adopting smart production in developing strategies to mitigate production issues. Therefore, soft computing approaches with flexible computing capabilities offer a unique method for organizations transitioning to smart manufacturing systems to identify critical capabilities and optimal technologies (Kılıç and Erkayman, 2023).

According to the research literature, several studies have addressed the requirements necessary for establishing a smart factory. However, there is a paucity of studies focusing on the importance of these requirements and the analysis of their internal relationships within SMEs. This research employs a multi-method approach to address the following questions:

What requirements are effective in creating and utilizing smart production systems in SMEs?

What are the relationships and influences among these requirements, and how important is their application for smart production systems?

The IFMBWM is applied to determine the relative importance of these requirements within the selected context. One of the key features of the Best-Worst Method is its ability to achieve more consistent pairwise comparisons and produce more reliable results. Subsequently, the TISM method was employed to understand the contextual relationships among these requirements and to compare the obtained levels with the results of IFMBWM. Previous research confirms that TISM is a highly effective multi-criteria decision-making tool that aids in theory development. This technique not only identifies relationships between variables and creates a hierarchical framework but also includes qualitative evaluation of these links to uncover their underlying causes (Dubey et al., 2018). Additionally, this technique has been utilized to investigate the contextual relationships among the effective requirements for the creation and application of smart production systems in small and medium-sized enterprises.

Literature Review

Numerous studies have been conducted on the literature of smart production systems, their features, and the technologies employed, and research in this area is ongoing.

Kumar (2018) reviewed the technologies critical for enabling smart manufacturing, including augmented reality and virtual reality (AR & VR), the Internet of Things (IoT), human-robot interaction, and cyber-physical systems (CPS). His study also examines the challenges that need to be addressed, such as existing methods and material technologies. Lu and Weng, (2018) conducted a literature review to identify 19 technologies for smart manufacturing industries in Taiwan that significantly impact the development of smart manufacturing both today and in the future. They proposed market maturity estimation with smart manufacturing technology. Mittal et al., (2019) reviewed the existing knowledge related to smart manufacturing and organized various features, technologies, and enabling factors. Qiu et al., (2019) proposed an integrated method for assessing the requirements of smart manufacturing systems in the era of Industry 4.0 and the Internet of Industrial Things. This method employs systematic research to identify, classify, and evaluate the requirements of smart production systems, considering uncertainty, multiple users, and multiple disciplines. The results of this research provide a preferred method for considering and framing the requirements of smart production systems. Kusiak, (2019) explained that the main features of smart production systems are based on data, network connectivity, resource sharing, durability, and sustainability. They focused on manufacturing flexibility and sustainability, as these areas had received only limited attention in the literature.

Mittal et al., (2019a) conducted a systematic review to identify the fundamental principles

and existing methods for adopting smart manufacturing. They found that smart products, parts and materials, interoperability, data sharing systems, and standards are widely recognized as essential principles for manufacturers. Mahmoud et al., (2020) proposed a four-step method to assist stakeholders in creating a smart manufacturing system with enhanced capabilities while increasing manufacturers' awareness of Industry 4.0 adoption. These four stages include the configuration of systems and robots, smart system components, smart system integration, and evaluation and selection. Ghobakhloo's, (2020) study demonstrated a complex priority relationship between smart production and the factors influencing digital technology acceptance. This study, through an advanced survey, content analysis of the research literature, consultations with university and industry experts, and the implementation of interpretive structural modeling methodology, identified eleven enabling factors and examined the contextual relationships among them. This study further elucidated the intricate precedence relationships among the determinants of IDT adoption in smart manufacturing. Phuyal and Bista, (2020) redefined smart manufacturing systems, assessed the current state of the program, and analyzed the gap between the present and the anticipated future of manufacturing systems with the aid of smart manufacturing technology. Larsen and Lassen, (2020) reviewed the considerations necessary when designing innovation processes for smart manufacturing. It is crucial to identify the parameters that influence the outcome of innovation during the design phase. Rauch and Vickery, (2020) compiled a list of requirements and needs for designing a smart manufacturing system in small and medium-sized enterprises. In another study, Sharma and Villányi, (2023) employed an analytical and descriptive research method to identify and evaluate functional and non-functional, technological, economic, and social evaluation components essential for assessing smart production systems. They presented a predictive analysis framework, which serves as a key component of many decision support systems, to assess company needs and propose and prioritize smart manufacturing system services. According to this study, analyzing the importance of services and operations of smart manufacturing systems aids traditional manufacturing organizations in achieving automation and advanced technologies through smart data analysis and real-time data connectivity.

Malaga and Vinodh., (2023) identified factors influencing the acceptance of smart and sustainable production systems and ranked the most effective factors using the fuzzy TOPSIS multi-criteria decision-making method. According to their analysis, this approach assists industry practitioners in selecting the most effective factors to successfully adopt smart and sustainable production systems and compete globally. Qu et al., (2023) presented a systematic method for compiling the list of requirements for smart manufacturing systems and elucidating the complex relationships among multi-stakeholder smart manufacturing systems. This research introduced a comprehensive approach to capture these requirements based on the stakeholder salience model and the stakeholder value network. In the second step, a quantitative analysis was proposed to determine the urgency and importance of the requirements using a comprehensive fuzzy Kano model. Finally, the list of requirements was obtained through systematic evaluation methods, including graph theory, dependency matrix, and network statistics. A case study in a Chinese company was also conducted to investigate the feasibility of the proposed approach. In Iran, Ardehi et al., (2023) conducted a study with the aim of designing a model for implementing the fourth generation industry to achieve sustainable development goals in Iran Khodro Company. In this study, interpretive structural modeling (ISM) with MICMAC software was used in the qualitative part to draw the initial model, and in the quantitative

part, one-sample t-test and SPSS software were used to assess the current situation. The research findings showed that the collection and analysis of big data affects simulation and automated robots. These factors affect horizontal and vertical integration systems, and as a result, lead to the Industrial Internet of Things, augmented reality, and cybersecurity. In addition, through the cloud computing system, additive manufacturing is affected, and this additive manufacturing leads to sustainable development. As previously mentioned, numerous studies have been conducted on the requirements of smart production systems, with the most significant ones discussed herein. It is noteworthy that, in the majority of the reviewed studies, with few exceptions, these requirements or indicators were merely examined, and the analysis of their contextual relationships was not observed. According to the review of the articles, in some instances, only the prioritization of the requirements or indicators was addressed. Furthermore, most of the studies were not specifically focused on SMEs; rather, they were conducted generally for all companies. Consequently, it can be stated that the solutions proposed by these studies, due to the unique constraints of SMEs, are generally inadequate in addressing their specific challenges.

Materials and Methods

This study has adopted a multi-method approach to address the questions posed in the introduction. As illustrated in Figure (1), the focus group technique was employed for the second research question, utilizing the expertise of subject matter experts in the chosen field. The focus group comprises five academic experts from Shiraz University, specializing in Industry 4.0, production systems, and smart production. Prior to this, a literature review was conducted to extract scientific articles from various databases such as Scopus and Google Scholar, forming the theoretical foundation of the smart production concept. From this stage, 8 requirements and 55 indices effective in smart production were identified. This research investigates eight main requirements.

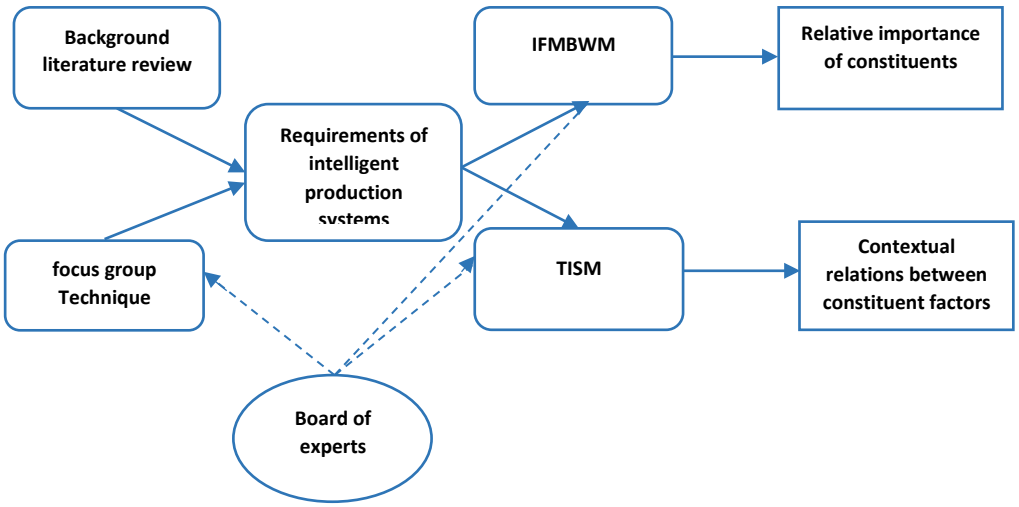

Figure 1. *Research flow chart*

IFMBWM

After the final list of constituent factors was confirmed, IFMBWM was used to find the relative importance of these dimensions in order to formulate their implicit weights and ranks. Rezaei, (2015) introduced the BWM to obtain the weighted coefficients of the criteria using the optimization model. This method uses the approach of paired comparisons to collect the preferences of

decision makers. This method has advantages over other methods. Achieving more consistent pairwise comparisons and more reliable results is one of its features. (Rezaei, 2015; Bonab et al., 2023). However, the BWM is inappropriate under uncertain conditions, which further limits the limited applicability of this method.

To overcome this limitation; Mou et al., (2016) proposed a new algorithm to rank criteria and obtain a directed graph. The IFMBWM is a method that has been extended to improve uncertainty conditions. In this method, in addition to the degree of membership, the degree of non-membership is also considered. Therefore, using the IFMBWM makes it easier to respond to environmental uncertainty. It is important to note that the IFMBWM is graph-based, and the data collection method employed is hierarchical analysis, which involves a complete pairwise comparison matrix. The steps of IFMBWM are as follows (Moet al., 2016):

Step 1. Determining the set of decision criteria: determine the set of decision criteria $C = \{c_1. c_1. \ldots. c_j. \ldots. c_n\}$ and based on Intuitionistic fuzzy multiplicative preference relations (IFMPR); Provide $A^{(k)} = (\rho_{ij}. \sigma_{ij})_{n\times n}$, $k \in S. i \in N. j \in N$.

Step 2. Intuitive fuzzy graph-based preference relationships $A^{(k)}(k = 1. 2. \ldots. s)$ presented by decision makers as weighted geometric aggregation based on intuitionistic fuzzy multiplicative weighted geometric aggregation (IFMWGA) using Summarize from E.q (1):

$$\mathrm{IMWGA}_{\lambda} = \left(\left(\prod_{k=1}^{s}(\rho_{ij}^{(k)})^{\lambda_k}, \prod_{k=1}^{s}(\sigma_{ij}^{(k)})^{\lambda_k}\right)\right)_{n\times n}$$

(equation 1[2])

By combining the opinions of experts, the cumulative matrix A (E.q (2)) is obtained as follows. This matrix is similar to the matrix of pairwise comparisons in the hierarchical analysis method.

$$A = \begin{bmatrix} (\rho_{11},\sigma_{11}) & (\rho_{12},\sigma_{12}) & \cdots & (\rho_{1n},\sigma_{1n}) \\ (\rho_{21},\sigma_{21}) & (\rho_{22},\sigma_{22}) & \cdots & (\rho_{2n},\sigma_{2n}) \\ \vdots & \vdots & \ddots & \vdots \\ (\rho_{n1},\sigma_{n1}) & (\rho_{n2},\sigma_{n2}) & \cdots & (\rho_{nn},\sigma_{nn}) \end{bmatrix}$$

(equation 2)

Step 3. Determining the most important and least important indicators: In this step, the most important and least important indicators should be determined by the decision matrix and the oriented graph. The most important index is indicated by C_B and the worst index by C_W.

In order to achieve this, first, the initial directed diagram is drawn using the information of the consolidated matrix, and then, according to the values of $\rho_{ij} \geq 1$, the final directed diagram is drawn.

Step 4. Determining the optimal weight: After obtaining the directed graph, the optimal weight vectors of the degree of membership and non-membership are modeled using the following relations.

Build models 1 and 2 and get the optimal weights by solving the two models. The optimal solutions of models 1 and 2 are respectively $\xi^*. (\upsilon_1^*. \upsilon_2^*. \ldots. \upsilon_n^*)^T$ and $\zeta^*. (\tau_1^*. \tau_2^*. \ldots. \tau_n^*)^T$.

Therefore, the optimal weight vector is obtained as: $W^* = \left((\tau_1^*. \upsilon_1^*). (\tau_2^*. \upsilon_2^*). \ldots. (\tau_n^*. \upsilon_n^*)\right)^T$:

Model 1- Degree of membership:	Model 2- degree of non-membership:
$min\ \xi$	$min\ \zeta$
s.t. $\left\|\tau_B/\tau_j - \rho_{B.j}\right\| \leq \xi$	s.t. $\left\|\upsilon_B/\upsilon_j - \sigma_{B.j}\right\| \leq \zeta$
$\left\|\tau_j/\tau_W - \rho_{jW}\right\| \leq \xi$	$\left\|\upsilon_j/\upsilon_W - \sigma_{jW}\right\| \leq \zeta$
$\sum_{j=1}^{n}\tau_j = 1$	$\sum_{j=1}^{n}\upsilon_j = 1$
$\tau_1 \geq \tau_2 \geq \cdots \geq \tau_n$	$\upsilon_1 \geq \upsilon_2 \geq \cdots \geq \upsilon_n$
$\xi \geq 0. \tau_j \geq 0.\ for\ all\ j \in N$	$\zeta \geq 0. \upsilon_j \geq 0.\ for\ all\ j \in N$

Step 5. Obtain the compatibility ratio using equation (1) based on CI1 and CI2 presented in Table 1 as well as the optimal values (ζ^* and ξ^*) obtained in the models.

[2] In this regard, λ_k represents the weight of different experts.

$$Compatibility\ ratio = max\left\{\frac{\xi^*}{CI_1}.\frac{\zeta^*}{CI_2}\right\}$$

(equation 3)

Table 1
Incompatibility index

ρ_{BW}	1	2	3	4	5	6	7	8	9
$CI_1(max\ \delta)$	0.00	0.44	1.00	1.63	2.30	3.00	3.73	4.47	5.23
σ_{BW}	1/9	1/8	1/7	1/6	1/5	1/4	1/3	1/2	1
$CI_2(max\ \varepsilon)$	0.08	0.08	0.09	0.10	0.11	0.12	0.12	0.12	0.00

TISM and MICMAC

After reaching the weights that show the relative importance of these factors, TISM technique has been used to understand the relationship between these dimensions and compare the obtained levels with the results of the IFMBWM. TISM is an improvement over ISM; A process that is used to convert unclear and vague mental models into hierarchical structures by interpreting contextual relationships on the interfaces in the diagram for greater clarity. In this study, this technique has been used for structural prioritization of factors to compare with the results obtained from IFMBWM and to discover contextual relationships to answer the second question. The step-by-step process of TISM is as follows: (Sushil, 2012; Sharma et al., 2021).

Step 1. The list of smart manufacturing requirements obtained utilizing the literature review and expert opinions.

Step 2: A pairwise analysis of the relationship between these factors is conducted to create a knowledge base that covers even the transitory relationship with the contextual meaning. (Table 5).

Step 3: Develop the reachability matrix based on the relationships covered by the knowledge base. (Table 6)

Step 4: Step-by-step partitioning to assign levels to factors based on interpretation logic.

Step 5: Developing TISM diagram according to the assigned levels from step 4 and add interpretative logic on the interfaces in the diagram (Figure 2). The binary reachability matrix developed in the TISM process can be used to analyze these factors using MICMAC. This helps to categorize the list of factors into four quadrants including: independent, linkage, dependent and autonomous. The position of these factors is determined by the driving power and dependence of a specific factor in the chosen field of study.

Results

Through a systematic review of the research literature and consultations with experts, the requirements effective in establishing and utilizing smart production systems in small and medium-sized enterprises were identified. These requirements are presented in Table 2.

Table 2
Requirements of Smart production systems

No	Requirements	Salient features
R_1	Modularity	Machine tools and modular material handling equipment as well as reconfigurable devices.
R_2	Agility	Easy to use and change production systems, rapid prototyping technologies and a high degree of adaptability, flexibility and changeability. In order to respond to short-term changes in product volume or type, production systems must be adaptable, flexible and changeable. This allows for a profitable mass customization strategy and enables efficiency.
R_3	flexibility	Flexible workstations, personnel and production processes.

No	Requirements	Salient features
R_4	Digitization and connection of real-time data	Automation, product improvement and management, feedback system and infrastructure, design, supply chain monitoring and control digitally.
R_5	Robotization	Robots under artificial intelligence, cobots and small-scale production, robotic packaging and shipping, robotic and Smart logistics distribution
R_6	Smartening communication with stakeholders	Chatbots, voice of the customer solutions, internal knowledge management and employee development
R_7	Automation	Automatic loading and processing, flow and control of materials between workstations, reinforcement learning tools, as well as automated guided vehicles
R_8	Smartening maintenance and inspection	Online maintenance, remote monitoring and customer troubleshooting, automatic maintenance, augmented reality in services, after-sales maintenance

Source: (Rauch et al., 2019; Rauch and Vickery, 2020; Sharma and Villányi, 2022; Kanakana-Katumba et al., 2022; Sahoo & Lo, 2022; Hammad et al., 2023; Haricha et al., 2023; Kılıç & Erkayman, 2023).

Also, by using the IFMBWM as a decision-making technique, the weight of each requirement was determined according to its importance in the application of Smart production systems in SMEs. The weight of all experts was considered here as 0.2. Table 3 is the aggregated matrix of experts' opinion, which was created by applying E.q (1).

Table 3
Aggregated matrix of pairwise comparisons.

	R_1	**R_2**	**R_3**	**R_4**	**R_5**	**R_6**	**R_7**	**R_8**
R_1	(1.00,1.00)	(0.80,1.38)	(0.24,4.36)	(0.13,8.59)	(0.16,6.12)	(0.18,6.12)	(0.15,6.15)	(0.27,4.57)
R_2	(1.38,0.80)	(1.00,1.00)	(0.51,1.25)	(0.12,8.14)	(0.24,4.08)	(0.19,4.36)	(0.21,6.15)	(0.72,1.62)
R_3	(4.36,0.24)	(1.25,0.51)	(1.00,1.00)	(0.15,6.92)	(0.65,1.25)	(0.27,3.73)	(0.16,4.13)	(0.23,3.37)
R_4	(8.59,0.13)	(8.14,0.12)	(6.92,0.15)	(1.00,1.00)	(8.16,0.12)	(7.38,0.15)	(6.43,0.16)	(8.59,0.12)
R_5	(6.12,0.16)	(4.08,0.24)	(1.25,0.65)	(0.12,8.16)	(1.00,1.00)	(3.00,0.24)	(5.16,0.19)	(1.93,0.42)
R_6	(6.12,0.18)	(4.36,0.19)	(3.73,0.27)	(0.15,7.38)	(0.24,3.00)	(1.00,1.00)	(2.55,0.35)	(3.68,0.25)
R_7	(6.15,0.15)	(6.15,0.21)	(4.13,0.16)	(0.16,6.43)	(0.19,5.16)	(0.61,2.55)	(1.00,1.00)	(3.90,0.19)
R_8	(4.57,0.27)	(2.14,0.23)	(3.37,0.23)	(0.12,8.59)	(0.42,1.93)	(0.25,3.68)	(0.19,3.90)	(1.00,1.00)

Then, according to the aggregated matrix, first, the initial directional diagram is drawn, and then, using the condition that among these elements, elements with $\rho_{ij} \geq 1$ must be selected; The final directed diagram is prepared. Figure 2 shows the final directed matrix.

Based on the number of outputs of each index, digitalization and real-time data connection index "R_4" with 7 outputs, as the most important index and modularity index "R_1" with zero output, as the least important index. the order of importance of the criteria is as follows:

$D_1^{our} = 0, D_2^{our} = 1, D_3^{our} = 2, D_4^{our} = 7, D_5^{our} = 5, D_6^{our} = 5, D_7^{our} = 4, D_8^{our} = 3$

$D_4^{our} > D_5^{our} \& D_6^{our} > D_7^{our} > D_8^{our} > D_3^{our} > D_2^{our} > D_1^{our}$

$\tau_4 \geq \tau_5 \geq \tau_6 \geq \tau_7 \geq \tau_8 \geq \tau_3 \geq \tau_2 \geq \tau_1$

and $\upsilon_4 \leq \upsilon_5 \leq \upsilon_6 \leq \upsilon_7 \leq \upsilon_8 \leq \upsilon_3 \leq \upsilon_2 \leq \upsilon_1$

Subsequently, by modeling using Models 1 and 2 and implementing them in Lingo software, the optimal weights for the degrees of membership and non-membership were obtained. The results of the criteria weights are presented in Table 4.

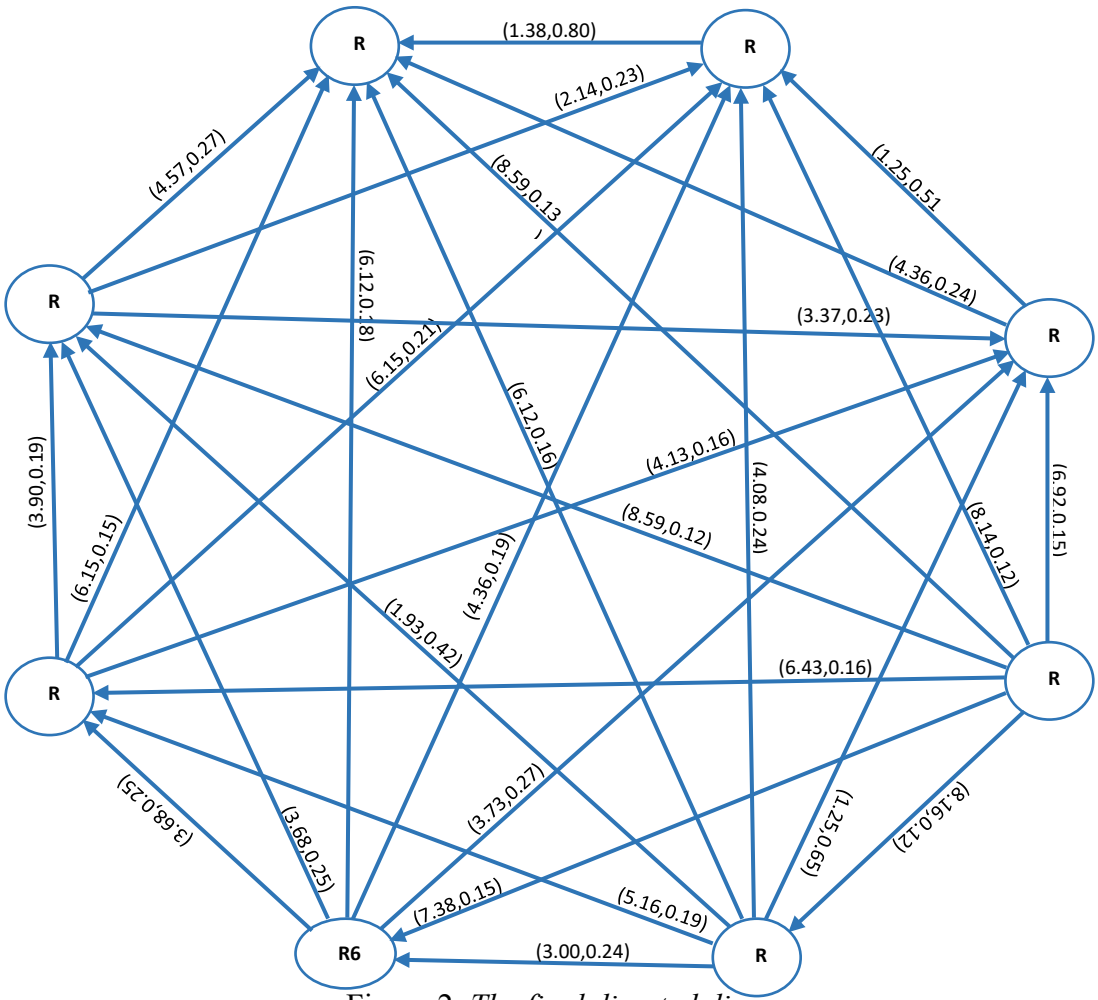

Figure 2. *The final directed diagram*

Table 4

The weights of the criteria using the IFMBWM

Requirements	Membership degree weight	rank	Non-Membership degree weight	rank
R_1	0.0417	8	0.2938	1
R_2	0.0860	7	0.2350	2
R_3	0.4125	6	0.1198	3
R_4	0.1361	1	0.0381	8
R_5	0.9674	2	0.0765	7
R_6	0.0960	3	0.0772	6
R_7	0.9207	4	0.0800	5
R_8	0.0204	5	0.0793	4

Using the E.q (3) indicators of incompatibility were determined.

$CR = max\left\{\frac{\xi^*}{CI_1}, \frac{\zeta^*}{CI_2}\right\} = \left\{\frac{0.5742}{5.23}, \frac{0.00431}{0.08}\right\} =$

$\{0.109 \& 0.00538\} = 0.109$

Given that the rate of intuitive fuzzy inconsistency is 0.109, and for a relationship to be consistent, the inconsistency rate must fall between 0 and 1, the paired comparisons are therefore consistent. As previously mentioned, after determining the weight of the factors, the TISM method was employed to understand the relationships between the requirements. The results of this analysis are presented below. On the basis, the knowledge

base was created based on expert interpretations of these relationships, as shown in Table 5.

Table 5.
Knowledge base developed using expert's opinion

No	Factor	Paired comparison of factors	Interpretation of relationships
1	R_1-R_2	Modularity and agility interact with each other	Considering characteristics such as reconfiguration and flexibility to changes, which are both important aspects of agility and modularity, it can be said that these two requirements are effective in improving and upgrading each other.
2	R_1-R_3	Modularity affects flexibilit	Modularity can help the flexibility of the system by helping flexibility in different aspects.
3	R_1-R_4	Digitization and connection of real-time data has an effect on modularity	Digitization can improve the level of modularity by helping to improve the flow of information between all units of the system.
4	R_1-R_6	The Smartening of communication with stakeholders has an impact on modularity	Since the employees are the beneficiaries of the company, the **Smartening** of communication with these people can be effective in employing multi-skilled workforce and promote modularity.
5	R_1-R_7	Automation affects modularity	Automation can increase the level of modularity by helping to move tools and equipment automatically
6	R_2-R_3	Agility and flexibility have mutual influence on each other	Using processes and systems with higher flexibility helps to make production more agile.
7	R_2-R_4	Digitization and connection of real-time data has an impact on agility	Digitization and connection of real-time data can have a significant impact on agility by digitizing product development, improvement and management, as well as real-time product change needs assessment.
8	R_2-R_5	Robotization has an effect on agility	Robotization of various aspects of the production system can help to respond faster and thus become agile.
9	R_2-R_6	Smartening the relationship with stakeholders has an impact on agility	Smartening the relationship with the stakeholders by creating a better relationship with the customers and the supply chain can improve the agility of the system.
10	R_2-R_7	Automation affects agility	Automating various aspects of the production system can help to respond faster and thus become agile.
11	R_2-R_8	Smartening maintenance and inspection has an impact on agility	Repairs, maintenance and inspection are important things that contribute to the agility of the production system, which can be improved by making it smarter.
12	R_3-R_4	Digitization and connection of real-time data has an effect on flexibility	Cloud, machine learning, artificial intelligence, digital assistants and online robots, which are characteristics of digitization and real-time data connection, have a significant impact on the flexibility of the system.
13	R_3-R_5	Robotization affects flexibility	Robots of any kind; Online or physically, they seriously increase the flexibility of any process or system.
14	R_3-R_6	Smartening the relationship with stakeholders has an effect on flexibility.	Due to Smart communication with customers who are the main beneficiaries of any organization, the flexibility of the system increases to respond faster to the changing needs of customers.

No	Factor	Paired comparison of factors	Interpretation of relationships
15	R_3-R_7	Automation affects flexibility	It is obvious that automation will help the flexibility of tracking any system.
16	R_4-R_5	Digitization and connection of real-time data has an effect on Robotization	Online and web-based robots, as well as robots that have artificial and digital intelligence infrastructure, contribute significantly to the robotization of the system.
17	R_4-R_6	Digitization and connection of real-time data has an effect on the Smartening of communication with stakeholders.	Digitalization from various aspects such as decentralization (decentralization is the ability of Smart production systems to be managed by other subordinates) can increase the Smartening of communication with stakeholders. And in general, this intelligence will be created with the infrastructure of information technology.
18	R_4-R_7	Digitization and connection of real-time data has an effect on automation	Information and digital technology can significantly affect and improve automation from various spectrums in the concept of "fully automated factory".
19	R_4-R_8	Digitization and connection of real-time data has an effect on the Smartening of repairs and maintenance and inspection.	Digital technology can increase the smartness of maintenance with the help of quick diagnosis, and in general, this intelligence will be created with the infrastructure of information technology.
20	R_5-R_6	Robotization has an effect on the Smartening of communication with stakeholders.	Robotization , especially robots based on artificial intelligence, can improve this criterion with the rapid flow of information between different stakeholders.
21	R_5-R_7	Robotization has an effect on automation.	It is obvious that rationalization increases the level of automation.
22	R_5-R_8	Robotization has an effect on the Smartening of repairs and maintenance and inspection.	By using self-repairing robotic systems, the smartness of the repair and maintenance system increases.
23	R_7-R_8	Automation affects the smartness of maintenance and inspection	Automatic maintenance can increase the smartness of maintenance.

The final reachability matrix was obtained after creating the self-interaction matrix and also forming the initial reachability matrix, which is presented in Table 6.

Table 6.
The final reachability matrix

	R_1	**R_2**	**R_3**	**R_4**	**R_5**	**R_6**	**R_7**	**R_8**	**driving**
R_1	-	1	1	0	0	0	0	0	2
R_2	1	-	1	0	0	0	0	0	2
R_3	1	1	-	0	0	0	0	0	2
R_4	1	1	1	-	1	1	1	1	7
R_5	1	1	1	0	-	1	1	1	6
R_6	1	1	1	0	0	-	0	0	3
R_7	1	1	1	0	0	0	-	1	4
R_8	1	1	1	0	0	0	0	-	3
dependency	7	7	7	0	1	2	2	3	-

By using the final reachability matrix of TISM process, the factors were classified using MICMAC analysis as shown in Figure 3.

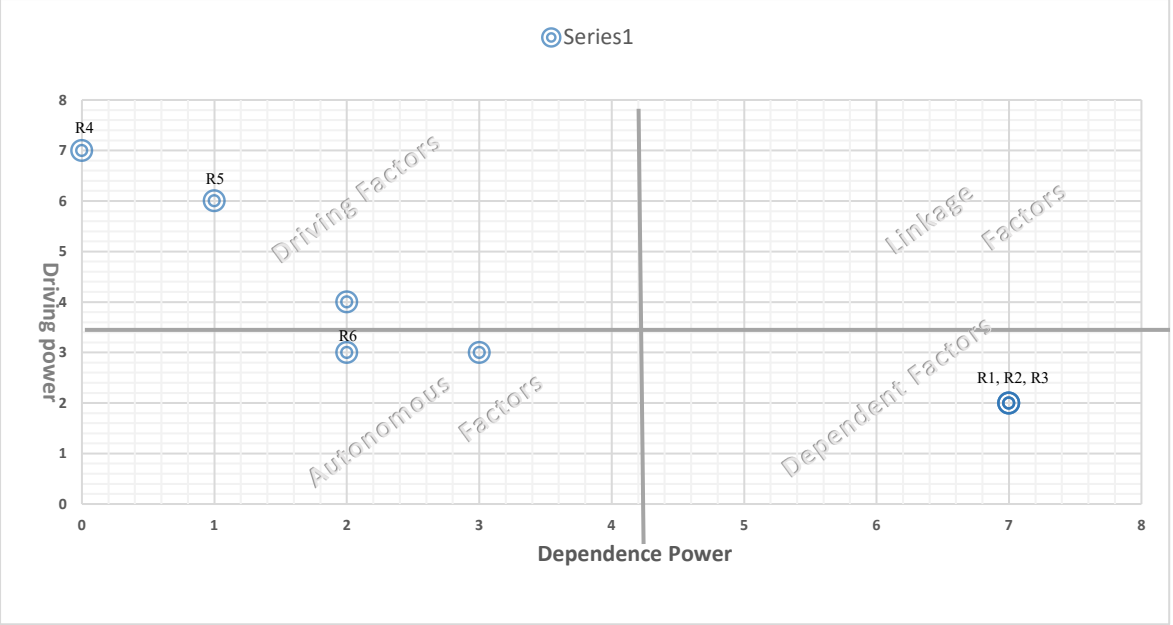

Figure 3. *MICMAC analysis of constituent factors (R_1-modularity, R_2-agility, R_3-flexibility, R_4-digitalization and real-time data connection, R_5-roboticization, R_6- Smartening of communication with stakeholders, R_7-automation, R_8- Smartening of repairs and maintenance and inspection)*

The hierarchical structure developed using TISM is shown in Figure 4 below, which depicts different dimensions with their contextual relationships as well as their relative importance based on the level they occupy in the diagram.

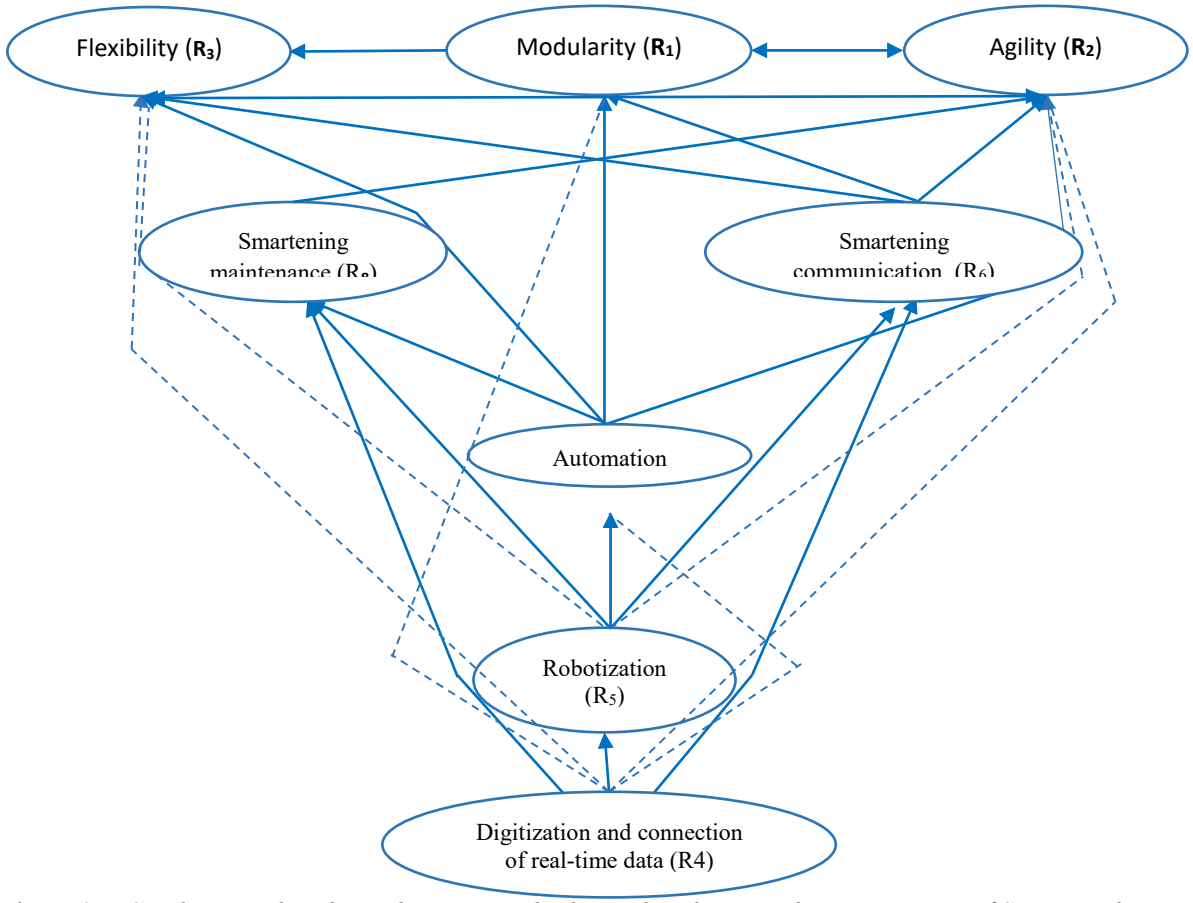

Figure 4. *TISM diagram that shows the contextual relationships between the requirements of Smart production systems*

Finally, a summary of the results of the two techniques used is given in Table 7, which compares the IFMBWM and TISM results. As can be seen, the only difference in the results; It is about R_5 and R_6 requirements. In the IFMBWM method, the higher rank belongs to R_6, and in the TISM method, the more basic level and, as a result, the better rank belongs to R_5.

Table 7
Comparing the results of quantitative and qualitative techniques

No.	Requirements	Method 1		Method 2		Variable type
		IFMBWM Weight	IFMBWM Rank	TISM level	TISM Rank	
R_1	Modularity	0.0417	8	1	5	Dependent
R_2	Agility	0.0860	7	1	5	Dependent
R_3	flexibility	0.4125	6	1	5	Dependent
R_4	Digitization and connection of real-time data	0.1361	1	5	1	Driving
R_5	Robotization	0.9674	2	4	2	Driving
R_6	Smartening communication with stakeholders	0.0960	3	2	4	Autonomous
R_7	Automation	0.9207	4	3	3	Driving
R_8	Smartening maintenance and inspection	0.0204	5	2	4	Autonomous

Discussion

Smart manufacturing systems are a fundamental concept for delivering contemporary services in a smartness manner. The implementation of these systems can be influenced by evolving social or industrial needs, global economic changes, and technological advancements. This necessitates the integration of innovative technologies to enhance and upgrade production systems, as well as to develop new systems aligned with smart production principles (Haricha et al., 2023). This study aimed to identify the factors that are critically important in the creation of smart production systems and to examine their relative importance and interrelationships for SMEs.

As observed, digitalization and real-time data connectivity, followed by robotics, were identified as the primary and most influential factors in this field, aligning with the existing literature. Most of the reviewed articles investigated the requirements, prerequisites, and characteristics of smart production through a systematic review method, with digitization and information technology being considered the main factors (Rauch and Vickery., 2020; Sharma and Villányi., 2022; Hammad et al., 2023; Haricha et al., 2023; Kılıç & Erkayman, 2023). The ICT, especially in certain industry sectors, provides powerful and compacted information in the service industry for organizations. It is very important to consider the widespread use of ICT for economic activities. First, the ICT directly leads to increased productivity and elevated economic growth of organizations. Secondly, it results in production and innovation, and the improvement of productivity and an important factor in advancing competitive advantage. Given the widespread use of information technology in business activities, governments are often portrayed in adaptation to the management practices experienced in the commercial world. The IT will play a dominant role in the new millennium, due to its very important capabilities, in improving the efficiency and effectiveness of the organizations' functional areas (Weber and Zink, (2014); Ghahremani & Saleh Ardestani, (2019)). In the limited number of articles that addressed this issue quantitatively (Qu et all., 2019; Qu et al.,

2023; Malaga and Vinodh, 2023), this criterion, along with robotics and sometimes the combination of robotics with automation, was assigned the most weight and the most fundamental level. Some articles also paid special attention to agility criteria (Rauch and Vickery, 2019).

In general, most traditional factories possess operational technology resources that are not always interconnected. The current trend in smart production fundamentally relies on the increased use of information technology to save time, reduce costs, and enhance maintenance and services. This is achieved through the convergence of emerging technologies and platforms such as artificial intelligence and the Internet of Things, which represent innovative concepts in smart production (Mohammadi and Minaei, 2019). Digitalization aids in improving production forecasts, production planning, raw material inventory management, and overall factory resource management, thereby reducing waste and enhancing productivity. Small and medium-sized enterprises should focus on the vertical integration of data, from sales data in the enterprise resource planning system to production planning and control tools, down to machine data at the production unit level. Such integration is essential to leverage the connectivity of machines and workstations and to collect their data in real time. By installing IoT connectors and sensors, the challenge of transforming old machines into "Industry 4.0" machines can be addressed (Rauch et al 2019). In general, the concept of IoT is the connection of different devices to each other through the Internet. With the help of the Internet of Things, various programs and devices can interact with each other and even humans through an Internet connection. In fact, the Internet of Things enables people to manage and control the objects they use remotely with the help of Internet infrastructure (Babaie et a., 2022). The digitized work environment facilitates appropriate work studies and employee participation, enabling the factory to retain only skilled workers and, when necessary, to engage casual employees, thus reducing waste in terms of human resources. Consequently, accessing data in real time through the Internet of Things allows part of the team to be freed from certain tasks, enabling them to focus on more critical activities.

As noted by researchers such as Sharma and Villányi (2022), the necessity for businesses to restructure their entire organization into a digital entity has reached a peak. Businesses are increasingly recognizing the need for cloud technology and software as a service (SaaS) to efficiently manage their operations, from fulfilling digital and physical orders to ensuring employee comfort. Consequently, manufacturers are adopting cloud computing at an unprecedented rate. Conversely, with the advent of new emerging technologies in the market, such as high-speed and high-precision machines for milling and turning, as well as the introduction of cooperative robots, SMEs can advance further towards automation, even for small-scale production. When introducing new technologies in SMEs, it is essential that learning them is straightforward and cost-effective. For instance, the use of robots in SMEs is often hindered by the lack of experienced staff capable of programming robotic systems. One of the challenges of smart production systems for SMEs is their reliance on highly skilled personnel to program robotic devices, a resource that is often scarce in these companies. Therefore, robotic systems in smart production, like most cooperative robots in the market, should be user-friendly, easy to program, and simple to control (Sharma and Villányi, 2022)

In general, spending time on irrelevant tasks is detrimental to the organization. Automation and robotics enhance the efficiency and motivation of the production team by eliminating repetitive and monotonous tasks. Additionally, these two requirements ensure stable and uninterrupted production by reducing unplanned downtime due to equipment failure.

Managerial Implications

Managers and owners of SMEs can develop their production systems by considering these factors to create more durable systems and avoid incurring additional costs during the initial establishment phase. These factors have been identified from globally utilized literature and have been validated and localized by academic experts.

Based on the identified requirements and according to the research results of Rauch et al (2019), recommendations for organizational actions, particularly for managers, are proposed from short-term, medium-term, and long-term perspectives. In the short term, before establishing and developing their production systems, SMEs should aim to promote digitalization within daily organizational practices, beginning with simple activities such as paperless automation. This can be achieved using cost-effective digital tools and devices such as smartphones and tablets. In the medium term, it is crucial to introduce connectivity within the production unit. This entails implementing a comprehensive enterprise resource planning (ERP) system. Machines and workstations can be integrated with an ERP system or a manufacturing execution system (MES) to facilitate real-time exchange of production data. Additionally, SMEs should prioritize advanced production technologies. Technologies such as high-speed and high-precision Computer Numerical Control (CNC) machines, collaborative robots, and 3D printers are currently more economically viable for SMEs.

In the long term, smaller companies should gradually engage with topics such as artificial intelligence (AI) and machine learning. Although the widespread adoption of these technologies is expected in the coming years, early adopters will gain a competitive advantage in the market. Industrial designers of production systems, who are involved in creating processes and production systems within companies, can also utilize the findings of this study to develop and enhance their designs towards smart manufacturing and Industry 4.0.

Conclusion

This study provides a summary of the results and related observations, addressing the research questions outlined in the Introduction section. The requirements essential for establishing smart production systems are identified in eight categories, each serving as the foundation for a group of effective sub-criteria in smart production. These categories include modularity (R_1), agility (R_2), flexibility (R_3), digitalization and real-time data connectivity (R_4), robotization (R_5), smart communication with stakeholders (R_6), automation (R_7), and smart maintenance, repair, and inspection (R_8). These primary factors were identified through a review of the research literature and confirmed by consulting academic experts.

Subsequently, a multi-method approach was employed, utilizing the IFMBWM and the Total Interpretive Structural Modeling-MICMAC (TISM-MICMAC) qualitative technique to examine the relative importance of these factors in establishing smart production systems. Additionally, the interactions among these factors were investigated within the context of smart production. These factors were classified as independent, stimulating, and dependent variables, and their relative importance for the transition of small and medium-sized enterprises towards smart production was determined using the best-worst technique. The research findings indicated that:

1. Digitalization and real-time data connectivity are key requirements and powerful drivers in the creation of smart production systems.
2. Robotics, even on a small scale, can serve as a significant driving force in establishing these systems for small and medium-sized enterprises.
3. Enhancing communication with stakeholders can facilitate the acceptance of change among stakeholders, aiding small

and medium-sized enterprises in their transition towards smart production.

In this study, as with most applied research, there is a limitation regarding the generalizability of the relative importance of the requirements to other geographical regions, particularly developed countries, due to the fact that all experts consulted were from Iran. Additionally, despite employing the best-worst technique within an intuitive fuzzy environment, which significantly mitigates uncertainty in decision-making, the experts' opinions remain subjective and are influenced by the context and geographical scope of the study. Future researchers are encouraged to investigate sub-criteria for these main criteria. They may also explore topics such as sustainability and key issues in Industry 5.0 that could impact the development and success of smart manufacturing systems. Further research utilizing specific surveys and statistical generalization to a broader population can enhance the validity and reliability of the findings presented in this study.

Declaration of interest

The authors have no relevant financial or non-financial interests to disclose.

The authors have no competing interests to declare that are relevant to the content of this article.

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RESEARCH ARTICLE **Open Access**

A Conceptual Model of Leadership for Learning Organizations in Higher Education Institutions

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Abstract
A growing body of research has highlighted that the capability for organizational learning is the singular competitive advantage that enables organizations to thrive in today's turbulent environment. The primary objective of this study is to design a conceptual model for leading learning organizations within higher education institutions in Fars Province.This research is developmental in nature, employing a qualitative design through thematic analysis and semi-structured interviews. Participants were selected using purposeful sampling and the concept of theoretical saturation, resulting in a sample of 25 faculty members and specialists in higher education. To obtain the credibility and validity of the data, two methods were used: participant review and expert review by non-participants in the research. Reliability was determined using the Holistic coefficient, which was found to be 0.87. To achieve transferability, interviews and consultations were conducted with 25 specialists, and to ensure dependability, all details of the research were meticulously recorded at every stage.The research findings indicate that the conceptual framework for learning organization leadership in higher education institutions in Fars Province encompasses four main dimensions: structural perspective, which includes flexibility, simplification, decentralization, and technology focus; contextual perspective, featuring policy-making, network expansion, strategic thinking, and culture focus; transformational perspective, characterized by leader mentorship, customer orientation, team trust, Magnificent Leader, and leader pragmatism; and knowledge-centered perspective, which supports knowledge production, knowledge sharing, and a belief in science. Identifying the key components influencing leadership in learning organizations within higher education institutions is essential. By prioritizing these elements in the strategic planning of higher education management, it can pave the way for a broader adoption of this leadership style nationwide.
Keywords: *Conceptual Framework, Leadership, Learning Organization, Higher Education*

Introduction

Today, a fundamental characteristic of contemporary organizations is their formation based on learning. In a learning organization, continuous learning is regarded as an essential requirement for all employees. This environment emphasizes not only the acquisition of knowledge but also the methods of learning, assimilating, and distributing new information. It fosters the creation and production of necessary knowledge and information, which is ultimately reflected in the behavior and performance of the organization's employees. Therefore, managers and employees are constantly learning and acquiring new skills, as the strength of any organization is directly related to the ongoing education of its leaders and staff. A learning organization is one that effectively identifies environmental needs and equips itself with the necessary tools to adapt, ensuring its longevity. By rapidly

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creating and nurturing the capabilities required for future success, it continually evolves. Many experts view a learning organization as one that is perpetually in a state of evolution, functioning as a living system focused on knowledge acquisition and skill development, which in turn enhances its overall performance (Amwoobai-Moghadam & Allahyari, 2023).

In today's dynamic landscape, the key to success for organizational leaders lies in their ability to adapt and lead effectively. Managers of organizations, institutions, and agencies must be equipped not only with management knowledge but also with leadership qualities and skills. Many leaders have realized that stability is an outdated concept, and that control and predictability are increasingly futile. As the world undergoes rapid changes fueled by technological advancements, complexities in organizational performance have escalated. Organizations that endure and thrive are those capable of responding adeptly to these shifts and meeting customer demands (zali, 2006).

Leadership style and approach within an organization are considered among the most strategic tools for achieving excellence or facing failure. The series of decision-making and organizational structures can only be realized under the guidance of effective leadership. Managers, as the central axis of organizing and directing their organizations, play a vital and complex role. Their inherent and acquired capabilities significantly contribute to the effective operation and productivity of the organization, facilitating successful organizational movement and overall efficiency (Ebrahimpour et al, 2014). It is evident that focusing on the growth and advancement of educational institutions is an unavoidable necessity. In the rapidly changing landscape of the 21st century, only those organizations that possess a comprehensive and responsible understanding of this complex world can ensure their survival and dynamism. Thus, university leaders and educators who guide themselves toward better visions are true artists in their field. These leaders not only have a clear and accurate understanding of what their institutions can achieve but also possess the potential to envision what they can ultimately become (Barkhoda & Amini, 2022).

Ghanbari & Mohammadi (2023) A study titled "The Role of Empowering Leadership of School Principals in the Professional Development of Teachers Mediated by Organizational Learning" focused on all primary school teachers (both male and female) in Kurdistan Province. The results indicated that empowering leadership and organizational learning have a significant positive direct effect on the professional development of teachers at the 0.05 level. Additionally, empowering leadership indirectly influences professional development through organizational learning at the same significance level. Furthermore, both empowering leadership and organizational learning account for 51% of the variance in teachers' professional development. Ultimately, the findings highlight a meaningful mediating role of organizational learning in the relationship between empowering leadership and the professional development of teachers.

In a study titled: Structural Analysis of the Dimensions of Knowledge Leadership and Its Relationship with Organizational Learning Capacity: A Case Study of the General Directorate of Education in Hamadan Province, it was found that

In a study titled "Structural Analysis of the Dimensions of Knowledge Leadership and Its Relationship with Organizational Learning Capacity: A Case Study of the General Directorate of Education in Hamadan Province," Samimi (2022) found that knowledge leadership consists of dimensions such as learning orientation, supportiveness, knowledge vision, strategic emphasis, and inquiry. The impact coefficients of the research variables indicated that among the components related to knowledge leadership, three components—learning orientation, knowledge vision, and inquiry—predict

changes related to the variable of organizational learning capacity.

Bazohori et al (2021) A study titled "Clarifying Self-Leadership and Self-Efficacy of Teachers Based on Transformational Leadership with the Mediating Role of the Learning Organization in Schools of Mashhad" demonstrated that the learning organization acts as a mediating variable between transformational leadership and both self-leadership and self-efficacy. Transformational leadership positively and directly influences the learning organization, self-leadership, and self-efficacy. However, it was found that transformational leadership did not have a significant impact on self-efficacy. The validity of the measurement model was confirmed by the cv.com test, and the structural model validation was supported by the cv.red test, indicating a strong model fit.

Peyvasteh et al (2020) A study titled "The Impact of Learning Leadership on the Willingness to Change in Police Force Employees with the Mediating Role of Organizational Trust in Tabriz County" indicates that this research is both applied in its objective and descriptive-survey in its nature and method. The statistical population consists of 725 police employees in Tabriz, with a random sample of 251 selected based on Cochran's formula. To ensure the validity of the data collection tools, content and face validity were employed, while internal consistency (Cronbach's alpha) was used to measure reliability. Structural equation modeling was utilized for data analysis. The findings of the research indicate that the analysis of structural equations revealed z coefficients of (0.853) and (0.769) in the primary hypothesis, showing that learner-centered leadership indirectly influences employees' willingness to change by approximately 8.4% through organizational trust. Additionally, the z coefficient of (3.281) demonstrates a positive impact of learner-centered leadership on employees' willingness to change, while the z coefficient of (16.59) and the standardized path coefficient (0.669) highlight the influence of learner-centered leadership on organizational trust. Lastly, the significance level of z (0.460) and the standardized coefficient (0.057) indicate a positive effect of organizational trust on employees' willingness to change. The results suggest that the police force, as an important social institution, can benefit from learner-centered leadership to enhance employees' attitudes in alignment with the organization's mission and strengthen organizational trust.

Assefa et al (2024) The objective of the research titled "Transforming Higher Education Institutions from Spaces for Formal Learning to Environments for Lifelong Learning: A Convergent Study" is articulated as follows: This mixed-methods study aims to determine comprehensive perspectives on the transformation of higher education institutions from mere providers of formal education to environments where lifelong learning can be integrated. This necessitates an investigation not only through a sample review but also through the accumulation of richer evidence, which plays a crucial role in deriving lessons and conclusions from existing realities. The goal is to illustrate how higher education institutions can serve as spaces that promote lifelong learning for individual benefit and social advancement. In this study, researchers identified the broad concepts of lifelong learning, potential stakeholders, learning content, and delivery methods applicable within higher education institutions. The investigation also addressed practical challenges, concerns regarding engagement and coordination, as well as policy and reform issues related to promoting lifelong learning. The findings provide significant evidence for education policymakers and practitioners striving to transform their institutions into environments where lifelong learning is integrated with other educational programs, ultimately optimizing professional development and social advancement for individuals.

Castro (2024) A study titled "Leadership Agility of School Leaders in Indonesia During a Crisis: A Grounded Theory

Approach" demonstrated that successful leadership in educational organizations thrives amidst challenges. As the post-COVID-19 era unfolds, school leaders must engage in self-assessment and actively participate in rebuilding and reevaluating their institutions. Efforts to revisit decisions made and to determine how to resume normal operations, while maintaining a focus on learning, are essential. This research highlights the importance of adaptability, resilience, active learning, role modeling, and a forward-thinking mindset for educational leaders during new crises in schools.

Lūsēna-Ezera et al (2023) A study titled "Learning Organization Approaches in Latvian Schools: Perspectives of School Staff, Students, and Parents" aims to analyze the current performance of the implementation of the school as a learning organization (SLO[2]) approach in public and vocational education in Latvia. The OECD[3]-integrated SLO model was utilized to ascertain whether differences exist in the perceptions of school staff, students, and parents regarding the current execution of the SLO approach. A concurrent triangulation design was employed, wherein qualitative data (from 38 school staff) and quantitative data (from 990 students and 620 parents) were simultaneously collected. Subsequently, the data were analyzed separately before merging and triangulating the study results. One of the key prerequisites for transforming a school into a learning organization is leadership, executed daily by the school principal or a broader management team. Research findings indicate that, based on the analysis of student and parent feedback, learning leadership is one of the weakest dimensions of School Learning Organizations (SLO). The study also concludes that the perceptions of students and parents regarding learning are not overly positive when related to the external environment and the broader educational system. This highlights the need to enhance staff awareness about the importance of collaboration in the current implementation of the SLO approach. It is essential to ensure that purposeful collaboration and coordinated action at the school level are undertaken to achieve the institution's shared goals.

Tran (2023) A study titled "The Library as a Learning Organization: The Impact of Leadership Skills on Organizational Citizenship Behavior in Vietnamese Libraries" aimed to examine the influence of leadership skills (technical, human, and conceptual) on organizational citizenship behavior within Vietnamese libraries, with organizational culture serving as a mediating factor. Utilizing a quantitative approach, data were collected from a sample of 356 participants employed across various libraries in Vietnam. The findings indicate that leadership skills significantly impact organizational citizenship behavior; however, only human skills have a meaningful effect on bureaucratic culture. This study also revealed that bureaucratic culture plays a crucial role in influencing the organizational citizenship behavior of organizations. Furthermore, bureaucratic culture was identified as a mediator in the relationship between human skills and organizational citizenship behavior.

Acevedo & Diaz-Molina (2023) A study titled "Learning Organizations in Emerging Economies: The Impact of Knowledge Management on Innovative Culture in Chilean Companies" aimed to investigate the influence of knowledge management on the development of an innovative culture within learning organizations in emerging economies. Utilizing a quantitative approach, the research employed a survey with a composite sample of 10,567 workers from 69 larger Chilean companies. Results were analyzed through exploratory factor analysis and multilevel regression. The findings provide significant insights into the positive impact of knowledge management—encompassing knowledge acquisition,

[2] School as a Learning Organization

[3] Organization for Economic Co-operation and Development

dissemination, and responsiveness—on innovative culture. Furthermore, the study indicates that managers who implement knowledge routines that foster a learning culture through skills in discovery, creativity, empowerment, and collaboration are more successful in their overall innovative efforts.

Malik (2023) A study titled "Measuring the Impact of Learning Organizations on Proactive Work Behavior: The Mediating Role of Employee Resilience" aimed to investigate the role of learning organizations in enhancing proactive work behaviors among employees. Data for this study were collected over two measurement periods (six months apart) using a structured questionnaire distributed among employees in the active IT service organizations in India. Confirmatory factor analysis was employed to test the proposed measurement model. The study's findings indicate that employees' perceptions of a learning organization (measured at Time 1) positively predict proactive work behavior (measured at Time 2), with this relationship mediated by employee resilience (measured at Time 1). This research suggests that organizational leaders aiming to enhance proactive behavior among employees should prioritize investments in developing a learning organization and focus on fostering employee resilience. Indeed, while it is essential to address adverse events and emphasize stress management, organizations should concentrate on building their employees' adaptability.

Kazemi et al (2020) A study titled "Evaluation of Learning Organization Components at Kabul University from the Perspectives of Faculty Members and Students" indicated that the realization level of learning organization components at Kabul University is at a moderate level. Notably, the index rankings reveal that emphasis on the components of "shared vision" and "team learning" exceeds that of "mental models," "systemic thinking," and "personal mastery." Overall, the findings underscore the need for greater attention from planners and university administrators to the characteristics of learning organizations. Consequently, higher education institutions must consistently strive towards becoming learning organizations without any hesitation to enhance their performance. Given the need for these centers to leverage learning leadership and the existing research gap in this area, the aim of this study is to design a conceptual model of learning organization leadership specifically for higher education institutions in the Fars province?

Research Methodology

The research method employed for this study is a qualitative case study, utilizing thematic analysis as outlined by Attride-Stirling (2011). Basic themes comprise the codes and key points derived from the text. A thorough examination of the text allows for the identification of the smallest codes, which are selected as foundational themes. Organizing themes emerge from the consolidation and synthesis of these basic themes. Researchers must review the primary codes and group similar concepts together, applying their discernment and expertise to assign appropriate names to each code category. Ultimately, overarching themes encapsulate the dominant themes that represent the text as a whole.

The sample size was determined based on the theory of saturation, where the researcher encounters recurring data. For instance, when similar statements and opinions are repeatedly heard during the ongoing interviews, the researcher can infer that data saturation has been achieved. However, it is suggested that once the researcher feels the data collected is repetitious, a few additional interviews should be conducted to confirm this belief. Throughout the interviews, saturation was reached after 21 interviews, but to ensure robust results, the process continued until 25 participants were interviewed. Participants were selected using purposive sampling with a criterion-based technique. Consequently, the selection method for qualitative participants was criterion-based, requiring a minimum of 10

years of experience at the relevant university, a rank of assistant professor or higher, and at least 5 years of management experience within the same higher education institution. Among the participants, 15 were male and 10 were female, comprising 15 assistant professors, 7 associate professors, and 3 full professors.

Data collection was conducted through semi-structured interviews. It is noteworthy that the criteria for sample selection in the qualitative segment included a minimum of 10 years of work experience, over 5 years of management, and a willingness to participate in the research and respond to questions, which were key considerations in purposeful sampling. The interview questions were developed using relevant literature and findings from qualitative research. In a semi-structured approach, the researcher asks a set of predefined questions but retains the flexibility to explore additional questions if a compelling or new line of inquiry arises during the interview process (Young et al., 2014). This adaptability helps the researcher delve deeper into the topic. Therefore, the semi-structured interview method was chosen for data collection. Prior to the interview sessions, participants were provided with an introduction to transformational leadership and the interview themes. According to Hooman (2011), the interview process continued with knowledgeable key informants, experts, and educational specialists until a comprehensive understanding of the various aspects and components of leadership in a learning organization was achieved. Initially, questions addressed the appropriate structure for transformational leadership in a learning organization, the context or environment for such leadership, and the content of transformational leadership, among others. Each interview lasted approximately 45 minutes, and recordings were made with the interviewees' consent, followed by transcription of the discussions.

Data analysis was conducted using thematic analysis based on the method outlined by Attride-Stirling (2011), ultimately leading to the development of a thematic network. In the initial step, segments of participants' interview texts were extracted, recorded on paper, and subjected to preliminary coding in separate tables. Subsequently, codes with semantic similarities were grouped to derive basic themes. These basic themes were then categorized into organizing themes based on practical similarities. Finally, the organizing themes were synthesized into an abstract and overarching theme, culminating in the compilation of a final thematic categorization table. To ensure the research's validity and robustness, the criteria established by Lincoln and Guba were applied. According to their framework, qualitative studies should be evaluated using four criteria: credibility, dependability, confirmability, and transferability. This research specifically employed the indicators of credibility and transferability.

To ensure the accuracy and appropriateness of the extracted codes, the coded texts were presented to two participants familiar with qualitative research methods for review and, when necessary, revision. These measures were implemented to maintain the validity and reliability of the data and the outcomes derived from the study. In order to enhance the transferability and applicability of the data in similar contexts, the greatest diversity in sampling was employed. This approach facilitates broader generalizability of the data. Furthermore, the study incorporated sampling from various levels to maximize data diversity, and the relevance of the data underlines the confirmation and accuracy of the interviews. These efforts collectively aim to ensure the transferability and reliability of the research results. To assess the reliability of the coding outcomes, a Holistic coefficient was utilized.

The Holsti coefficient is a measurement criterion assessing the degree of agreement between two coding schemes, representing the percentage of shared elements relative to the total number of items coded by both schemes. The formula for calculating the Holsti coefficient is as follows:

$$H = 2 * (a * d - b * c) / ((a + c) * (b + d))$$

The overall Holsti index of above 0.90 indicates a high level of confidence in the validity of qualitative analysis. However, various studies have considered a Holsti index value above 0.80 as acceptable. In this research, the computed value was determined to be 0.87.

Findings

In this phase, a thematic analysis method was employed to extract and categorize themes, requiring three distinct stages. The first stage, descriptive coding, involved identifying elements within each model as codes, from which the basic themes—characterized by recurring and distinctive features in the text—were identified. The second stage, interpretive coding, classified these basic themes based on theoretical foundations and conducted interviews, resulting in what are referred to as organizing or axial themes. The final stage determined the overarching theme that encompasses all identified themes (King & Brooks, 2018). Ultimately, a total of 210 initial codes were extracted, which, after multiple reviews and the removal of redundancies, were categorized and merged based on similarities and relevance into 72 basic themes, 16 organizing themes, and 4 main themes, as detailed in Table 1.

The conceptual framework of the leadership model for learning organizations in higher education institutions in Fars Province was developed through a systematic review of interviews and the guidance of supervisors and advisors. Feedback from participants was incorporated, leading to the refinement and abstraction of themes. In this phase of thematic analysis, efforts were made to organize the initial themes into abstract categories, which are presented in Table 1.

Table 1.
Core Themes, Organizer, and Comprehensive Elements of the Organizational Learning Leadership Model

Key component	Overarching theme	Organizing themes	Core subjects
Leadership of the learning organization	Structuralism	Flexibility	Aligning the organizational structure with current needs. Utilizing technology to expedite processes. Focusing on network structures. Enhancing horizontal communication within the university.
		Decomplexification	Prevent the quantitative expansion of university departments. Reduce organizational levels. Eliminate unnecessary departments within the university. Merge and outsource functions.
		Decentralization	Involving individuals in decision-making processes. Eliminating unnecessary administrative policies. Delegating authority and transferring power to designated levels. Ensuring fluidity and openness within the university structure. Paying attention to various communication tools.
	Contextual Analysis	Core technology	Aligning your organization and employees with modern technologies. Keeping pace with rapid technological advancements. Establishing performance-based electronic systems and instant feedback mechanisms.
		Policy Making	Having a plan to address challenges such as declining student enrollment and securing funding. Providing solutions to make education more effective. Considering learning as a lifelong strategy. Continuous improvement towards university development. Efforts towards

Key component	Overarching theme	Organizing themes	Core subjects
			organizational renewal. Creating an appropriate organizational plan for potential changes. Improving order and changing attitudes and beliefs.
		Networking	Establishing a mutually beneficial relationship with customers and the community. Utilizing virtual and internet networks to advance organizational goals. Introducing university achievements to the community. Holding periodic internal and external meetings and seminars. Inviting local, regional, and national officials to the university and keeping them informed about the university's progress.
		Strategic Thinking	Having a plan for globalization and international activities. A precise understanding of the internal and external environment. Assessing the successes and failures of oneself and colleagues and transforming opportunities. Having a long-term vision. Establishing a shared perspective and tangible goals. Creating a favorable organizational atmosphere.
		Learning Culture	Creating a conducive environment for learning. Encouraging and motivating staff to learn and share knowledge. Paying attention to diversity in the university. Modeling for learning. Injecting new insights for learning and implementing them within the organization.
		Mentorship	The role of coaches and teachers for employees in learning. Being risk-taking and innovative leaders. Understanding others' personal experiences to promote organizational learning. Assisting and supporting employees in achieving personal and organizational goals. Modeling appropriate behaviors for the production, dissemination, and application of knowledge in the university.
	Transformationalism	Customer Orientation	Attention to a culture of equity and inclusion. Engaging with clients and gathering information. Identifying potential and existing clients along with their needs. Considering the opinions of faculty members, staff, and students in planning.
		Team Spirit	Promoting group activities at the university. Empowering staff, students, and faculty members towards collective insight. Networking and team building. Creating teams tasked with addressing internal issues.
		Magnificent Leader	Decisiveness in decision-making. Creativity and innovation in decisions. Patience in a university environment and in interactions with stakeholders. Utilizing intelligence and insight in dealings with others.
		Leader Pragmatism	Listening attentively and curiously as a leader or manager to stakeholders' remarks.

Key component	Overarching theme	Organizing themes	Core subjects
			Considering the speech and opinions of stakeholders in practice. Asking questions to achieve precision. Providing timely and accurate feedback.
		Support in Knowledge Creation	Focusing on product and process-centric learning and organization. Paying attention to principles and styles of discipline in knowledge production and sharing. Having a system thinking approach and holistic perspective. Maintaining employee independence in knowledge production and its application and sharing. Using training to enhance employee capabilities. Supporting the development of individuals' skills and paying attention to it.
		Support in Knowledge Sharing	Providing sufficient human resources and resources for learning in the university. Assisting in cultivating the learning mindset of organizational members and consciously guiding and encouraging employee learning. Identifying learning resources and being supportive for individuals.
		Science Orientation	Facilitating the transfer of individual and group knowledge to the organization. Helping in the sharing and application of learning within the university. Training for knowledge sharing and learning.

As seen in Table 1, after reviewing and removing repetitive core themes, a total of 72 core themes, 16 organizing themes, and 4 comprehensive themes were ultimately categorized.

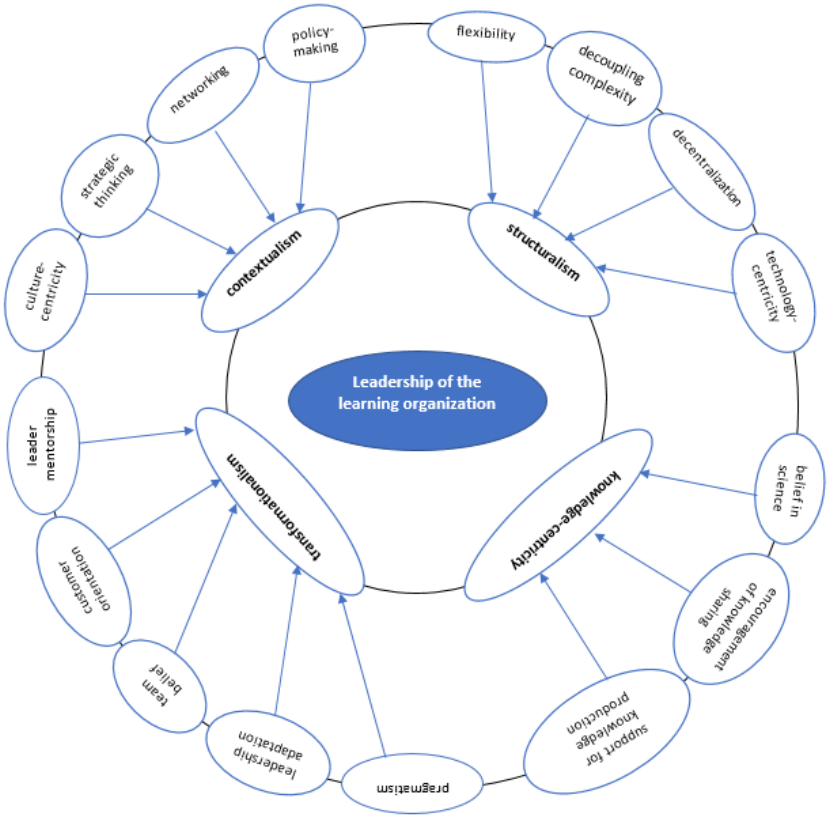

Figure 1. *The Network of Themes of the Components of the Learning Organization Leadership Model*

Final Research Model

Following the completion of the analysis and assessment of various data, the final research model is presented as follows.

As shown in the above figure, the network of themes of the components of the learning organization leadership model in higher education institutions consists of four overarching themes: structuralism, contextualism, transformationalism, and knowledge-centricity. Each of these overarching themes encompasses its own organizing themes. Structuralism includes organizing themes such as flexibility, decoupling complexity, decentralization, and technology-centricity. The overarching theme of contextualism includes policy-making, networking, strategic thinking, and culture-centricity. The overarching theme of transformationalism incorporates elements such as leader mentorship, customer orientation, team belief, Magnificent Leader, and pragmatism. Additionally, the overarching theme of knowledge-centricity includes support for knowledge production, encouragement of knowledge sharing, and belief in science. Following the identification of these components and based on previous studies, along with guidance from the supervisor and consultant, and the theoretical sensitivity of the model, a proposal for the leadership of learning organizations in higher education institutions in Fars Province is suggested.

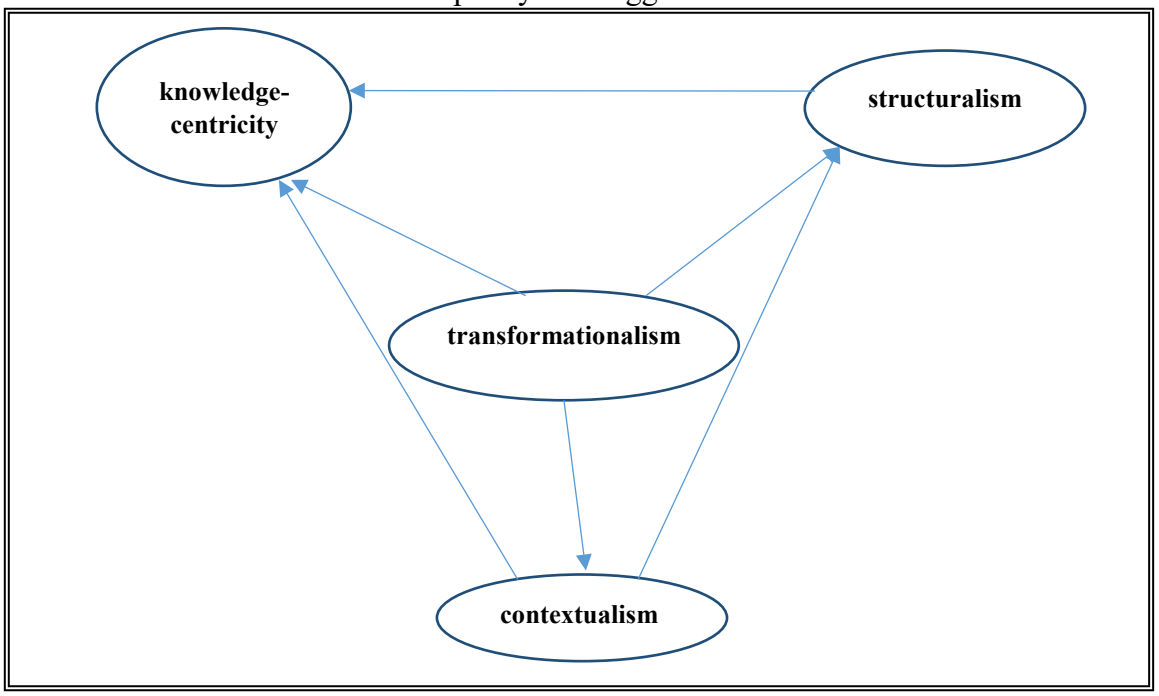

Figure 2. *The Learning Organization Leadership Model in Higher Education Institutions in Fars Province*

Discussion and Conclusion

This section provides a description and explanation of the findings. Based on the research objective and findings, the conceptual framework of the learning organization leadership model in higher education institutions in Fars Province is the focal point of this article. Given the research gap in this area, using qualitative research methods and thematic analysis in the style of Attride-Stirling, indicators and criteria of the framework were discovered and reported. The findings indicated that the conceptual framework of the learning organization leadership model in higher education institutions includes the main dimensions: structuralism, contextualism, transformationalism, and knowledge-centricity.

Structuralism

In today's variable work environment, organizational structures are considered important components because of their

significance on operational effectiveness and achievement of goals (Conner & Douglas, 2005; Armstrong & Rasheed, 2013). The foundational dimensions in the overarching theme of structuralism include flexibility, decoupling complexity, decentralization, and technology-centricity.

Flexibility: Clearly, the role of managerial flexibility is more pronounced in the success of businesses with specialized and international characteristics (Ross, 2017). Organizations are facing increasing and uncertain competition and, to adapt their structure to current needs, the use of technology to streamline operations, attention to network structures, and the horizontal development of communication at universities seem essential. In this context, Ross (2017) also concluded that one of the features of a learning organization is its flexibility.

Decoupling Complexity: Understanding the nature and rules of simplification is crucial to overcoming organizational complexity challenges. Although governmental organizations are also exposed to rapid changes due to technological advancements and the growing trend of globalization, in the "continuously evolving process of technology and growing globalization, due to the need to confront new challenges and remain in a chaotic and competitive market, these organizations have increasingly and naturally become complex." This finding aligns with the results of Ferastkhah (2016). From the perspective of research participants, decoupling complexity includes indicators such as preventing the quantitative expansion of university sectors, reducing organizational levels, eliminating unnecessary departments, integration, and outsourcing. Currently, the Director General of the Department of Higher Education Expansion at the Ministry of Science has stated that quality enhancement is the most important motto for this ministry in the higher education arena, indicating that, under current conditions, quantitative development cannot help alleviate the problems faced by universities and society.

Decentralization: Decentralization facilitates and accelerates decision-making while eliminating redundant administrative policies; it increases competition among local governments, promotes regional development, and enhances transparency and accountability by bringing government closer to the people. One of the fundamental changes in new institutions is the transition from a tall and centralized organizational structure, where a powerful individual dominates, to a horizontal and decentralized framework where power is broadly dispersed. Kamali (2014) noted this issue in his research. Decentralization has been recognized as one of the indicators for reducing the power gap, particularly at the level of government organizations, which refers to the delegation of authority to lower levels, and at the state level, which means delegating power in administrative and political matters to local units and organizations. In the first case, it results in a reduction of the power gap within the organizational structure among different levels, while in the latter, it reduces the power gap between the government and the people (World Bank, 2008).

Technology-centric approach: The rapid advancement of science and technology on one hand, combined with its inherent complexity on the other, has made it impossible for organizations to solely achieve technological capabilities. Therefore, organizations rely on external sources of knowledge and technology to meet their needed innovations. External sources include competing organizations, suppliers, students, universities, research centers, and others. A technology-centric approach supports timely programs and the establishment of informational connections, creates electronic performance-based systems, and reduces costs within the organization. Beyond positively influencing organizational performance and impacting corporate capabilities, it provides a mechanism for storing, accessing, and efficiently sharing information. Additionally, it enables organizations to leverage the

flexibility of their value chains, resulting in agility and ultimately increasing their competitive advantage. The agility of an organization is a function of the integration of its information technology. The issue of accessing external technology resources for organizations located in developing countries is also significant from another perspective: these organizations can more rapidly close their technological gap with developed countries and shift their research and development sectors from focusing solely on "incremental innovations" to creating conditions for "radical innovations." This finding aligns with the research of Swafford et al., 2008, and Karami Pour et al., 2014.

Contextual analysis: The context or environment refers to the collection of factors whose changes impact the characteristics of the organization, as well as the factors whose characteristics change as a result of organizational behavior. In this case, contextual analysis includes elements such as policy-making, networking, strategic thinking, and a culture of learning.

Policy-making: Since education is one of the most central and decisive social inputs in achieving national development, it is essential to engage in professional policy-making within the educational system, emphasizing future studies and foresight to address conflicts and challenges. Therefore, education should be oriented towards the future and consider future outlooks. The closest study that can be compared to this aspect is the research by Jafari and Karimi (2017). Policies are needed to establish programs for tackling challenges such as declining student enrollment and attracting funding, providing strategies to enhance educational effectiveness, recognizing learning as a lifelong strategy, continuously improving university development, striving for organizational renewal, creating organizational plans for potential changes, improving order and changing attitudes and beliefs, and drafting and approving strategic documents with oversight from higher authorities, including provincial supervisory boards acting based on these documents.

Networking: Undoubtedly, networks are a powerful support for universities in advancing social, scientific, and cultural goals. Holding virtual meetings has numerous advantages, the most significant being the lack of requirement for a specific location for gatherings. This reduces travel, consequently cutting costs and saving time. Additionally, the challenge of determining a suitable time and place for an in-person meeting and coordinating with all participants is alleviated by conducting meetings virtually through platforms equipped with the necessary interactive tools. Just as communication and information technology has transformed many everyday processes in organizations, the use of virtual and internet networks for learning or electronic education has heralded the realization of goals that seemed out of reach two decades ago. The development and advancement of information and communication technology has transformed the educational landscape and led to the emergence and expansion of new educational tools and opportunities in the virtual space, which aligns with the findings of Hosseinzadeh et al. (2012).

Strategic Thinking: This approach creates the foundation for developing a correct understanding of business. Strategic thinking calls managers towards rapid learning and the creative application of new value creation. This way of thinking brings distinct perspectives compared to competitors, which can lead to innovative strategies and competitive advantages. If the strategic function is seen as creating a competitive edge, then strategic thinking is essential for the survival and growth of organizations in today’s competitive environment. On the other hand, designing and implementing coherent training and development programs for strategic thinking is unavoidable. The future direction of an organization relies on the strategic thinking of top managers; the forward-looking concepts and mental frameworks can foster expectations for strategic actions and outcomes when present and reinforced in managers. One of the main

challenges for managers is the lack or insufficiency of the ability to identify strategic priorities and delineate a shared vision. Thus, in the realm of strategic skills, the ability to create a shared vision and achieve collective agreement on future-generating organizational flows is necessary. Strategic thinking cannot be injected; it must be practiced. While understanding the concepts of strategic thinking and studying them is a prerequisite for practicing strategic thinking, it is not sufficient alone. It is not feasible to prescribe a set of empowering packages for developing strategic thinking and expect individuals to become strategic thinkers simply by successfully completing these packages. This point is also aligned with the findings of Ghafariyan (2009) and Namdari Varposhti et al. (2023).

Learning Culture: One of the responsibilities of universities is to empower students and faculty in various fields, which can be influenced by their learning culture. A learning culture is one where learning is valued and barriers to learning are not tolerated. The goal of an organizational learning culture is to exchange valuable knowledge and information that leads to creativity, improved performance, and sustainable competitive advantage within the organization. A genuine learning culture continuously challenges the way things are done, ensuring continuous improvement and the capacity to embrace change. Organizations that have established a strong learning culture perform well in creating, acquiring, and transferring knowledge, as well as in changing behaviors to provide new insights. Therefore, the goal of fostering a learning culture is to exchange valuable knowledge aimed at guiding innovation, improving performance, and enhancing the organization's competitiveness. The learning culture encompasses the time and space in which learning occurs, the individuals involved, the material conditions present during the learning process, and the locations where topics are formally or informally prescribed, such as conventional classroom sessions and student groups along with their professors. The findings of this section align with the research results of Pasha et al. (2022), Prewitt (2003), Kucharska (2020), Khodami and Asanlu (2015), Dixon (2020), Khodam Abbasi et al. (2017), and Barabasch et al. (2020).

Transformationalism: Transformation is a new form of change that occurs in a more complex manner within any organization. Today, the survival of any organization hinges on its ability to react swiftly to changes. In recent years, the country's education system has faced numerous issues such as the lack of a philosophy grounded in local theoretical foundations derived from value systems, the absence of purpose-driven cultural engineering, a deviation from its primary mission, neglecting secondary aspects, a lack of participatory engagement and interaction with cultural heritage, and an inability to effectively utilize a large pool of educated individuals. In light of these issues, the implementation of the fundamental transformation document was initiated to address existing problems; however, several years after its introduction, we have not witnessed significant changes in the system. Transformationalism includes (servant leadership, customer orientation, team reliance, Majestic Leader, and pragmatism of the leader), which aligns with the findings of research by Andam et al. (2014), Jahaniyan (2014), and Mowgeli et al. (2016).

Servant leadership: According to Imam Khomeini (RA), the servant leadership approach of an educational leader includes sincerity, a sense of duty, and a commitment to service. Sincerity means making divine service the guiding principle of one's actions. A sense of duty involves viewing oneself as obligated to fulfill their responsibilities, regardless of whether the organization's goals are achieved or not; such an outlook from the organization's leader will significantly impact both the quality and the advancement of the organization. Service means that effective leaders in educational organizations should consider serving their subordinates as a selfless duty and should not shy away from any efforts in this regard (Imam's sayings).

Furthermore, this concept aligns with the findings of Moaednia's research (2006), which states that in mentoring-oriented organizations, coaching has become increasingly common and has transformed into an inseparable part of the organizational learning culture. Coaching is a skill that managers should develop and utilize to become leaders in the role of mentors. These organizations are innovative and responsive to understanding the personal experiences of others to foster organizational learning, modeling appropriate behaviors to generate, share, and apply knowledge, adapting to competitors' skill changes, evolving customer needs, shifts in societal morale, changes in international business conditions, and government regulations, thereby reevaluating their production methods and transforming themselves.

Customer-centricity means placing the customer at the center of the organization's strategy and goals. This strategy is based on the needs and satisfaction of customers. The main element of customer-centricity is researching and analyzing customer needs. In reality, a customer-centric organization must have a deep understanding of the needs and expectations of its customers. Customer-centricity involves attention to a culture of equal consideration, focusing on customers' perspectives, and delivering what they want, rather than what is readily available in the market. Customer-centric organizations do not aim for a one-off transaction; instead, they establish close relationships with their customers. They excel at meeting the unique needs of their clients because it is only through building a sincere and close connection and understanding customers that they become aware of their profound needs. Since developing a customer-centric culture is a prerequisite for fostering customer-oriented behaviors and embedding these behaviors within the organization, it is crucial that human resources systems and processes align with this value for customer-centric behaviors to manifest. The next mechanism for being customer-centric is the mechanism of training. In fact, it must be said that training is the best method for addressing the shortcomings of other tools. Just as in large companies, the education and learning manager, who falls within the ranks of senior management, organizes necessary training on the organization's strategic topics for employees. This aligns with Mohammad Esmaeili's (2018) findings that one of the main concerns for managers is the development of customer-oriented behaviors.

Team Trust: Team building within an organization, which combines diverse realities and viewpoints to create new capabilities, fosters innovation. Dynamic team building enhances performance and improves interactions among members, leading to increased creativity, flexibility, and ultimately organizational effectiveness, especially in today's complex environment. When achieving goals requires the expertise, experience, and skills of various individuals, team building forms, and the amalgamation of different realities and perspectives promotes innovation. This concept is consistent with the findings of Dehnavi and colleagues (2023). Therefore, team trust can facilitate the promotion of group activities in universities and contribute to empowering employees, students, and faculty members toward collective insight.

Majestic Leader: According to transformational leadership theory, followers observe heroic traits and extraordinary leadership abilities in these leaders. These leaders have a vision and accept risks to achieve their goals, being very sensitive to followers' needs and exhibiting outstanding behaviors. They possess personality traits like extroversion, self-confidence, goal orientation, decisiveness in decision-making, creativity and innovation in their choices, patience in organizational settings, and skillful handling of stakeholders through intelligence and insight. Research indicates a significant correlation between transformational leadership, high performance, and follower satisfaction. Individuals who work for these leaders have greater motivation to exert their efforts because they like their leader, respect them,

and experience higher levels of satisfaction. The clearer and more precisely the organizational values are articulated for employees, provided they are accepted by individuals, the greater the emotional commitment and sense of belonging employees will feel towards the organization. As a result, they will exert more effort and develop a deeper attachment to the organization. Managers should prioritize internal relationships, create opportunities for improving communication, and strive to involve employees in decision-making processes to enhance their commitment and sense of belonging. This component is aligned with the findings of the research by Pashaee, Yusef-Kandi, and Hassani (2021).

Pragmatic Leadership: Pragmatic leadership is an exchange relationship between the leader and followers aimed at achieving mutual benefits. A pragmatic leader operates within the existing organizational culture and structure, carefully listens to stakeholders, continues discussions until reaching the desired outcome, and takes into account the opinions and inputs of stakeholders during decision-making. They are capable of providing accurate and timely feedback, setting standards for work and performance, clearly explaining their expectations to followers, and promising rewards in exchange for meeting those expectations. A pragmatic leader's primary concern is identifying the needs of followers, aligning promised rewards, and securing resources to meet those needs. In this approach, the leader guides followers towards optimal performance levels by clarifying their requests and rewarding appropriate behaviors. Conversely, an effective leadership style is essential for fostering a supportive environment for empowered employees. Unlike autocratic managers who seek to undermine subordinates, empowered managers act as guides, facilitators, and mentors. This aligns with the findings of research conducted by Bass (2009), Harms and Credé (2010), and Clapp-Smith et al. (2019).

Scholarship

Leadership plays a crucial role in the effectiveness of knowledge management initiatives within organizations. In all credible models of knowledge management implementation, "leadership" is considered one of the core components. Organizations that can succeed in knowledge management are those with informed, engaged, and supportive leaders. In such cases, employees are more motivated to engage in knowledge-related activities, ultimately leading the organization to achieve a higher level of maturity. Knowledge management encompasses support for knowledge creation, knowledge sharing, and the promotion of a culture of learning.

Support for knowledge creation: Knowledge Creation and Management (KCM) is one of the main strategies for enhancing improvement in any organization, including educational institutions. There has been a growing focus on KCM in educational service providers, such as schools or higher education institutions, compared to other organizations. Knowledge can be generated through various processes, from bold innovation efforts to research activities. In educational organizations, the generation of new knowledge and awareness, along with innovations and initiatives, is not merely a specialized task, but rather a collective behavior that all members of the organization engage in. Consequently, the leader in the organization focuses on process-oriented learning, principles, and a disciplined style in the production and sharing of knowledge; adopts a system thinking and holistic perspective; upholds employee independence in producing and utilizing knowledge; and emphasizes training and skill development to enhance employee capabilities. Today, given the importance and value of knowledge in the success and advancement of organizations, managing this intangible resource has become one of the most critical organizational issues. Therefore, with the recognition of knowledge as a strategic resource for organizations and its significance in an organization's capacity and

sustainability in a competitive environment, there is an urgent need to develop methods for knowledge production, sharing, and application within organizations. This conclusion aligns with the findings of the studies by Rodríguez-Gómez and Sallán (2015), Wiig (1997), and Jazayeri and Alvani (2018).

Knowledge Sharing Support: In most books and articles written about knowledge management, the appropriate distribution of knowledge from the right individuals to the right people at the right time is emphasized as one of the greatest challenges of knowledge sharing. This is because if the tacit knowledge held in individuals' minds cannot be effectively shared with others, it gradually fades and loses its effectiveness. Therefore, knowledge sharing is a reflection of social interactions within organizations and requires individuals to share what they know. This concept aligns with the findings of Riege (2005), which state that knowledge sharing is a complex yet value-generating activity that serves as the foundation for many management strategies, enabling adequate resources for learning within organizations. Consequently, it is essential that organizations not only recognize this topic's significance in their success and knowledge creation but also take steps to identify and eliminate or mitigate barriers to foster a more favorable environment for knowledge sharing.

Knowledge Belief: Knowledge belief significantly aids in the transfer of individual and group knowledge while facilitating learning and its application within organizations. Knowledge belief is one of the distinguishing factors of developed nations compared to less developed ones. For organizations to effectively meet fundamental goals and societal interests, they must be rich in knowledge, capabilities, and expertise to promote knowledge creation and sharing within their bodies. This component is consistent with the research conducted by Salmani- Jolodar and Gholam-Aliei (2016).

In conclusion, based on the findings of the present study and the detailed examinations carried out, it can be concluded that the proposed model for developing leadership in learning organizations within higher education institutions can serve as a fundamental approach for promoting learning organizations in higher education institutions in Fars's province and even across the country. Identifying the key components influencing leadership in learning organizations within higher education and considering them in macro-planning and educational management can pave the way for the widespread application of this research at the national level. This research, by identifying the components and factors affecting leadership in learning organizations in higher education and developing a suitable proposed model, can be a useful tool for managers and educational planners in expanding this methodology.

Practical recommendations from the research

Considering the results of this study on leadership in learning organizations within higher education institutions and the organizing themes, several research suggestions for future researchers in this field are as follows:

1. Developing a model for the connection between higher education institutions and lifelong learning within these institutions.
2. Although measuring changes in organizational behavior over time is quite complex and challenging, paying attention to these changes as a result of organizational learning can represent a novel approach in this area.
3. Creating a model to articulate the relationship between learning organizations and the concepts of learning and forgetting organizations (organizational unlearning).
4. Presenting and promoting models for maintaining and sustaining organizational learning (clarifying the concept of sustainable learning organizations).
5. Research can investigate how leadership in learning organizations can enhance a culture of interaction and collaboration,

as well as its impact on the interactions among students, staff, and faculty members. These studies can be conducted through field observations, interviews, and questionnaires, contributing to the understanding of the factors that influence the establishment of a culture of interaction and collaboration in universities.

6. Research can explore how leadership in learning organizations can facilitate the professional development of employees and its impact on their performance and satisfaction. These studies can be carried out using questionnaires, interviews, and field observations, helping to identify the role of learner-centered leadership in the professional development of staff in higher education institutions.

Ultimately, the research conducted in this area can aid in the development of suitable policies and structures in higher education institutions and improve the performance of leaders.

Ethical Notes

Adherence to Research Ethics Principles

In the present study, consent forms were completed by all participants.

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The costs of the present study were covered by the authors of the article.

Authors' Contributions

Design and Conceptualization: Hamideh Mohammadi, Nader Shahamat, Ebadallah Ahmadi, Reza Zarei.

Conflict of Interest

According to the authors, there is no conflict of interest in this article.

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RESEARCH ARTICLE **Open Access**

Innovative Design of Digital Transformation Model (Case Study: Food Packaging Industry)

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Abstract
A fundamental transformation has occurred in businesses due to digital technologies, so no business is an exception to this rule. Due to the vital role of food packaging industries from economic, social and environmental perspectives, this study was conducted with the aim of Innovative design of digital transformation model in food packaging industries. The food packaging industry has been investigated as a case study in this study.The present study was conducted based on interpretive philosophy[4] and with an inductive approach[5]. Also, the present study is an applied-developmental study in terms of objective, and it is a non-experimental (descriptive) research in terms of data collection method. A qualitative research design was used to achieve the research objective. In this study, population includes professors of management and food industry managers. Purposeful sampling (snowball method) was used and theoretical saturation was achieved with 20 participants. The participants of this research include theoretical experts (university professors) and experimental experts (food industry managers). A semi-structured interview and a decision matrix-based questionnaire were used to collect data. The results of qualitative coding were validated with the Holsti method (0.717) and Cohen's Kappa (κ) (0.659). The validity of the questionnaire was confirmed by the formal method and the reliability of the questionnaire was also confirmed by estimating the internal correlation coefficient (0.815). Analysis and coding of the text of the interviews was done using the theme analysis method in MaxQDA 20. Also, structural-interpretive modeling method and MicMac can be used to determine relationships between constructs and model design in the second part. According to the results, the investigated factors and components were grouped in seven levels. These components are: Level 7 components including business resources, digital transformation leadership and digital/sustainable foresight, Level 6 components, including digital/sustainable innovation strategies, the components of level 5, including the use of new technologies in processes and operations, core digital/sustainable capabilities, and employees' digital experience, level 4 components of the model, including a new approach to food packaging industry processes, improving sustainable food packaging functions, and designing innovative food packaging, the level 3 components, including the alignment of the digital/sustainable innovation strategy with Digital/Sustainable Capability and Business Sustainability in the Digital Age, the level 2 components, including the component of improving customer experience (digital/sustainable), and finally, the "consequences of digital transformation" component with an sustainability-driven innovation approach in the food industry.
Keywords: *Digital transformation, Innovation approach, Sustainability, Food packaging industries*

Introduction

Nowadays, a major change is happening in the world, an innovations & evolving-based technologies change that will have a significant impact on people's lives, the thinking and structure of organizations, and

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even the interactions of countries (Mirfallah Leyalistani and Khamseh, 2021). This era is called the digital era. Digital transformation refers to the process through which individuals can adapt to modern technologies (Mirfallah Layalestani and Khamseh, 2021). Traditional business beliefs have changed fundamentally in the digital age due to the emergence of new technologies. Keeping up with existing changes is the only option for organizations to advance; otherwise, they will be eliminated from the competitive scene (Zamani and Khamseh, 2022). Disruptive technologies lead to the digital transformation (DT) of businesses, and digital transformation has entered the business literature as a concept (Tolboom, 2016). According to some researchers, digital transformation refers to the changes that affect all aspects of human life using digital technologies. In this era, organizations must seek to make fundamental changes and transformations and create innovations based on sustainability in their digital transformations. This is essential for their survival in the competitive arena, so that they can maintain their sustainability due to digital transformation, population growth, and the shortage of natural resources, and subsequent social issues. Now, leaders, senior managers, and other stakeholders recognize that organizations, institutions, and industries are being impacted by two fundamental challenges: a) digital transformation, which leads to the creation of new opportunities, and b) sustainability, which has become the main focus of organizations, institutions, and companies. As a result, organizations, institutions, and industries are actively pursuing digital transformation to achieve sustainable development in an unstable and uncertain environment (Xu et al., 2023). In recent years, sustainability has attracted much attention through digital transformation and has been considered as a major focus of organizations and small and medium-sized industries. Digital transformation refers to an important and fundamental strategic path for companies and industries to achieve high-quality development and accelerate their transformation into first-class enterprises (Yang et al., 2024). Also, digital transformation enables organizations and industries to integrate sustainable practices into their operations, enhance resource efficiency, and minimize their ecological footprint.[6] Also, digital technologies can improve the value proposition of businesses by designing products and circular services[7], and as a result, increase product quality and longevity (Atiyeh Khodai et al., 2024). Using technologies such as data analytics, the Internet of Things, and cloud computing, artificial intelligence enables organizations and institutions to optimize energy consumption, minimize waste, and make informed decisions that support sustainable production processes. The digital transformation of industries, as the fourth generation industry, provides opportunities to realize development in new products, processes, and services, and on the other hand, digital strategies can move towards sustainability by improving operational processes as well as optimizing resource use (Verhoef et al., 2021). According to the results of previous studies, there are limitations in previous digital transformation models that as a digital transformation model for how and when an organization or company plans to make strategic improvements to core systems and processes, which do not allow these models to be replicated exactly in various industries. Almost all organizations in various industries have taken numerous steps to adopt digital technologies in recent years, but nevertheless, findings indicate that the desired benefits have not been achieved in

[6] The ecological footprint measures human demand on natural capital, i.e. the quantity of nature it takes to support people and their economies. It tracks human demand on nature through an ecological accounting system.

[7] Circular Services uses innovative technology to improve sortation, processing, and reuse of valuable commodities, including paper, metal, glass, plastics, organics, textiles and electronics for continual reuse in domestic supply chains.

proportion to the organizational investments made (Gerth & Peppard, 2016). It can be said that only 21% of executives have seen meaningful results from the digital transformation of their organization, from manufacturing services to finance and technology. On the other hand, according to the results, the main challenge is not IT, budget or access to extraordinary talent, but rather the barriers to this transformation are change management, risk-averse culture, traditional systems and organizational silos[8]. Also, the leadership, vision, skills, and approach required are often immature and underdeveloped (Genpact, 2016). Due to the growth of new technologies, population growth, scarcity of natural resources and subsequent social issues, today's organizations and industries must inevitably seek to make fundamental changes and transformations and create sustainability-based innovations in their digital transformations in order to maintain their sustainability. Now, senior managers and other stakeholders know that organizations and industries are affected by two fundamental challenges, which are: a) digital transformation that leads to the creation of new opportunities and b) sustainability that has become the main focus of organizations, institutions and companies. As a result, organizations, institutions and industries are actively pursuing digital transformation to achieve sustainable development in an unstable and uncertain environment (Xu et al., 2023). Corporate sustainability has been mainly addressed in existing models; and almost no attention has been paid to the sustainability of manufactured products. Accordingly, the company needs to shift from a marketing focus and attention to customer demands and needs to actively promoting the sale of environmentally friendly goods and services (El Lafjafari et al., 2024). According to Brown (2019), the lack of sufficient knowledge about the dimensions and various factors of this phenomenon and the lack of guidance to guide organizations has prevented organizations and industries from implementing digital transformation projects. Most managers or owners of organizations and industries, stakeholders and investors do not know how to face a digital transformation due to fear of failure and often do not even move towards transformative technologies. Unfortunately, most managers do not identify the critical capabilities of their organization or industry, these capabilities can lead the organization in process innovation, product innovation and management innovation, and lead the organization towards sustainability (Teichert, 2019).

In fact The importance of digitization[9] and digital transformation is always a subject that is increasingly discussed among researchers, researchers and scientific experts in various fields. Due to the interest of businesses in the concepts and practical benefits of digital transformation for business, the scientific world seeks to conceptualize digital transformation and its interrelationship with business management, organization, open innovation, sustainability and other concepts (Robertsone and Lapiņa, 2023: 1). Studies indicate that digital transformation has a significant impact on the production activities of companies. This phenomenon has the potential to improve internal management and reduce production costs (Deng et al., 2022) and it can offer businesses with distinct competitive advantages around the world (Pauliuk et al., 2022). It can also help companies to create dynamic capabilities to make them more compatible with changes in the external environment (Lee et al., 2021). Digital transformation leads to facilitating the improvement of existing products, services, and processes, and the introduction of new services (Wu et al., 2021) to meet rapidly changing market needs, and thereby ensuring sustainable development based on continuous innovation (Kim et al., 2021). Digital transformation

[8] In business, organizational silos refer to business divisions that operate independently and avoid sharing information.

[9] Digitalization focuses on using digital technologies to improve processes and operations.

leads to the strengthening of innovation, because it requires the acquisition of new knowledge and skills, requires new forms of cooperation in different organizations and industries, promotes the creation of new business models, and leads to the sustainable use of organizational resources (Mayakova, 2019).

Also, innovation promotes changes and makes them real (Robertson. & Lapiņa, 2023). Digital transformation naturally refers to a fundamental and fundamental change that completely revises the way companies and industries operate, design, develop, produce, sell products and provide services (Prokhin, 2020). Therefore, it is driven by innovation. Also, innovation refers to a set of small but impactful ideas for continuous improvement that help companies and industries to achieve higher levels of efficiency and sustainability. These improvement ideas can be created inside the organization or borrowed from outside (Robertson. & Lapiņa, 2023). Digital transformation removes boundaries and allows suppliers and customers to integrate in the creation of innovation (Gassmann et al., 2010), where customers are a valuable source of ideas that may lead to innovation (Oganisjana and Kozlovskis, 2019).

From a corporate point of view, sustainability is a balance between many economic, social and environmental factors affecting the company and its performance, which ensures sustainable development (Beltrami et al., 2021).

The trend of international companies has changed due to the advancement of digital technologies, such as the Internet of Things (IoT)[10], process automation[11], robotics, and 3D printing, and has contributed to their sustainability, development, and survival in the global market (Martínez-Peláez., 2023). Sustainability has emerged as a vital aspect of digital transformation in recent years, and has a significant impact on various economic sectors, including agriculture (Di Vaio, 2023). The transformative changes in digital transformation are accompanied by fundamental consequences for the performance, organizational capabilities and strategic orientation of small and medium-sized companies in the pursuit of environmental sustainability (Bartolacci, 2020). The paradigm of sustainable digital transformation should provide internal and external benefits for the company (Rupeika-Apoga, 2022). Also, it should promote greater economic, human, environmental and social responsibility through business practices. Sustainability-driven innovation[12] based on are defined as management systems, development of processes, products to meet organizational needs in economic, social and environmental dimensions (Behnam et al., 2018).

Food industry is one of the industries where sustainability is very important. For this reason, many companies active in this field have put sustainability at the top of their food product packaging (Nair et al., 2023). The use of digital technologies has saved costs, reduced waste, increased health and the possibility of recycling product packages. Therefore, digital technologies can be of great help for packaging in the food industry (Polyakov et al., 2020).

Although much research has been done on digital transformation and sometimes digital transformation models, it is essential to need a structure to create a specific digital transformation for the food packaging industry, considering the nature and specific characteristics of the food packaging industry

[10] The term IoT, or Internet of Things, refers to the collective network of connected devices and the technology that facilitates communication between devices and the cloud, as well as between the devices themselves.

[11] Process automation is defined as the use of software and technologies to automate business processes and functions in order to accomplish defined organizational goals, such as producing a product, hiring and onboarding an employee, or providing customer service.

[12] The term 'sustainability-driven innovation' describes new or improved products, services or processes that reduce the use of natural resources (such as materials, energy, water and land) and the release of harmful substances into the environment. It can also refer to marketing solutions that achieve these same goals.

(standards governing this industry, generating foreign exchange for the country, technological, uncertainty in production planning and inventory management, industry foresight, stakeholder pressure, environmental conditions, etc.). The innovation of the research includes creating a specific digital transformation model for the food packaging industry, and the other is that sustainability in economic, environmental and social matters can be achieved by creating innovation in processes and packaging. Therefore, although sustainability and digital transformation are among the most fundamental issues in the food packaging industry, and this industry is of great importance both in terms of profitability and environmental and social aspects, previous research shows that there is no model that specifically designs digital transformation for the food packaging industry. Therefore, this research seeks to design an innovative digital transformation model in the food industry. For this reason, qualitative and quantitative methods (mixed approach) of interpretive structural modeling were used to identify and examine the relationships between the factors effective in the innovative design of the digital transformation model in the food industry. Therefore, the present study answers the key question, "How is the innovative design of the digital transformation model in the food packaging industry?"

Theoretical foundations of research

Digital innovations and initiatives have become a fundamental and important challenge for organizations and industries in today's constantly changing environment. The challenge that transformative technologies are the basis of, and given the competitive environment, this challenge is not specific to a specific industry and almost all organizations and industries are involved in it. This challenge is known as digital transformation. Although the term digital transformation is widely used in the scientific literature, there is no consensus on the definition of this term (Nadeem et al., 2018). Digital transformation refers to a significant change in the performance of a country or an organization centered on transformative technologies. In a comprehensive definition, digital transformation is defined as "the use of new digital technologies such as: social media, cloud computing, mobile applications, Internet of Things, data analytics, blockchain and artificial intelligence to significantly improve business in the field of operational processes and create new business models". The entire organization or industry is the scope of digital transformation, where all dimensions must be redefined in the digital age by applying transformative technologies. But, "What exactly does digital transformation mean and why and how can industries bring about this transformation?" This transformation includes fundamental changes in operational routines, business processes, organizational capabilities, as well as a different presence in today's and new markets (Noori et al., 2019). Organizational transformation generally involves changes in structure, strategy, and distribution of power. Therefore, digital transformation is specifically the impact of information technology on information flow, organizational structure, routines, and organizational capabilities in order to adapt to technology. Therefore, the term transformation refers to the comprehensive actions that an organization must take in the face of new technologies, and this transformation is an organization-wide digital transformation strategy that goes beyond departmental thinking, and takes a holistic view of the risks and opportunities arising from technology, and this digital transformation strategy guides the organization on its journey towards digital transformation. As mentioned, digital transformation is not simply the acquisition and deployment of digital technology, but also refers to an approach to management issues such as human resources, business process redesign, and business development. It can be said that most today's organizations and industries are engaged in creating a specific model for the digital transformation

of their business, but they need to identify their strengths and weaknesses in order to properly utilize their digital capabilities before starting the digital transformation (Schwaferts & Baldi, 2018).

Digital transformation: Digital innovations and initiatives have become a fundamental and important challenge for organizations and industries in today's constantly changing and evolving environment. A transformative technologies-based challenge that is not specific to only one special industry considering the competitive environment and almost all organizations and industries are involved in it. An era where they can interact with each other and even humans through Internet connections, with the help of the Internet of Things, various applications and devices (Babaei et al., 2022).This challenge is known as digital transformation. Although the term digital transformation is widely used in scientific literature, there is no consensus on the definition of this term (Nadeem et al., 2018). The term Fourth Industrial Revolution is the Latin translation of " Industrie 4.0 (in Germany)", which was proposed in 2011 during a high-tech project in Germany's state industries in Hanover. This term expressed a new generation of industry based on intelligentization and the use of technology that emerged after the previous three periods of the industrial revolution (Adadm et al., 2024). According to Boffa and A. Maffei(2024: 2), digital transformation leads to a fundamental change in industry technologies, which provides the possibility of creating a connected smart factory. You (2022) in another study concluded that digital transformation is based on digital technology that leads to unique changes in operations, processes and value creation. Imran et al. (2021) provided another definition of digital transformation: "Digital transformation refers to the process of adapting to changes in digital technology and organizational practices to improve services and products, enhance customer experiences, gain competitive advantage, create new processes, and innovate business models.

Digital transformation refers to a deep change in the functioning of transformative technologies-based country or an organization. We can claim digital transformation when these technologies have changed the business models, the experiences of the stakeholders and the operational processes of the organization in a favorable way. Digital transformation in an organization or industry means building an organization or industry at the level of the digital age. This phenomenon in the organization refers to new organizational capabilities that can guarantee the success of that organization in this era.

Operational definition of digital transformation: Research findings show that this term refers to the score that research participants consider for the subcomponents of digital roadmap, digital governance, organization, digital resources, improvement in productivity and operations of the food packaging industry, changes in the organization, differentiation in strategies to gain competitive advantage, improvement of environmental policies and individual safety, community security and health, new digital/sustainable services and products, smart packaging technology, and optimal food packaging design.

Innovation approach: Researchers have examined innovation from different angles. Innovation can be defined as "turning opportunities into new ideas and bringing those ideas to practical application and finally to the market" (Tidd& Bessant, 2011). Innovation strategy refers to a management term that supports a set of potentially innovative external and internal activities and functions. It oversees a set of structured, comprehensive and creative activities that are developed in order to support the future growth of the organization (Carrasco et al., 2023). The innovation strategy must be aligned with the company's overall strategy to be most effective. Also, companies can differentiate their innovation strategy based on two types of exploitation strategy, which refers to current technologies and tasks, and exploratory strategy, which consists of new

or radical technologies and tasks (Koehgivi, 2021). According to recent developments, innovation is a compelling means to increase sustainability in businesses (Horn and Brem, 2013).

Operational definition of innovation approach: Research findings show that this term refers to the score that research participants consider for the subcomponents of creating digital innovations, creating sustainable innovations, creating digital innovation value, digital innovation processes, green process innovation, customized and personalized packaging, sustainable and environmentally friendly food packaging design, interactive packaging design, optimal packaging design, coordination, balance, and complementarity.

Sustainability: The term sustainability refers to continuity and stability, but in the 21st century, it refers to peaceful cooperation between human life and the environment. Sustainability is a process that involves policymakers, individuals, organizations, the environment and natural resources and includes changes in trends, behaviors, purchasing habits, consumption patterns and how the environment is perceived and valued by society.

The sustainability movement quickly included various organizational concepts, including product packaging (Trinh et al., 2023). Packaging is very important and refers to the imagery of the product. Packaging forms the first direct contact with the customer, which is largely responsible for providing a favorable mental imagery of the product.

This package includes identifying, describing, protecting, displaying, promoting, facilitating product movement and product cleanliness (Elkhattat & Medhat, 2022). Sustainable packaging refers to environmentally friendly practices used to package, store, ship, or shelf products. It is a new way of packaging products, which is made of recyclable and environmentally friendly materials (Liu et al., 2023). Sustainable packaging refers to environmentally friendly practices used to package, store, ship, or shelf products. It is a new way of packaging products that is made of recyclable and environmentally friendly materials (Liu et al., 2023).

Operational definition of sustainability: Research findings show that this term refers to the score that research participants consider for the subcomponents of political-legal, economic, application of new technologies, socio-cultural, functional food packaging, sustainable computing, sustainable execution, sustainable attachment, product and service, social factors, environmental factors, digital marketing mix.

Food packaging industries: packaging is known as one of the principles of product supply and has been accompanied by many changes over the years, which is still changing (Ramji and Sabbaghpour Langroudi, 2019: 6). In the past, the only protection of a product, the packaging, was considered acceptable, while after some time, the advantages of durability, printability and beauty were added to it (Asadi Khansari and Dehghani Firouzabadi, 2013). The industrial revolution faced the world with the introduction of various industrial goods. The development and expansion of packaging led to the independence of this industry from other industries and the competition and need caused the packaging industry to allocate a significant share of the budgets of manufacturing companies. Today, the packaging industry has become a powerful technology.

An industry called the food packaging industry was introduced to the world due to the human need to maintain the health and quality of consumed food, which has developed with the increasing population (Drago et al., 2020). So far, several definitions have been presented. of packaging, but in general, packaging can be defined as "protection to preserve the health of the packaged product and ultimately guarantee the health of the consumer from the time of receipt to the time of consuming the product (Eskandari et al., 2022: 17). Packaging while protecting the product from

the adverse effect of biological, physical and chemical factors makes it easier to transport and reduce its costs, increase economic productivity, reduce waste and increase marketability (Eskandari et al., 2022: 17). The food packaging industry is very wide in the world and is considered one of the industries that the modern lifestyle needs a lot. In the field of food packaging, in addition to the fact that the product is prepared for storage, marketing and distribution, it faces a problem called packaging hygiene. Hygiene in all areas of packaging is a factor that should be considered, but it is especially important in the field of food packaging. Food packaging refers to the art and science of preparing food for storage and eventual sale. Packaging should be as simple and cheap as possible, and it should also have the primary purpose of packaging, i.e. protection and attractiveness. Food packaging is of great interest in the marketing of the food industry as well. Also, it is used to prevent damage and possible food manipulations during transportation.

The food packaging industry is very wide in the world and is considered one of the industries that the modern lifestyle needs a lot. In the field of food packaging, in addition to the fact that the product is prepared for storage, marketing and distribution, it faces a problem called packaging hygiene. Compliance with hygiene in all areas of packaging is considered as a factor that should be taken into account, but it is especially important in the field of food packaging. Food packaging is defined as "the art and science of preparing food for storage and eventual sale". The packaging should be as simple and cheap as possible, and should also have the primary purposes of packaging, i.e. protection and attractiveness. Food packaging is of great interest in the marketing of the food industry as well. Also, it is used to prevent damage and possible food manipulations during transportation.

Research Background

Modarresi Yasman et al. (2023) designed a conceptual framework for digital soft components using content analysis. This study was qualitative, and was conducted using content analysis and its information sources included articles from reputable international databases and journals. 43 samples were selected using purposive sampling. The resulting conceptual framework includes the overarching themes of culture, skills, organization manager, and digital leadership. According to the results, the organization relies on the organization manager as the person who guides and steers the organization's ship for success in digital transformation. Amini et al. (2022) presented an improved methodology for digital transformation of business models in a study. The method of narrative review and action research were used in this study. This improved methodology was used in strategic planning for digital transformation of business model of Resis Sazeh Asia Company. According to the results, the improved framework was used to draw the target company's digital transformation roadmapafter improving the Schallmo framework, the current state, the desired state, the digital gap analysis, and the digital transformation roadmap of the company were developed and approved by the company's expert team for implementation. Firouzbakht and Rezaian (1401) designed and explained the digital transformation model of project-oriented organizations in the Iranian oil and gas industries. This study was an applied research with a mixed exploratory approach. Its qualitative part was carried out by collecting data through in-depth interviews and analyzing data using grounded theory and screening components with the fuzzy Delphi technique. Firoozbakht and Rezaian (2022) designed and explained the digital transformation model of project-oriented organizations in the Iranian oil and gas industries. This study was an applied research with an exploratory approach. The qualitative part was carried out by collecting data through in-depth interviews and analyzing data using grounded theory and screening components with the fuzzy Delphi technique. The interpretive structural modeling technique was used, and PLS

structural equation modeling was used to validate the model. In the quantitative part, the model was designed. Digital transformation causes fundamental changes in the leverage points of operational processes, project services and products, project knowledge, increasing reliability and increasing employee satisfaction and project stakeholder experience. Robertson and Lapina (2023) conducted a study on digital transformation as a facilitator for sustainability and innovation. This study identifies the interrelationships between digital transformation, open innovation, and sustainability. A three-stage methodology was used in this study. A limited review was conducted to develop basic principles and conceptual frameworks for sustainability, digital transformation, open innovation, and their interrelationships to expand the existing body of literature and identify knowledge gaps. As a result, the framework of the interrelationships between digital transformation, open innovation, and sustainability development suggests that digital transformation is an enabling factor for sustainability and open innovation. Martínez-Peláez et al. (2023) examined the role of digital transformation in achieving sustainability: The mediating role of stakeholders, key capabilities and technology. This study aims to identify "how shareholders, leaders, owners or senior managers of SMEs and industries can initiate a sustainable digital transformation project". A systematic literature review was conducted, which included 59 publications from 2019 to 2023. The research identifies the first steps that SMEs can take to get started. Big data technology can provide the most important advantage for SMEs, as it enables the analysis of data (any type). Zhiying Jie et al. (2023) investigated the impact of digital transformation on corporate sustainability: Evidence from listed companies in China. This study investigated "Does digital transformation improve corporate sustainability?". A new analytical framework combines the resource-based view (RBV), the institution-based view (IBV), organizational efficiency theory, and dynamic capability theory to explain the relationship between digital transformation and corporate sustainability. According to the findings, digital transformation is considered an important tool to improve corporate sustainability, but this relationship is affected by heterogeneous factors of ownership, industry, and location.Ilaria Guandalini (2022) reviewed a paper titled "Sustainability through Digital Transformation: A Systematic Literature Review to Guide Research". This paper identified the relationships between sustainability and digital transformation to further focus companies and organizations on the topic of "How can digital transformation help improve and advance sustainability?". This study pioneered a systematic review of 153 academic articles with the aim of a) integrating existing research, b) understanding thematic connections between different studies, and c) identifying research gaps in the study of "digital sustainability".According to the results of the review of past studies and literature, especially in the country, industries should pay more attention to sustainability issues due to adverse environmental conditions. Considering the fact that corporate green production is increasing with emphasis on environmental sustainability and social responsibility (Wang.X and Shi.X, 2024: 3). Food packaging industries are required to comply with this point, also companies should reduce their environmental impact as the main consumers of resources and pollutants (Ran et al..: 2023). According to the results of the past literature, the subject of sustainable packaging has been less studied from the perspective of digital transformation with an innovative view, and there is also a consensus regarding the issues of packaging sustainability. Therefore, this study seeks to design a digital transformation model with an innovation approach based on sustainability in the food packaging industry using an approach based on an exploratory mixed research design.

Research Methodology

The present is based on interpretive philosophy from a philosophical perspective, and was done with an inductive approach. Also, in terms of its purpose, it is an applied-developmental study that seeks to design a digital transformation model with an innovation approach based on sustainability in the food packaging industry. This study is considered as a non-experimental (descriptive) research from the point of view of the data collection method. A qualitative research design was used to conduct the research. In this study, the population includes theoretical experts (university professors) and experimental experts (food industry managers). According to the view of Miller et al. (2010), five criteria of keyness, popularity, theoretical knowledge, variety, motivation to participate were used to select the participants. The selection criteria for theoretical experts are at least ten years of teaching in the field of marketing and food industry or having scientific publications in the form of books and articles in this field. Also, well-known, motivated and experienced activists and managers of the food industry who had graduate degrees were also selected.

The samples were selected in the qualitative part of this study using purposive sampling and by snowball method. The sampling process continued until reaching theoretical saturation. Repetition was observed in the coding results after 19 interviews, but to avoid false theoretical saturation, 1 more interview was also conducted, and at the end after 20 interviews, it was ensured that theoretical saturation was achieved. Interviews and questionnaires were used to collect research data. Since semi-structured interviews are more suitable for qualitative studies that are conducted with the purpose of exploration and pattern design (Danaeifard et al., 2021), semi-structured interviews with experts were used in this research as well. Then, a decision matrix - based questionnaire was also used to design the structural model of the research. The validity of the qualitative part was evaluated and confirmed from the judges' point of view based on Guba and Lincoln's proposal, Four-Dimensions Criteria (FDC) of credibility, dependability, confirmability and transferability. Holsti's method[13] was used to check the reliability of the qualitative part and coding of the conducted interviews. The text of the interviews conducted in two stages was coded for this purpose. Then, the percentage of observed agreement (PAO) was calculated:

$$\mathrm{PAO} = \frac{2\mathrm{M}}{\mathrm{N1} + \mathrm{N2}} = \frac{2 * 214}{319 + 278} = 0.717$$

In the above formula, M is the number of common coding cases between two coders. In this equation, N1 and N2 are the number of all coded items by the first and second coders, respectively. PAO value is between zero (no agreement) and one (complete agreement) and if it is greater than 0.6, it is favorable. The value of PAO in this study is 0.717, which is greater than 0.6. Also, Cohen's kappa was estimated to be 0.659 and greater than 0.6. Therefore, the reliability of the qualitative part is desirable. Also, the internal Intraclass correlation (ICC) was estimated at 0.815 to determine the reliability of the structural-interpretive modeling, which is between 0.75 and 0.9 and shows that there is a good reliability. The theme analysis method is the main method used in the qualitative section, and by using this method, the themes of the innovative Desingn Model of the digital transformation model were identified. MaxQDA 20 was used, and the structural-interpretive modeling method was used to perform theme analysis. In the second part. MicMac was used to perform structural-interpretive modeling calculations.

[13] Holsti's method is a way to measure how much coders agree with each other when they are not coding the exact same sections of the data.

Findings

The demographics of food industry experts are presented in Table 1:

Table 1.
Demographic characteristics of food industry experts

Percentage	Frequency	Demographic characteristics	
30%	6	Theoretical experts (university professors)	**Expertise**
70%	14	Experienced experts (food industry managers)	
75%	15	Male	**Gender**
25%	5	Female	
10%	2	Less than 40 years	**Age**
40%	8	40 to 50 years	
50%	10	50 years and more	
40%	8	Master's degree	**Education level**
60%	12	Ph.D	
50%	10	15 to 20 years	**Work experience**
50%	10	Over 20 years old	
100%	20	Total	

The text of the interviews was coded and analyzed using thematic analysis (theme) with the the six-step method of Attride-Stirling (2001). 210 codes were identified in the open coding stage. In the end, 14 main themes and 61 basic themes were obtained through axial coding. Table 2 shows the innovative design themes of digital transformation model extracted from the interviews using thematic analysis method.

Table 2.
Innovative Design Thems of the Digital Transformation Model

Sub-theme	Main theme
1. Political-legal	Digital/Sustainable Foresight
2. Economic	
3. Using new technologies	
4. Socio-cultural	
5. Functional food packaging	
6. Digital roadmap	Digital transformation leadership
7. Digital governance	
8. Organization	
9. Digital resources	
10. Financial resources and conditions	Business resources
11. Organizational resources	
12. Digital resources	
13. Creating digital innovations	Digital/sustainable innovation strategies
14. Creation of sustainable innovations	
15. Creating the value of digital innovation	
16. Digital innovation processes	
17. Green process innovation	
18. Marketing, selling digital products and services	Using new technologies in processes and operations
19. Digital support	
20. Digital marketing mix	
21. Digital factory	
22. Digital innovation infrastructure	Core digital/sustainable capabilities
23. Digital innovation capabilities	
24. Organizational capability to promote sustainable development	
25. Strategy	Employee digital experience

Sub-theme	Main theme
26. Leadership	
27. Technology	
28. Physical environment	
29. Cultural	
30. New food packaging methods and techniques	A new approach to food packaging industry processes
31. Improving the executive process of the food packaging industry using artificial intelligence	
32. Recovery of existing processes with an innovative approach	
33. Improving the processes of the food packaging industry	
34. Improving skill performance	Improving the sustainable performance of food packaging
35. Improving protection performance	
36. Improving the performance of the retainer	
37. Improving transportation performance	
38. Improving the notification function	
39. Improving sales performance	
40. Improving safety and health	
41. Customized and personalized packaging	Designing innovative food packaging
42. Sustainable and environmentally friendly design of food packaging	
43. Interactive packaging design	
44. Optimum packaging design	
45. Coordination	Alignment of digital/sustainable innovation strategy with digital/sustainable capabilities
46. Balance	
47. Complementarity	
48. Stable computing	Business sustainability in the digital age
49. Sustainable implementation	
50. Stable attachment	
51. Products and services	Improvement in customer experience (digital/sustainable)
52. Social factors	
53. Environmental factors	
54. Digital marketing mix	
55. Improvement in productivity and operations of food packaging industries	Consequences of digital transformation
56. Changes in the organization	
57. Differentiation in strategies to gain competitive advantage	
58. Improving environmental policies and safety of people, security and health of society	
59. New digital/sustainable services and products	
60. Smart packaging technology	
61. Optimal design for food packaging	

The Interpretive structural modelling (ISM)[14] was used in order to present the research model. The relationship pattern between the identified indicators was determined using the symbols listed in Table 3.

[14] Interpretive structural modelling (ISM) is a well-established methodology for identifying relationships among specific items, which define a problem or an issue. This approach has been increasingly used by various researchers to represent the interrelationships among various elements related to the issue.

Table 3.
Symbols used in interpretive structural modelling (ISM)

O	X	A	V	Symbol
There is no significant relationship.	Two-way relationship	Construct j has a significant effect on i.	Construct i has a significant effect on j.	Relationship

The relationships of comprehensive structures are characterized by four symbols V (variable I has a significant effect on j), A (variable j has a significant effect on i), X (two-way relationship), and O (There is no significant relationship.) (Habibi and Afridi, 2021). A structural self-interaction matrix (SSIM) was formed by identifying the relationships of the indicators. The Structural Self-Interaction Matrix, SSIM is presented in Table 4.

Table 4.
The Structural Self-Interaction Matrix, SSIM of the research model

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

The Reachability matrix, Reachability matrix (RM): The reachability matrix is obtained by transform- ing the structural self-interaction matrix into a two-valued matrix of zero and one. In the RM, the main diameter is equal to one. Also, secondary relationships should be controlled for certainty. That is, if A leads to B and B leads to C, then A must lead to C. That is, if direct effects should have been included based on secondary relationships, but this did not happen in practice, the table should be corrected, and the secondary relationship should also be considered. The final access matrix is presented in Table 5.

Table 5
The final access matrix of the research model

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

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

"Achievement set" and "prerequisite set" should be identified after forming the access matrix to determine relationships and level indicators. For the Ci variable, the Achievement set (output or effects) includes the variables that can be reached through the Ci variable. The prerequisite set (inputs or effects) consists of the variables through which the variable Ci can be reached.

Table 6.
Set of inputs and outputs to determine the level

D14	D13	D12	D11	D10	D09	D08	D07	D06	D05	D04	D03	D02	D01	TRM
1	1	1	1	1	1	1	1	1	1	1	1	1	1	D01
1	1	1	1	1	1	1	1*	1	1	1	1	1	1	D02
1	1	1	1*	1	1	1	1	1	1	1	1	1	1	D03
1	1	1	1	1	1	1	1	1	1	1	0	0	0	D04
1	1*	1	1	1	1	1	1	1	1	0	0	0	0	D05
1	1	1	1	1	1	1	1	1	1	0	0	0	0	D06
1	1	1	1	1	1	1	1	1	1	0	0	0	0	D07
1	1	1	1	1	1	1	0	0	0	0	0	0	0	D08
1*	1	1	1	1	1	1	0	0	0	0	0	0	0	D09
1	1	1	1	1	1	1	0	0	0	0	0	0	0	D10
1	1	1	1	0	0	0	0	0	0	0	0	0	0	D11
1	1	1	1	0	0	0	0	0	0	0	0	0	0	D12
1	1	0	0	0	0	0	0	0	0	0	0	0	0	D13
1	0	0	0	0	0	0	0	0	0	0	0	0	0	D14

According to the results of the calculations, the sequence of constructs in this research is as follows:

The "Consequences of digital transformation with a sustainability-driven innovation approach in the food industry (D14)" construct is at level 1.

The "Improvement in customer experience (digital/sustainable) (D13)" construct is at level 2.

The "Alignment of digital/sustainable innovation strategy with digital/sustainable capability (D11)" construct is at level 3.

The "Business sustainability in the digital era (D12)" construct is at level 3.

The "New approach to food packaging industry processes (D08)" construct is on level 4.

The "Improving sustainable practices of food packaging (D09)" construct is at level 4.

The "Innovative food packaging design (D10)" construct is at level 4.

The "Using new technologies in processes and operations (D05)" is at level 5.

The "Core Digital/Sustainable Capabilities (D06)" construct is at level 5.

The "Employee Digital Experience (D07)" construct is at level 5.

The "Digital/sustainable innovation strategies (D04)" construct is at level 6.

The "Digital/Sustainable Foresight (D01)" construct is at level 7.

The "Digital Transformation Leadership (D02)" construct is at level 7.

The "Business Resources (D03)" construct is located at level 7.

The research model is presented in Figure 1:

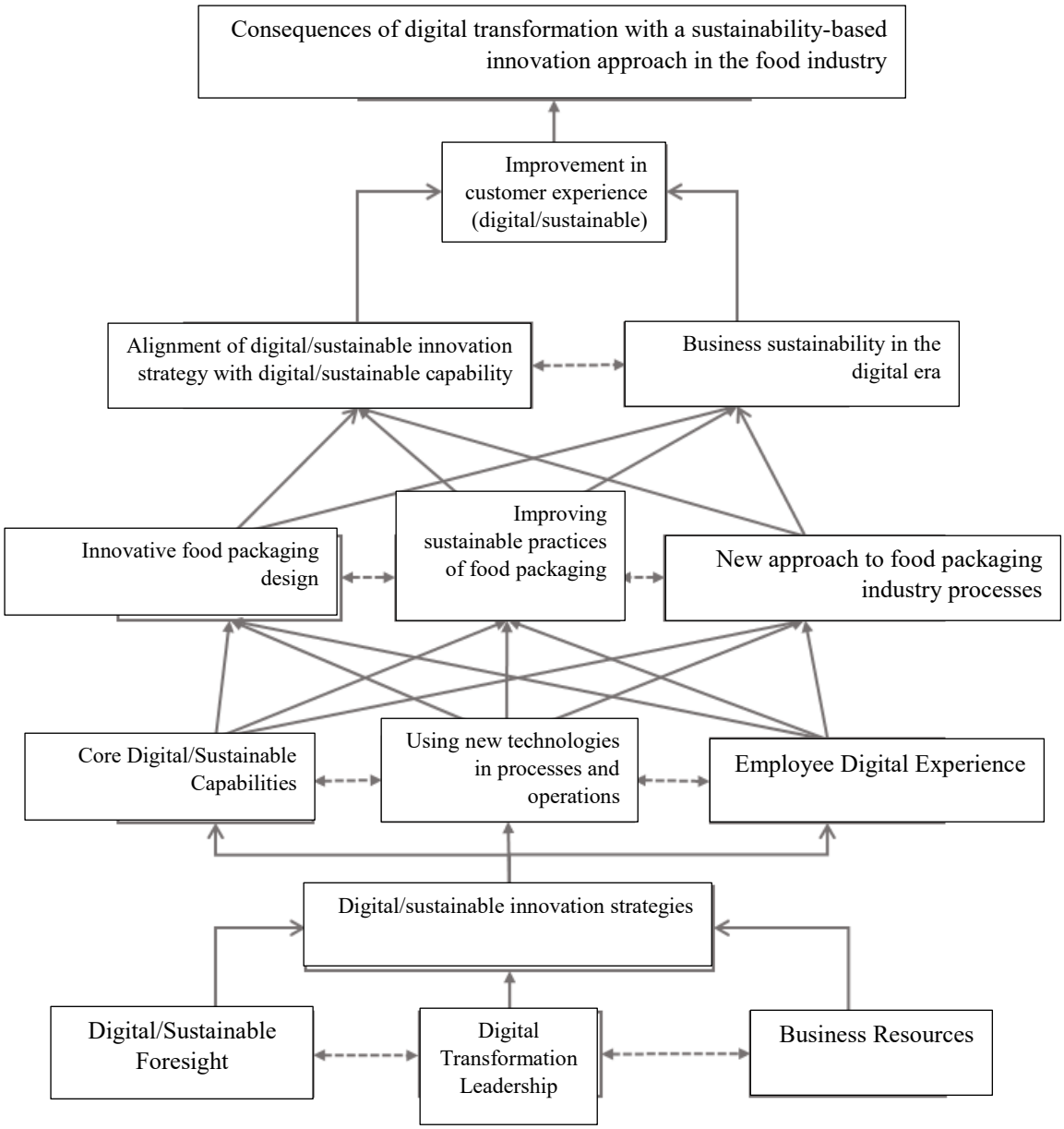

Figure 1. *Innovative design of a Digital transformation model in the food packaging industry*

The set of inputs and outputs for each element is used in the formation of the influence-dependence matrix (MICMAC analysis). The influence-dependence matrix was presented in Table 7. In the model (ISM), the interrelationships and influence between the criteria and the relationship of the criteria of different levels were well shown, which leads to a better understanding of the decision-making environment by managers. In order to determine the key criteria, the influence and dependence of the criteria are formed in the final access matrix.

Table 7.
Influence power and dependency degree of the research model

Level	Influence power	Dependence degree	Research structures
7	14	3	Digital/Sustainable Foresight (D01)
7	14	3	Digital transformation leadership (D02)
7	14	3	Business Resources (D03)
6	11	4	Digital/sustainable innovation strategies (D04)

Level	Influence power	Dependence degree	Research structures
5	10	7	Using new technologies in processes and operations (D05)
5	10	7	Core Digital/Sustainable Capabilities (D06)
5	10	7	Employee Digital Experience (D07)
4	7	10	A new approach to food packaging industry processes (D08)
4	7	10	Improving sustainable practices of food packaging (D09)
4	7	10	Designing innovative food packaging (D10)
3	4	12	Alignment of digital/sustainable innovation strategy with digital/sustainable capabilities (D11)
3	4	12	Business sustainability in the digital age (D12)
2	2	13	Improvement in customer experience (digital/sustainable) (D13)
1	1	14	Consequences of digital transformation (D14)

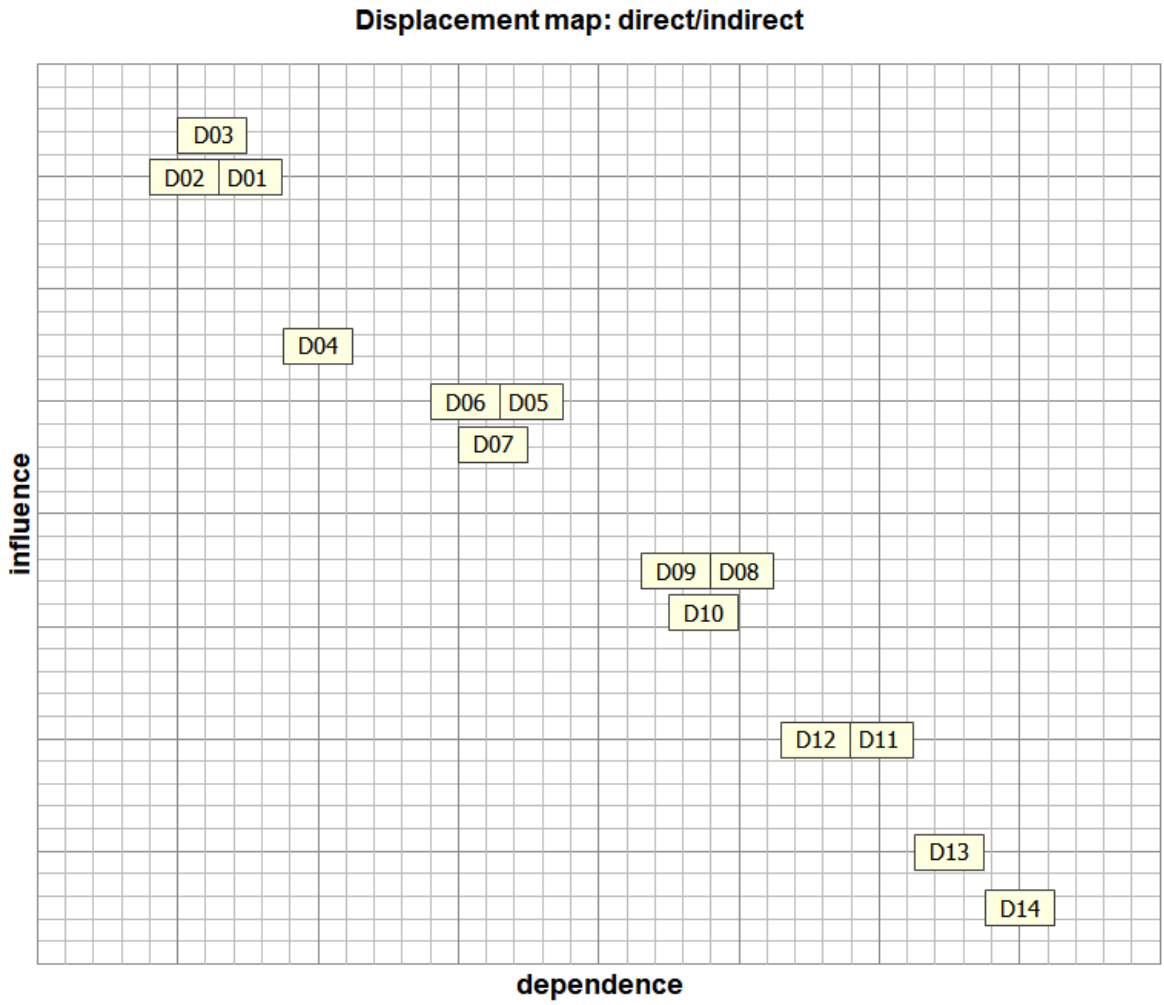

Figure 2. *Influence power and dependency degree diagram of the research model*

According to the Influence power and dependency degree diagram, the constructs of "digital / sustainable foresight" (D01), "digital transformation leadership " (D02), "business resources "(D03), "digital / sustainable innovation strategies" (D04), "using new technologies in processes and operations" (D05), "Core Digital/Sustainable Capabilities" (D06), "Employee Digital Experience" (D07) have high influence power, and low dependency, and were placed in the category of independent constructs.

The constructs of "A new approach to food packaging industry processes" (D08), "Improving Sustainable Food Packaging Practices" (D09), "Designing Innovative

Food Packaging" (D10), "Aligning Digital/Sustainable Innovation Strategy with Digital/Sustainable Capability" (D11), "Business Sustainability in the digital age" (D12), 'improvement in customer experience (digital/sustainable)" (D13), "consequences of digital transformation" (D14) also have high dependence but low influence, so they are in the dependent constructs section. No construct was placed in the first quadrant, which is the Autonomous area, and the third quadrant, which is the connected area.

Conclusion and Discussion

The present study was conducted with the aim of designing an innovative digital transformation model.. The results of this analysis show that the level 7 components including business resources, digital transformation leadership and digital/sustainable foresight have a significant impact on the level 6 component including digital/sustainable innovation strategies. According to the results presented by Denicolai, Stefano & Previtali (2023): Digital innovation is a product-oriented approach that includes a combination of physical and digital characteristics to present and produce a new product. It was also shown that the mentioned component has a significant impact on level 5 components, including the use of new technologies in processes and operations, core digital/sustainable capabilities, and employees' digital experience .In this regard, the results of the study by Xing Jie et al. (2023) showed that digital transformation is considered an important tool for improving corporate sustainability, but this relationship is influenced by heterogeneous factors of ownership, industry and location.. The previous components have a significant impact on the components of level 4 of the model, including a new approach to the processes of the food packaging industry, improving the sustainable functions of food packaging and designing innovative food packaging, and they have a significant impact on the components of level 3, including the alignment of the digital/sustainable innovation strategy with Digital/sustainable capability and business sustainability in the digital age. In this regard, the results of the study by Martinez-Plaza et al. (2023) showed that big data technology can provide the most important advantage for small and medium-sized companies, as it allows for the analysis of data (any type).

In this regard, Koh Givi (1401) showed in a study that the innovation strategy is actually a framework for innovations, ideas and creativity to ensure that the effort, energy and cost of the company are spent in the right direction. This strategy must be aligned with the company's overall strategy to be most effective. Also, companies can differentiate their innovation strategy based on two types of "exploitation strategy", which refers to current technologies and tasks, and "exploratory strategy", which consists of new or radical technologies and tasks.

Finally, the results showed that the aforementioned components had a significant impact on level 2, including the component of improving the customer experience (digital/sustainable), and finally, all components lead to achieving the results of digital transformation with a sustainability-driven innovation approach in the food industry.

In this regard, the results of the study by Firouzbakht and Rezaian (2022) showed that digital transformation has created fundamental changes in the leverage points of operational processes, project services and products, project knowledge, increased reliability, and increased employee satisfaction and project stakeholder experience.

According to the results of the research, the following recommendations are presented:

In the field of "digital/sustainable foresight", it is suggested that the economic dimension in the food Packing industry should also be taken into account while paying attention to the political-legal dimensions. The best way to achieve economic development is to pay special attention to comparative economic advantages, as all planning and spending in

this area will fail in the absence of a systematic perspective (Dolabi et al., 2020). In this regard, it is important to examine the state of competition laws, the state of social security and pay attention to the legal rights of customers, and the degree of stability of the government and its support of foreign trade facilitation regulations to achieve the goals of digital/sustainable foresight.

In the field of "digital transformation leadership", it is suggested to develop a digital vision first and then develop a digital strategy to create a digital road map. Planning and coordination and supervision and control and monitoring are required to achieve digital governance in this field and can be achieved with the help of organization that includes digital leaders, organizational structure, digital work environment, digital partners and digital culture.

In the field of "business resources", it is suggested to check the economic status of the organization, the financial status for digital transformation activities in order to strengthen financial resources and conditions. Also, it is important to strengthen the existing organizational structure, employee relations, digital skills of employees, support of the senior manager, which are considered organizational resources as well as business resources. Providing digital resources based on organization's infrastructure and equipment, organization's hardware and software resources, organization's current technology programs are also recommended to improve performance in this field.

In the field of "digital/sustainable innovation strategies", it is suggested to create sustainable innovations by creating digital innovations and digital technology management (transaction platform development, innovation platform development, two-speed information technology, innovation risk management). This type of innovation includes product innovation, environmental innovation, production innovation, social innovation and industry technology innovation.

In the field of "using new technologies in processes and operations", it is suggested to provide digital product support while considering marketing, selling digital products and services. In this context, it is important to create digital buying and selling channels with the help of smart information technology and application website design.

In the field of "core digital/sustainable capabilities", it is suggested to address digital innovation capabilities while strengthening the infrastructure of digital innovation and things such as access, transparency and information security, advanced analysis of artificial intelligence and automation of activities. This important issue has gained meaning with the capacity to absorb and accept digital innovation and predict trends and technologies, and create organizational capability to promote sustainable development also has a significant impact on the establishment of digital transformation with a sustainability-driven innovation approach in the food packaging industry.

In the field of "digital employee experience", it is suggested to pay attention to strategy and leadership more than any other action. Improving the digital experience of employees is possible by using strategic elements focused on the digital experience of employees, continuous re-engineering of processes with the help of a long-term approach along with clarifying and operationalizing goals, continuous investment in people and managers and supporting different ideas of employees and it leads to the improvement of the performance of the food packaging industry. It is also recommended to consider the technology factor and elements such as the attractiveness of technology, technology acceptance and service convenience and ease of using technology. In addition to the mentioned cases, it is important to create a physical and cultural environment and elements such as physical and technological facilities and equipment according to the needs of employees, intelligence of the work environment along with flexibility and agility.

In the field of ‘a new approach to the processes of the food packaging industry”, it is suggested that the improvement of the implementation process of the food packaging industry with the help of artificial intelligence is also investigated while promoting the new methods and techniques of food packaging.

In the field of improving the sustainable performance of food packaging, it is suggested that appropriate measures be taken to improve the skill performance and improve the protection performance based on the industry. Skill performance improvement from industry perspective refers to enabling product distribution and from customer perspective refers to packaging or physical properties of packaging.

In the field of "innovative food packaging design", it is suggested to get guidance from specialists and experts in this field for customized and personalized packaging along with sustainable and environmentally friendly design of food packaging. In fact, personalization is the process by which your packaging is designed to meet the needs of the consumer in a customized and exclusive way.

In the field of "alignment of digital/sustainable innovation strategy with digital/sustainable capabilities", it is suggested to take necessary measures to coordinate between business needs and digital innovation, the dynamics of problems and solutions in the organization, and finally create a sustainable competitive advantage with digital/sustainable innovations. The mentioned items along with the consistency and coherence of the allocation of resources to digital capability and innovation, the flexibility of digital capability is meaningful in interaction with the innovation strategy and the transparency of powers and responsibilities in the field of digital/sustainable innovation, and can be achieved with the complementarity of innovation and digital capability programs and measures, support of innovation programs by digital capabilities and adjustment of innovation programs and digital capabilities.

In the field of "business sustainability in the digital era", it is suggested to pay special attention to the field of sustainable computing and sustainable execution. Green computing (the mutual relationship between the environment and digital technologies), social computing (the mutual relationship between society and digital technologies) and business computing (the mutual relationship between business and digital technologies) have a significant impact on digital transformation with an innovation approach based on sustainability in the industry. food packaging, and lead to the creation of stable attachment and pillars such as environmental attachment, customer attachment and social attachment.

In the field of improvement in customer experience (digital/sustainable), it is suggested to pay attention to the dimension of social factors while paying attention to the dimension of products and services (technological features (utility dimension), product/service experience, customer support, customized services, service environment, experience sensory, stable or intelligent and controllable product). In this dimension, the aspects of communication, quality of interaction, social experience, social environment, customer interaction with providers, service, social experience with other customers, the presence of other customers and the quality of exchange are of great importance and are influenced by environmental factors such as the service environment experience), online environment, amenities and sensory factors.

Finally, positive consequences such as improvement in productivity and operations of food packaging industries, changes in the organization, differentiation in strategies to gain competitive advantage, improvement of environmental policies and safety of people, security and health of society, new digital/sustainable services and products, intelligent packaging technology, optimal design of food packaging will not be far from expected through the use of digital marketing

mix and paying attention to the effective elements in the digital transformation model with an innovation approach based on sustainability in the food packaging industry.

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RESEARCH ARTICLE **Open Access**

Digital Marketing Model and Its Impact on Social Media for the Development of Foreign Trade

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Abstract
The study was conducted with the aim of offering a social media-based digital marketing model for the development of foreign trade. This is an applied-developmental research in nature, following a mixed-method approach in terms of data. Information was gathered through library research, and data collection was conducted via fieldwork. In the qualitative section, the variables, components, and indicators of the model were identified and extracted using content analysis. The qualitative statistical population consisted of 17 marketing managers from exporting companies in the detergent, cosmetic, and hygiene product sectors, selected through non-probability, purposive, and theoretical sampling using the snowball technique. The quantitative statistical population included 151 managers, experts, and marketing experts randomly selected based on stratified sampling. Data collection was done through fieldwork, and the tool for gathering data was a researcher-made questionnaire. The qualitative content analysis results identified the model variables as: "Social Media Trade Strategy in International Markets", "Marketing Communications in Social Media in International Markets", "Social Messaging Strategy in Social Media in International Markets", "Marketing Actions in Social Media in International Markets", "Customer Value Creation in Social Media", and "Export Trade Development". Interpretive-structural modeling was used to generate the model, and the findings from this section indicate that the structural model consists of five levels, with "Social Media Trade Strategy in International Markets" and "Marketing Actions in Social Media in International Markets" being the most influential and independent variables. The variables "Marketing Communications in Social Media in International Markets" and "Social Messaging Strategy in Social Media in International Markets" are interconnected, and finally, "Customer Value Creation in Social Media" is the most dependent and affected variable, with a sequential effect on the others. Subsequently, the relationships within the generated model were tested using SEM. The validation findings demonstrated on export development were positively and significantly confirmed in the model. The results of this study suggest that to enhance social media marketing for export development, customer value creation should be strengthened through marketing communications and the implementation of social media marketing.
Keywords: *Digital Marketing, Social Media Marketing, Foreign Trade Development*

Introduction

Social media marketing has evolved into a trend where exporting companies utilize social media to reach global audiences. Social media marketing encompasses marketing initiatives conducted through online social platforms. Despite the rapid growth of social media and the excitement surrounding social media advertising in global markets, there is limited theoretical and practical knowledge about the effectiveness of social media marketing and

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export development in international markets. With the advancement of sophisticated technologies, social media emerged, and due to the ease of sharing information (Curiel, 2020) and the facilitation of content creation by individuals (Tajvidi & Karami, 2021), the number of global users has steadily increased. This has created an opportunity for companies to grow and expand in foreign markets through these platforms (Almeida & Santos, 2020). Currently, many companies rely on information technology and the internet to improve international coordination, manage customer service, and enhance company performance (Alarcón et al., 2016). In cross-border trade, communication with relevant players in foreign markets (such as providers, distributors, and customers) is conducted electronically (Eid et al., 2020). Recent advancements in e-commerce have led to improvements in the efficiency, effectiveness, and overall performance of exporters in foreign markets, and the sale of goods through these means continues to grow (Ferreira et al., 2021& Zedgan, et al. 2023). As a result, online marketing management has gained the attention of marketers (Alarcón et al., 2016).

Social media encompasses a vast volume of user-generated content, which helps organizations better understand consumer behavior (Saari et al., 2022). It eliminates barriers of time and distance and can assist exporting companies by reducing market delays through simultaneous knowledge exchange. This technology has the potential to provide greater access to customer information, either directly through company-customer interactions or indirectly through customer-customer interactions (Alarcón et al., 2016). Additionally, it enhances customer relationship management and flexible responsiveness to new international market opportunities (del Carmen Alarcón et al., 2015) while facilitating the sharing of news about products (Hurmelinna-Laukkanen et al., 2020). Social media reduces marketing costs and can be utilized for marketing efforts (Almeida & Santos, 2020). Moreover, this type of technology serves as a way to gather ideas for improving products and services and for expanding businesses (Virglerová et al., 2022).

Establishing social media marketing is essential for modern organizations seeking to serve suppliers and customers, increase business performance, enhance competitiveness, and achieve customary success in global trade (Kasemsap, 2018a). Companies with international activities need to understand how social media functions in an international environment and how it can be leveraged (Saari et al., 2022). Researchers are exploring how companies use social media for communication, customer support, stakeholder engagement, marketing, and sales, research and development, human resource management, and market penetration in an international context (Pogrebnyakov et al., 2017). Therefore, they must invest in social media marketing and expand their social media marketing efforts to develop international markets (Curiel, 2020).

Recently, businesses and researchers have begun to pay more attention to social media, particularly in the context of international business, as well as the opportunities that social media provides for enhancing and expanding business operations globally (Fraccastoro et al., 2021). However, the topic of social media marketing for international markets continues to suffer from a lack of publications, both in the academic and business worlds. It remains largely an unexplored territory (Curiel, 2020). Specifically, knowledge about the drivers of cross-border e-commerce performance for exporters is limited, which makes it difficult to analyze digital marketing tactics (Goldman et al., 2020). Many corporate functions where social media plays a role have received relatively little attention. Exporting companies face marketing and sales challenges in competitive environments when entering international markets, as spatial and temporal distances make it difficult to reach their targets. This is one

reason why many companies have not succeeded in expanding their businesses in foreign markets (Nazari, et al. 2023). Amidst these challenges, advanced social media technologies have emerged, providing a potential opportunity for marketing managers to assist them in their marketing efforts. However, marketers are still not fully aware of the opportunities that social media marketing presents in global markets and have not fully capitalized on its benefits. The challenge that managers face is determining which features of social media they should focus on to achieve their goals of trade development in international markets. The central research question of this study is "what dimensions of social networks lead to increased sales and export development in global markets through social media?" To answer this question, a content analysis approach was adopted. Overall, this study can contribute to advancing the literature by combining the results of previous studies on the dimensions of social networks in facilitating customer engagement and creating value through social networks. Additionally, the findings of this study provide insights that can guide industry and business owners toward the targeted use of social network capabilities to enhance customer engagement.

Theoretical Foundation and Research Background

Theoretical Background

Digital Marketing: The growth of the internet and technology has turned digital marketing into an extremely popular strategy used by almost all marketers worldwide, making the internet a forward-looking marketplace (Ardani, 2022). E-marketing is a strategic process that involves developing, distributing, promoting, and pricing goods and services in target markets via the internet or digital devices such as smartphones. E-marketing is now considered one of the most effective and efficient advertising mediums, particularly for digital products like music, videos, and similar items (Adiyono et al., 2021). Digital marketing consists of a set of marketing strategies conducted through the internet or online platforms. With relatively low investment costs, this form of marketing can yield satisfactory results. The primary goal of digital marketing strategies is to increase visibility, facilitate access for customers and potential consumers, and enhance the exposure of products or services. One of the added values of this marketing strategy is its user-friendly nature (Amalia & Khoirotunnisa, 2023).

Several digital marketing strategies, as mentioned by experts in the field, include: search engine optimization (SEO), social media marketing, content marketing, influencer marketing, email marketing, paid advertising, viral content, community engagement, affiliate marketing, and the use of podcasts (Maulana & Saefudin, 2023; Taheri et al., 2021).

Social Media and Sales: In general, social media is widely used in business for marketing, customer relationship management, product innovation, branding, and ultimately sales, due to its broad accessibility to extensive social networks and the ease of mutual interactions between users (Salo, 2017). Factors such as management attitudes and beliefs about social media, the competence of companies related to social media, the use of social media by supplying companies and customers, and cross-functional collaborations determine the actual adoption of social media by companies for selling products and services (Guesalaga, 2016). Other researchers have identified individual characteristics of salespeople, such as age, social identity, motivations, voluntariness, past performance, attitudes, and beliefs about social media, as key factors influencing individuals' use of social media (Itani et al., 2017). Both companies and sales personnel play a role in the effective use of social media in sales. The literature has identified and documented the significant role of social media usage in sales. For instance, Mangold and Faulds (2009) were among the first researchers to highlight the crucial role of social media in marketing and sales, arguing that social media should be an

integral part of a company's promotional mix. Social media has been identified as a generational and global sales interface that fosters strong connections between sellers and customers, serving as a dominant sales tool that revolutionizes buyer-seller relationships. Therefore, social media can be a useful learning tool for both sellers and companies. Researchers have suggested that social media is an innovative resource in the sales process for companies in communication activities and a strategic resource for executing effective business networking efforts (Bocconcelli et al., 2017).

Social Media Marketing: Marketing through social media (social media marketing) is a form of direct or indirect marketing aimed at creating awareness and engagement for a brand, business, individual, or other entity, using tools from the social web, such as blogging, microblogging, social networks, social bookmarking, and content. The term "social media marketing" refers to the practice of using social networks for marketing purposes. Constantinides and Fountain (2008) proposed a classification based on different types of applications that can be used as social media marketing channels for delivering and promoting social media services. This includes blogs, such as personal online journals; social networks, which are applications like Facebook; content forums, which are websites designed to organize and share specific types of content (like YouTube); message boards/bulletin boards, and content aggregators (Eid et al., 2020).

Social Media and International Marketing: Social media helps companies understand how to adjust to foreign markets and accurately identify the habits of foreign customers and collaborates in real-time. By offering instant access to target foreign audiences, which has a positive impact on international marketing campaigns, social media serves as a key element for business development and effective internalization. While social media can provide specific details about potential business contacts and common characteristics of the audience, companies can create a database and identify their top contacts to streamline and enhance the efficiency of the entire international sales process (Eid et al., 2019). As a result, companies can improve both the quality and quantity of their contacts throughout the internalization process. Social media contributes to creating a competitive advantage for companies in foreign markets by monitoring competitors, increasing advertising and traffic, and raising brand awareness. For these reasons, internalization and digitalization are powerful drivers of export performance for companies (Mahmoud et al., 2020).

Empirical Background

In reviewing the empirical background of previous studies, Asaryan et al. (2023) developed an indigenous social media marketing model for online stores using a mixed-method approach. The result of the data analysis was the presentation of a paradigmatic model that includes six components: causal conditions (information and communication technology, time management, and cost management), contextual conditions (infrastructure of online stores), intervening conditions (sanctions and economic problems, and risk management), strategies (utilization of specialized human resources and influencers), the central phenomenon (social media marketing), and outcomes (sustainability in the use of social networks, brand equity). Several indicators were also identified for each of the main categories. The quantitative results showed that the proposed research model has appropriate validity. Moradi (2022) examined the impact of social media marketing on the export development of companies. The findings indicated that perceived ease of use, perceived relative advantage, and subjective norms significantly affect social media marketing. However, visibility does not have a significant impact on social media marketing. Social media marketing positively and significantly affects brand awareness, export development, international

business contacts, and competitive perception. Furthermore, brand awareness, international business contacts, and competitive perception significantly influence export development, while customer understanding does not have a significant impact on export development. Amini (2022) explored the impact of social media resources and export performance with the mediating role of trust and commitment. The results of this study show that social media resources and marketing capabilities directly impact export performance through commitment and trust. This study aimed to use an integrated model (resource-based view and trust-commitment theory) to understand and explain an international marketing phenomenon. Focusing on Ghana, this research offers new insights into the path followed by exporting companies in emerging markets. Alhamami et al. (2023) examined the impact of using foreign social media on the business performance of small and medium-sized enterprises (SMEs) in Saudi Arabia, with the mediating role of market orientation. This study examines how the use of foreign social media impacts the performance of small and medium-sized enterprises (SMEs) in Saudi Arabia. The results from Smart PLS 4 showed that foreign social media has a positive impact on business performance, profitability, customer satisfaction, and market orientation. Market orientation also influenced business performance, profitability, and customer satisfaction and partially mediated the effect of foreign social media on business performance, profitability, and customer satisfaction. Having a high level of foreign social media usage and market orientation is critical for improving the business of SMEs. The use of foreign social media can be a useful tool for SMEs in Saudi Arabia to enhance their business performance (Alhamami et al., 2024). Zhou et al. (2023) explored how the use of social media in B2B export sales affects sales performance. Despite the increasing interest in the role of social media usage in improving performance, few studies have examined its effect on sales performance specifically in the context of B2B export sales. However, the underlying mechanisms of such effects have yet to be fully explored. Drawing on Media Synchronicity Theory, the study suggests that social media usage in sales first affects intercultural communication performance, which in turn influences sales performance. Training and experience are the allocated factors for using social media in sales (Toudeh Bahambari, 2022). The results indicate that intercultural communication performance fully mediates the impact of social media usage in sales on sales performance, and training and experience are prerequisites for utilizing social media in sales. The overall effect of training on sales performance, through social media usage in sales and intercultural communication, is stronger than the effect of experience (Zhou et al., 2023).

As the theoretical and empirical background of the studies shows, in recent years, with the growth of smart technologies such as social platforms, managers have been leveraging this opportunity to enhance their sales and seek profits in international markets to maximize these opportunities. In this regard, theoretical studies by academics and researchers have also grown, and they consistently strive to assist managers in this area. Previous studies, both domestic and international, have focused on social media marketing in the development of foreign trade. Moreover, most prior studies have looked at the correlation between social media usage and the performance of domestic companies (e.g., Gabandi & Iyamu, 2022; Tarascou et al., 2020; Maleki Shirababdi, et al. 2022) and the export of foreign markets (e.g., Zamroudi & Il Hyun, 2022; Del Carmen Alarcon et al., 2015; Alarcon Del Amo et al., 2016; Imran & Jian, 2018). The inference drawn from past studies is that researchers have paid less attention to the aspects and dimensions of international social media marketing and its role in export development. The marketing value of social media in developing international market trade has not been comprehensively studied.

Since foreign trade development leads to economic growth and is crucial for increasing a country's gross domestic product (GDP), understanding how to leverage social media for international marketing and boosting sales is essential for both academics and business managers. Thus, given the lack of comprehensive studies on identifying the aspects of social media marketing in improving international sales, this research addresses this issue to reveal its outcomes for decision-makers. In conclusion, we state that the innovation of this research lies in identifying the aspects of international social media marketing and its role in export development. Past studies, in domestic and foreign literature, have paid attention to social media marketing in the development of foreign trade. Most of the previous studies focused on the correlation between the use of social media and the performance of domestic companies. But the conclusion that comes from the past studies is that the researchers have paid less attention to the aspects and dimensions of international marketing of social media and their role in the development of marketing and the marketing values of social media in the development of business in international markets as a whole and saturation has not been studied. Considering that the development of foreign trade leads to economic growth and is important for the country's economy in terms of increasing the gross national product, so how to benefit from social media for international marketing and to strengthen sales in this way for both academics and managers. Implementation is essential. Therefore, due to the lack of comprehensiveness of previous studies regarding the identification of social media marketing aspects in improving international sales, we have addressed this issue in this research to reveal its consequences for decision makers. In the end, we declare that the innovation of the current research is to identify the marketing aspects of international social media and their role in export development. Therefore, to fill this research gap, this study seeks to answer the question: Does digital marketing influence social media to develop foreign trade, and how does this impact manifest?

Research Methodology

The present research is applied and developmental in nature according to its objective, and mixed-method (qualitative-quantitative) in terms of data type. The data collection is cross-sectional. In terms of nature and qualitative method, it employs content analysis and data coding techniques, while the quantitative phase is causal and correlational. In the qualitative section, the nature and method of the research involve content analysis. In this section, the theoretical foundations and literature of the research were reviewed, and semi-structured interviews with experts were conducted using content analysis techniques. After identifying the variables and components obtained from the expert interviews, a theoretical model was presented using the inductive approach and data coding techniques.

In the quantitative section, the nature and method of the research are causal. The study lacks predefined hypotheses or predictions, so the interpretive-structural modeling (ISM) technique was employed based on expert opinions to design the relationships between the identified variables and the conceptual model. Additionally, the causal relationships between the model's components were derived using the fuzzy cognitive map method, which justifies the causal nature of the research methodology. Finally, the designed model was validated using structural equation modeling (SEM) with the partial least squares (PLS) technique, in a population sample, making this section of the research correlational as well.

The qualitative research population consists of senior managers and marketing managers from exporting companies in the detergent, cosmetic, and hygiene product sectors. A non-probability purposive and theoretical sampling method was used, appropriate to the method of the research. The main criterion for determining the

sample size was theoretical saturation. In sampling, the iterative process continued until content adequacy was reached, bringing the study to a level of theoretical abstraction and the discovery of a theory (or valid hypothetical propositions). Given the exploration and description of the opinions and attitudes of the interviewees, and considering the time and resources available, 17 experts were purposefully and theoretically interviewed until theoretical saturation was achieved. The statistical population of this section includes 45 exporting companies in the detergent, cosmetic, and hygiene sectors, which use social platforms such as Instagram, Facebook, YouTube, Twitter, LinkedIn, WeChat, Clubhouse, Pinterest, and Telegram for marketing and selling goods in international markets. The sample consisted of 225 senior managers, managers, senior experts, and marketing and commerce experts, of whom 142 were randomly selected based on Cochran's formula. Finally, considering a 10% probability of non-response error, 156 electronic questionnaires were sent to respondents, and 151 were fully completed and prepared for analysis. Reliability of the qualitative part is examined using validity, reliability, adaptability, transferability and originality. In terms of validity, interview questions were critically validated by reference groups to obtain appropriate rich data. In a small part, the content validity index has been used for the validity of the indicators. It's CVI index was presented by Waltz and Bassel. To calculate CVI, experts are asked to determine the degree of relevance of each item with a four-part spectrum including "not relevant", "needs basic revision", "relevant but needs revision", "completely relevant". The number of experts who selected the option "relevant but needs revision", "completely relevant" is divided by the total number of experts. If the resulting value is smaller than 0.7, the item is rejected. If it was between 0.7 and 0.79, it should be revised, and if it was greater than 0.79, it is acceptable.

The data collection tool in the qualitative section was the use of semi-structured interviews to construct the model and gather expert opinions. In this phase, semi-structured interviews were conducted with 17 experts, and theoretical saturation was achieved as no new codes were added by subsequent experts. Hence, the interview process was not continued further. It is worth mentioning that each interview lasted between 30 to 60 minutes, and the interview process took place during the winter of 2023.

In the quantitative section, a questionnaire was used. At this stage, to collect data, a researcher-designed questionnaire with closed-ended questions was utilized. The foundation for the questionnaire was based on the components and indicators identified in the qualitative section, which were derived from the interview topics. In this research, six questionnaires were used: The first questionnaire was for calculating the Content Validity Index (CVI). The second questionnaire was for examining the Content Validity Ratio (CVR) of the indicators and determining them using the Lawshe coefficient. The third questionnaire was for screening the components of the social media-based digital marketing model for the development of foreign trade, based on the qualitative content analysis. The fourth questionnaire was used to determine the causal relationships between the model components using the fuzzy cognitive map technique. The fifth questionnaire was designed to produce the social media-based digital marketing model for the development of foreign trade by specifying the internal relationships among the model's variables using the interpretive-structural modeling (ISM) technique. The sixth questionnaire was used for analyzing structural equation modeling (SEM).

Research Findings

As described in the methodology section, a combination of inductive and deductive content analysis methods was used to identify the components and indicators. Data were extracted from the interview transcripts using

inductive content analysis, and key points were coded based on the suggestions by Glaser (1992) from the 17 experts. In this method, instead of coding each individual word, key points were identified and coded. Thus, in this study, in the first stage, key points from the interviews were converted into open codes, and these codes were then transformed into concepts related to the research topic. In the second stage, axial coding involved two phases: reviewing and forming categories. The first phase included reviewing the coded summaries, while the second phase considered the validity of the categories in relation to the data set. The concepts derived from open coding were compared, and those with similar meanings and relevance to a common theme were grouped into categories, leading to the formation of the components. The next step was selective coding or the third level of coding. Based on the concepts obtained from the previous stage, in this stage, after multiple rounds of study and review and back-and-forth comparison between concepts and categories, the concepts were classified into five categories, as presented in Table 1.

Table 1.
The indicators, components, and variables extracted in the content analysis section

Variables (Selective Coding)	Components (Axial Coding)	Indicators
Social Media Trade Strategy in International Markets	Utilizing social media	Recognizing the popular social media platforms of the target country
		Number and type of social platforms for marketing
	Implementing social media marketing	Leveraging social media capabilities for identifying and delivering services
		Flexibility in organizational structure for social media marketing
		Integration of the company's existing systems with social media requirements
		Cultural shifts within the organization to support social media marketing
		Human resource requirements (e.g., skills, training) to support social media marketing
		Management and leadership style for supporting social media marketing
		Connection with social marketing networks
		Methods for targeting the audience
	Global networking on social media	Effective management of multiple target groups on social media
		Coordination with advertising campaigns
		Coordination with suppliers and distributors
Marketing Communications in Social Media in International Markets	Customer relationship management in social media	Collecting information and needs of international customers
		Establishing, maintaining, and enhancing relationships with international customers
		Accessing internationally branded customers
		Factors influencing foreign customer preferences
		Public relations
		Monitoring trade practices with customers
		Analyzing consumer attitudes and behaviors
		Supporting international customers
	Customer engagement in social media	Capability to engage international customers
		Continuous emphasis on customer engagement

Variables (Selective Coding)	Components (Axial Coding)	Indicators
Social Messaging Strategy in Social Media in International Markets	Social media advertising strategy	Sharing information and knowledge with customers
		Accurate transfer of information and knowledge
		Interaction with international customers
		Motivating customers to engage
		Sharing true value
		Determinants for identifying the most effective social influencers
		Raising brand awareness and international branding
		Monitoring competitors' social media ads and content in international markets
		Electronic word-of-mouth marketing by international customers
		Sales incentives through social media
	Advertising content in social media	Advertising tools on platforms (e.g., Hashtag use on Instagram)
		Assessing the effectiveness of social media ads in international markets
		Localized images and videos for international brand awareness
		Effective localized messages and content in international branding
		Functional and emotional appeal in advertising content
		Relevance and alignment of content with international ads
		Introducing the product and highlighting pros and cons in advertising content
		Volume of messages in advertising content
Marketing Actions in Social Media in International Markets	Marketing aspects of social media	Differentiating content from competitors' brands internationally
		Providing and supporting services for international customers
		Attention to cultural factors among foreign customers
		Considering institutional and regulatory influences of countries
		Appropriate market segmentation using social media
		Providing suitable social media marketing tactics for the target country
		Targeting and positioning strategies for the target countries
	Social media marketing analysis	Changes in international targeting strategy in social media
		Identifying international audiences for products and services
		Analyzing customers based on their social media data
		Social media tools and capabilities for data analysis
	Social media marketing strategy	Marketing strategy and tactics based on social media feedback
		Insights into international competitors' social media strategies

Variables (Selective Coding)	Components (Axial Coding)	Indicators
Customer Value Creation in Social Media	Customer experience in social media	Market foresight based on social media predictions
		Capacity to implement international marketing strategies
		Reducing the time spent on searching for customer information
		Feedback and responsiveness to international customers
		Personalizing the customer experience
		Creating positive customer attitudes towards usefulness
		Assessing the experience of social media content
		Providing up-to-date news and information on the platform
		Respecting the privacy of international customers
		Evaluating and managing risks in advertising content
	Customer trust in social media	Ensuring credibility and authenticity
		Attending to the perceived value of international customers
		Ensuring data security for sharing
		Building trust through fulfilling commitments
Export Trade Development	Export development	Contribution of social media to total export profits
		Contribution of social media to foreign market share
		Contribution of social media to export sales

At this stage, the components of the social media-based digital marketing model for the development of foreign trade, identified in the qualitative section through coding, were screened. To finalize the variables of the social media-based digital marketing model for the development of foreign trade, the fuzzy Delphi method was employed. In the fuzzy Delphi method, after three rounds, the level of disagreement among the experts in the second and third stages for the remaining options was less than 0.2, and thus, the survey was stopped at the third stage. The results showed that all the components of the social media-based digital marketing model for the development of foreign trade were ranked in the high range in the surveys, and due to the majority agreement of the experts, they remained in the conceptual model of the research. Therefore, after three rounds of the survey, 13 components of the conceptual theoretical model of the social media-based digital marketing model for the development of foreign trade were confirmed. Fig. 1 demonstrates the results of the qualitative section, confirming the variables, components, and indicators of the social media-based digital marketing model for the development of foreign trade.

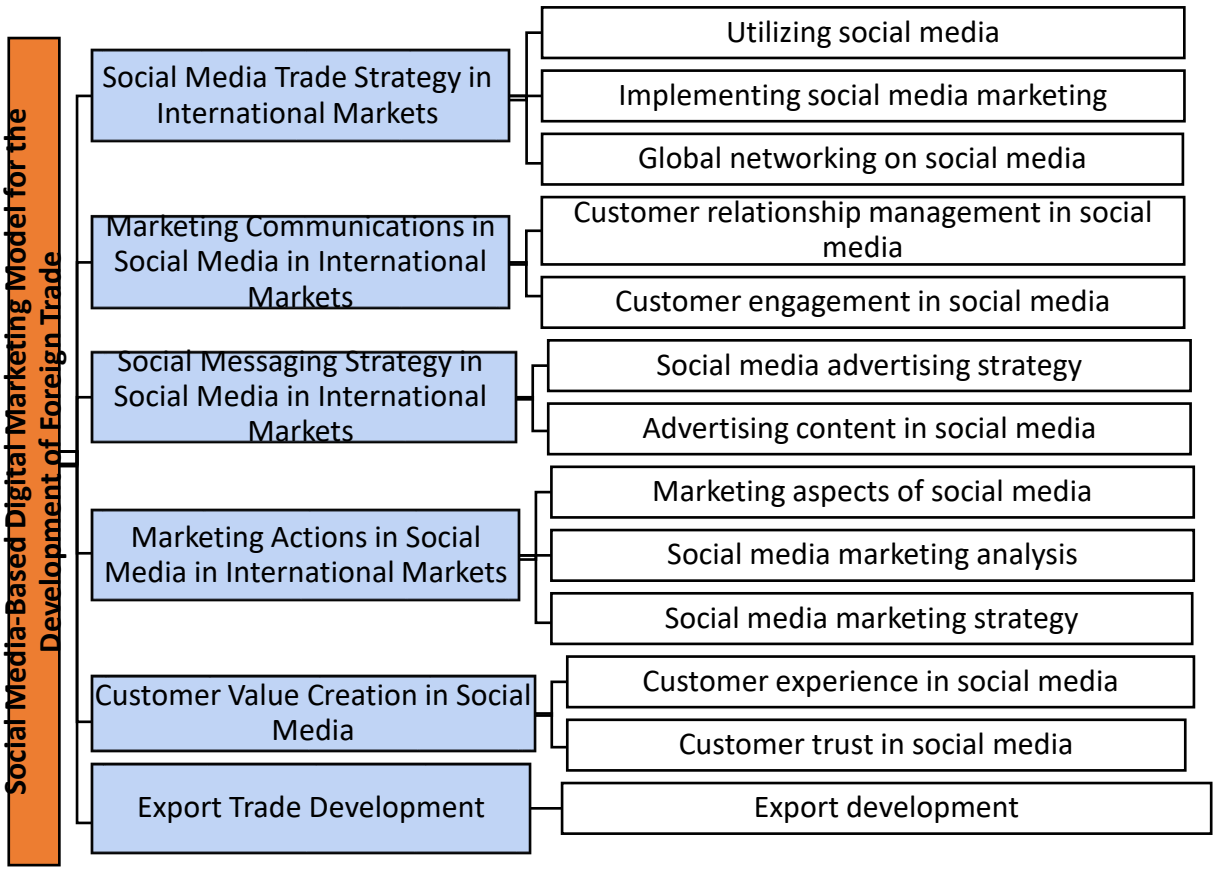

Fig. 1. *Variables and Components of the Social Media-Based Digital Marketing Model for the Development of Foreign Trade*

At this stage, we use the ISM (Interpretive Structural Modeling) method to analyze the relationship between the defined variable characteristics of the social media-based digital marketing model for the development of foreign trade. After determining the relationships and the level of the variables, a network structure model was drawn using the extracted data. To this end, the variables were initially arranged from top to bottom based on their levels. These relationships can be seen in Fig. 2.

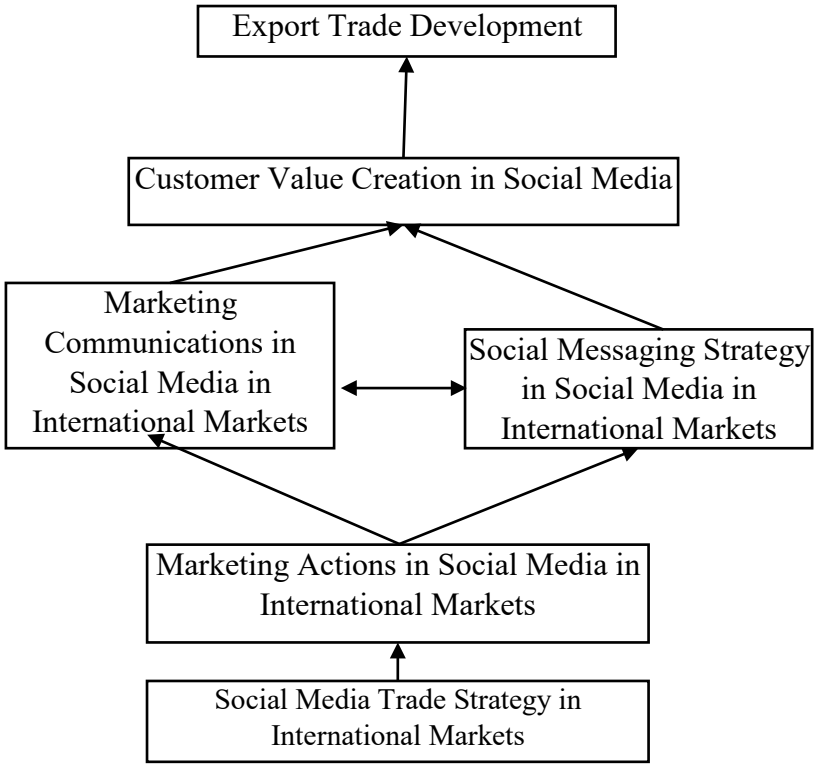

Fig. 2. *Interpretive-Structural Model of the Social Media-Based Digital Marketing Model for the Development of Foreign Trade*

As shown in Fig. 2, the interpretive-structural model consists of five levels. At the base level, Level 5, is the variable "Social Media Trade Strategy in International Markets", with the most significant impact on social media-based digital marketing for the development of foreign trade. Marketing must start from this variable. This variable is the most influential and affects all other variables. Hence, to strengthen social media-based digital marketing for the development of foreign trade, managers must first focus on this variable. Having a strategy helps us achieve our goals. At Level 4, the variable "Marketing Actions in Social Media in International Markets" is placed, influencing the subsequent variables in the structural model. Before utilizing social media in international marketing, actions to achieve sales goals must be defined. At Level 3, there are two variables, "Social Messaging Strategy in Social Media in International Markets" and "Marketing Communications in Social Media in International Markets", affecting the next variable. At Level 2, the variable "Customer Value Creation in Social Media" is located, which affects Level 1, where the variable "Export Trade Development" is situated. This variable is influenced by the five other variables. Thus, the most influential variable in social media-based digital marketing for foreign trade development is export trade development itself, which is dependent on the improvement of the other variables.

Since one of the objectives of the present research is to determine causal relationships as well as the impacts of direct or inverse relationships between components, the fuzzy cognitive map approach was employed in this study. The causal relationships and node sizes are based on the closeness centrality of a component to other components of the social media-based digital marketing model for foreign trade development, indicating the strength of the components' relationships. In fact, a component with higher centrality indicates its closeness to other components. In other words, these components have the strongest connections to other components, and information flow occurs mostly through them. Any change in these components leads

to changes in the entire system. The intermediate strength of the components in the model is shown in color and highlighted in Fig. 3. Accordingly, with higher centrality and strength, the component "Networking on Social Media" is connected to 18 other components. After that, the component "Social Media Marketing Strategy" is connected to 17 other components, indicating the strength of its connection. These findings suggest that focusing on networking and marketing strategy accelerates the flow of information through the system and enhances marketing effectiveness.

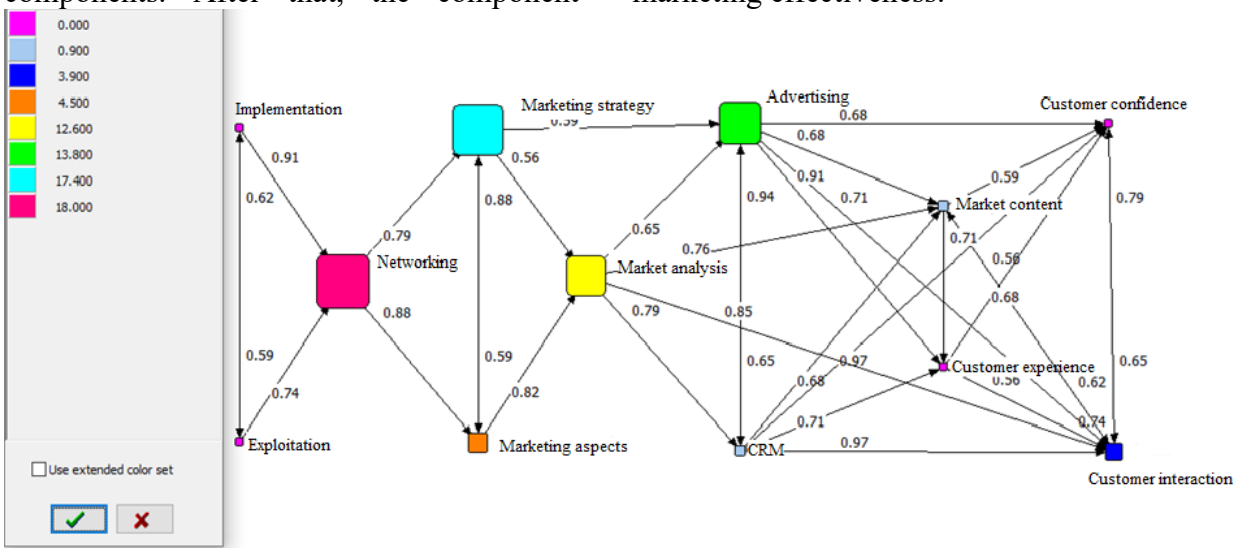

Fig. 3. *Causal Relationships and Node Sizes Based on Closeness Centrality of the Components in the Social Media-Based Digital Marketing Model for the Foreign Trade Development*

For validating the generated model, structural equation modeling (SEM) and the Smart PLS software were used. The interpretive-structural model, created earlier, was selected as the expert-based model, and the relationships between the model's variables were tested using structural equation modeling. The hypotheses proposed in this study, derived from the model, are presented below. The model is then evaluated using empirical data, and the results are discussed:

- ✓ The social media trade strategy in international markets has a significant impact on marketing actions in social media in international markets.
- ✓ Marketing actions in social media in international markets have a significant impact on the social messaging strategy in social media in international markets.
- ✓ Marketing actions in social media in international markets have a significant impact on marketing communications in social media in international markets.
- ✓ The social messaging strategy in social media in international markets has a significant impact on marketing communications in social media in international markets.
- ✓ The social messaging strategy in social media in international markets has a significant impact on customer value creation in social media.
- ✓ Marketing communications in social media in international markets have a significant impact on customer value creation in social media.
- ✓ Marketing actions in social media in international markets have a significant impact on export trade development.
- ✓ Marketing communications in social media in international markets have a significant impact on export trade development.
- ✓ The social messaging strategy in social media in international markets has a significant impact on export trade development.

- ✓ Customer value creation in social media has a significant impact on export trade development.

Fig. 1 displays the confirmatory factor analysis (CFA) model and structural equation modeling (SEM) in the estimation of standardized coefficients for the social media-based digital marketing model for the development of foreign trade. As previously mentioned, the factor loadings indicate the reliability coefficient between the indicators and the variables, which should exceed 0.6. According to Fig. 4, all questions have factor loadings above 0.6, and the factor loadings for all model variables have been confirmed. These findings indicate that the respondents believe that the indicators can construct the variables and that the variables may be evaluated using these indicators.

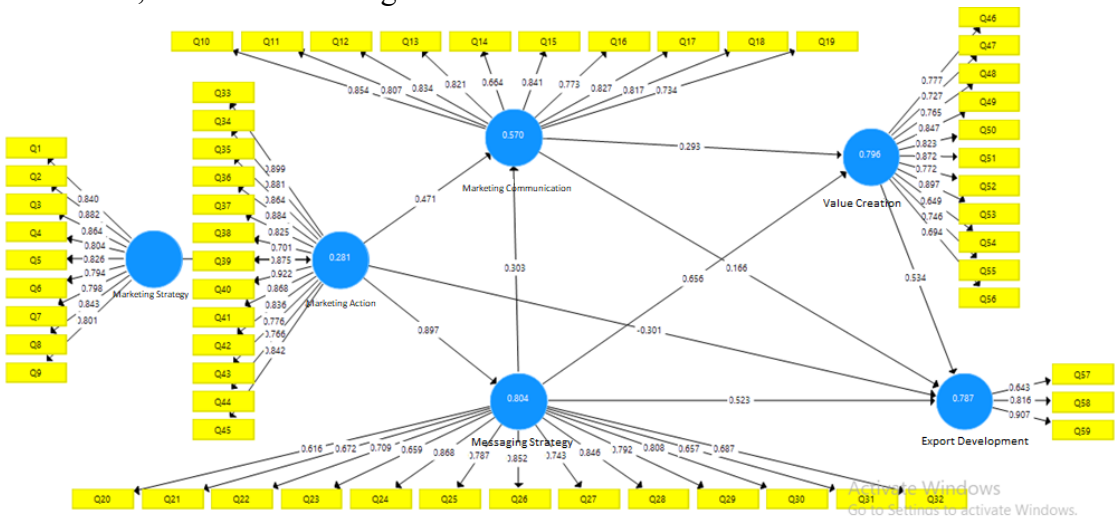

Fig. 4. *Measurement Model and Factor Loadings*

Fig. 5 presents the confirmatory factor analysis (CFA) and structural equation modeling in the estimation of standardized coefficients, showing that the t-statistic is greater than 1.96, and the path coefficient is significant at a 95% confidence level, thus confirming the model.

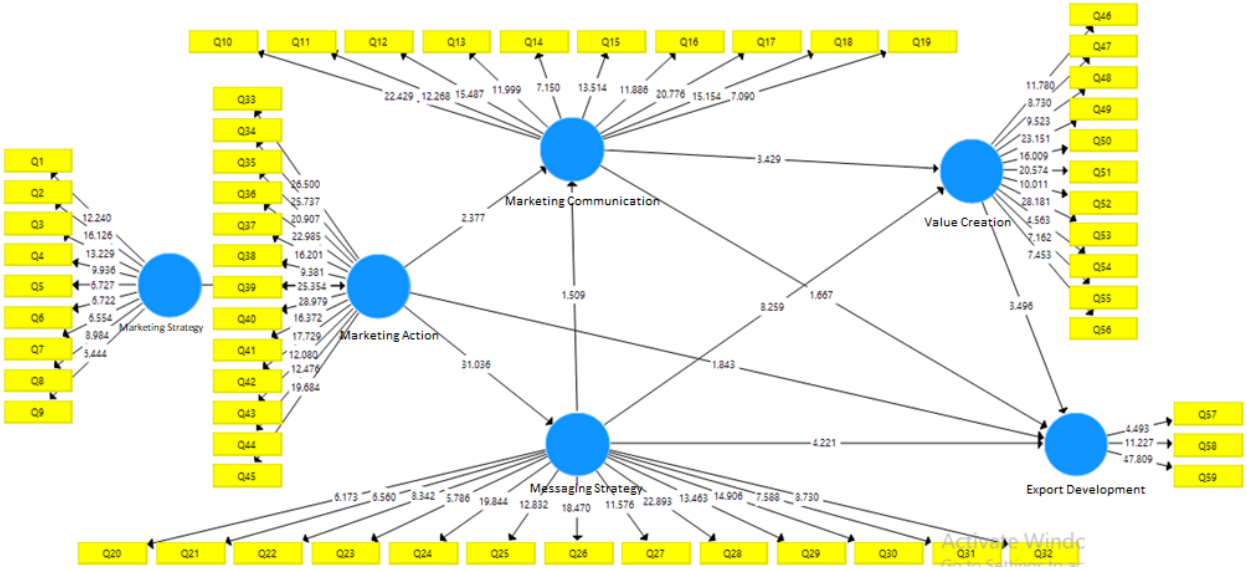

Fig. 5. *Standardized Coefficients of the Confirmatory Factor Analysis Model*

Table 2 shows the calculated values for evaluating the confirmation indicators of the model, extracted from Smart PLS software. To measure the model, we assessed indicator reliability, construct reliability, convergent validity, and discriminant validity. Construct reliability was tested using composite reliability (CR) and Cronbach's alpha. The decision rule for composite reliability is that the reliability score should exceed 0.7. For all constructs, this value was higher than 0.8, indicating that the constructs were reliable, i.e. meeting this criterion. Cronbach's alpha (α) was also higher than 0.75, confirming the model. Convergent validity was tested using the average variance extracted (AVE), which, according to Table 4-26, has a coefficient greater than 0.5 and is confirmed. Thus, in summary, the construct reliability, indicator reliability, and convergent validity of the constructs were satisfactory.

Table 2.
Measurement Model: Factor Loadings and Convergent Validity and Reliability

	Cronbach's Alpha	**Composite reliability (CR)**	**Convergent Validity Average Variance Extracted (AVE)**
Marketing communications	0.937	0.946	0.639
Value creation	0.936	0.945	0.612
Trade strategy	0.948	0.952	0.686
Messaging strategy	0.934	0.943	0.563
Marketing action	0.966	0.970	0.711
Export development	0.716	0.836	0.634

To assess discriminant validity, the Fornell and Larcker method was used, and the findings are shown in Table 3. As observed in the results of this table, at a 95% confidence level, the variables in this study exhibit an acceptable level of correlation with each other. This is because the values on the diagonal are greater than the values below them. The numbers on the diagonal of the matrix are the square roots of the AVE (Average Variance Extracted) index.

Table 3.
Correlation Coefficients and Discriminant Validity between Research Variables

	Marketing communications	Value creation	Trade strategy	Messaging strategy	Marketing action	Export development
Marketing communications	0.799					
Value creation	0.769	0.782				
Trade strategy	0.418	0.614	0.829			
Messaging strategy	0.726	0.769	0.554	0.750		
Marketing action	0.743	0.777	0.531	0.797	0.843	
Export development	0.733	0.753	0.521	0.738	0.761	0.796

After confirming the measurement model, the structural model was tested to examine the direct effects. Fig. 3 presents the hypothesis testing, and Table 4 shows the results of the direct effects. A greater significance value was considered for testing significance. These findings demonstrate that the use of information in social media by companies exporting detergent, cosmetic, and hygiene products contributes to the enhancement of foreign trade development. Table 3 provides a summary of the results of the relationship tests between variables in the social media-based digital marketing model for the foreign trade development.

Table 4.
The results of structural equations and test of the model's relationships

Relationships	Beta	t -Test	P-Values	Result	Relation direction
Trade Strategy → Marketing Actions	0.531	3.513	0.000	✓	+
Marketing Actions → Messaging Strategy	0.897	31.036	0.000	✓	+
Marketing Actions→Marketing Communications	0.471	2.377	0.018	✓	+
Messaging Strategy→Marketing Communications	0.303	1.509	0.132	×	
Messaging Strategy → Value Creation	0.658	8.259	0.000	✓	+
Marketing Communications → Value Creation	0.293	3.429	0.001	✓	+
Marketing Actions → Export Development	-0.301	1.843	0.066	×	
Marketing Communications → Export Development	0.166	1.667	0.096	×	
Messaging Strategy → Export Development	0.523	4.221	0.000	✓	+
Value Creation → Export Development	0.534	3.496	0.001	✓	+

|t|>1.96 Significant at P<0.05, |t|>2.58 Significant at P<0.01,

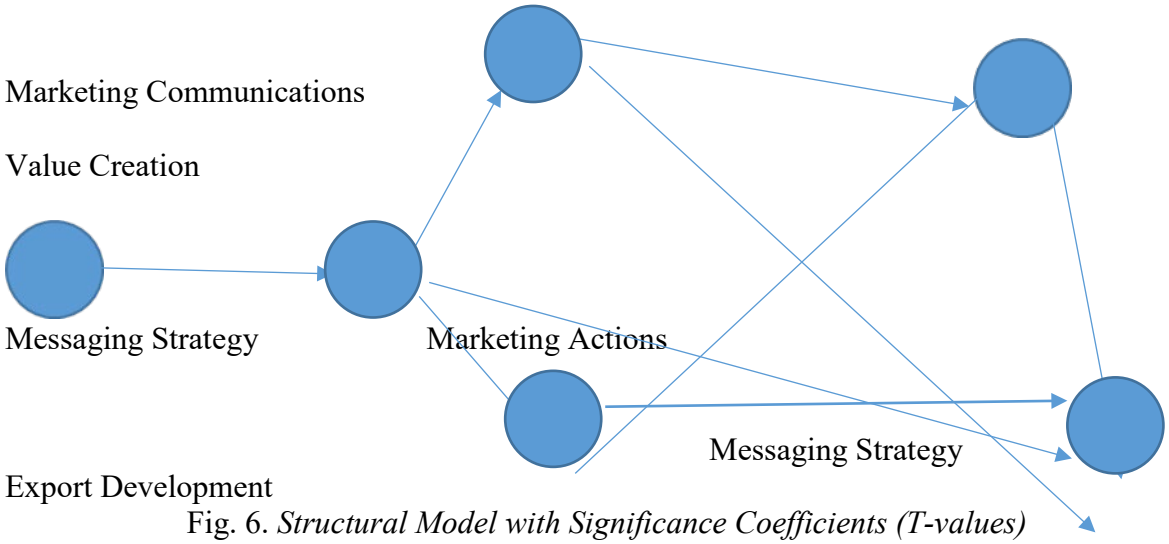

Fig. 6. *Structural Model with Significance Coefficients (T-values)*

Discussion and Conclusion

In today's highly competitive environment, where companies aim for profit and seize the potential opportunities provided by foreign markets, entering international markets through digital marketing has become increasingly important. This significance is magnified by the rapid growth of social media in global markets, prompting marketing managers to seek appropriate digital marketing strategies to penetrate global markets and reap the benefits. However, marketers are not yet fully aware of the opportunities that social media marketing offers in global markets, nor are they fully utilizing its benefits.

The challenge for managers is determining which aspects of social media to focus on in order to achieve their trade development goals in international markets. To address this issue, the present study has examined social media-based digital marketing for the development of foreign trade. Initially, an inductive content analysis approach was used to extract the social media-based digital marketing model for the development of foreign trade, followed by coding to create the theoretical model. The findings of this section revealed that the theoretical model comprises 6 variables, 13 components, and 71 indicators.

Next, the content validity of the indicators was evaluated using the CVI (Content Validity Index) and CVR (Content Validity Ratio) techniques. In summary, the relevance of the indicators was first assessed with CVI,

and after they were confirmed, their necessity was evaluated using CVR. The findings of this section indicated that 12 indicators were not essential and were removed from the model. After confirming the indicators, the importance of the components was assessed using the fuzzy Delphi method. The opinions of 17 experts regarding the importance of the components were collected, and adjustments were made. The theoretical model is presented in Fig. 4.

The results showed that the theoretical digital marketing model includes five variables: "Social Media Trade Strategy in International Markets", "Marketing Communications in Social Media in International Markets", "Social Messaging Strategy in Social Media in International Markets", "International Marketing Actions in Social Media", and "Customer Value Creation in Social Media." These are influential in social media marketing for the development of foreign trade. It is expected that focusing on these dimensions can improve global trade development. In fact, social media-based digital marketing activities, such as marketing communications, customer engagement, monitoring and analyzing customer behaviors and feedback, and uncovering hidden customer needs, contribute to increased product sales in target countries, ultimately leading to the development of global trade.

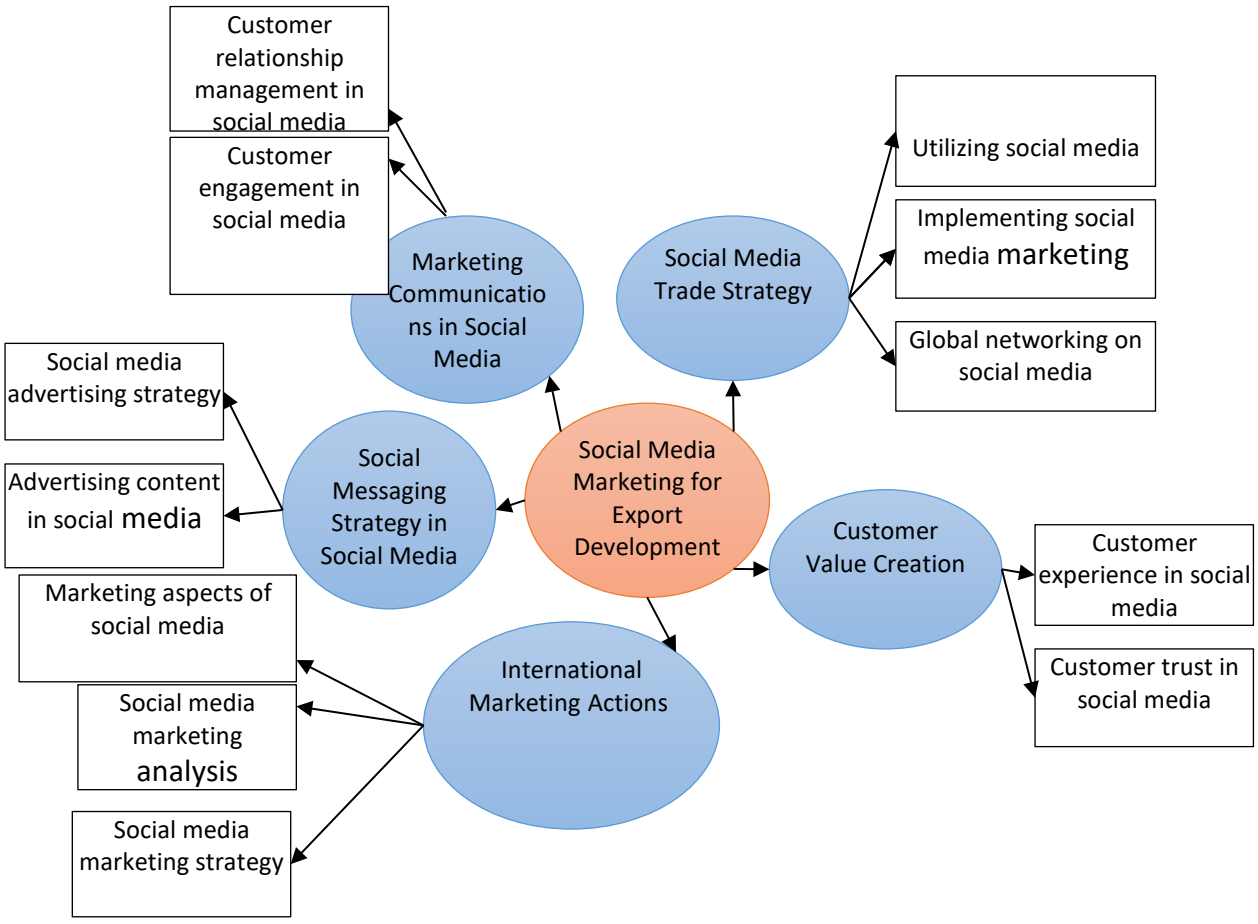

Fig.7. *Structural Equation Modeling Results and Direct Relationship Tests of the Model*

In the section "Social Media Trade Strategy in International Markets", exporting companies must adopt an appropriate strategy for utilizing social media to enter global markets. Many managers do not take advantage of the potential benefits of social media in marketing their products to target countries, even though the popular social media platforms in each country have the marketing potential to encourage and

persuade customers to purchase products. In this regard, many researchers, such as Amalia and Khoirotunnisa (2023) and Azizah and Siswahyudianto (2022), believe that social media marketing strategies are a very low-cost path that facilitates access to potential customers and is the best digital platform to establish effective communication with customers, especially in overcoming time and distance constraints with target countries. Therefore, using international e-commerce platforms can expand sales channels and make purchasing easier for global customers.

The next variable, "Marketing Communications in Social Media in International Markets", can be effective in social media marketing for export development. Social media is a digital platform based on interpersonal communication, where individuals interact virtually. In this regard, experts emphasize that customer relationship management and customer engagement on social media are two key components that play a significant role in marketing communications. Social media communications are highly effective in attracting users, and enhancing these communications is considered essential by marketing managers. Fraccastoro et al. (2021) emphasized that marketing communications lead to increased customer engagement, heightened awareness, and facilitate the sharing of news about products.

In the proposed theoretical model, the variable "Social Messaging Strategy in Social Media in International Markets" can also play a role in the development of global trade. This variable comprises two components: the social media advertising strategy and the social media advertising content, both of which can convey product and service information to social media users. These messages motivate customers to make purchases. In this context, Chung et al. (2019) show that social networks can effectively convey a company's messages to its foreign customers.

Another variable that experts consider important in social media marketing for global trade development is "International Marketing Actions in Social Media." Digital marketing on social media can provide in-depth analytical data on customers, which managers can use to identify markets, understand consumer preferences, and develop more effective marketing strategies. According to Saputra (2023), a detailed analysis of the global digital business environment, along with appropriate strategies, can help companies optimize their digital marketing potential at an international level.

Finally, the last variable is "Customer Value Creation in Social Media", seeking to create value for customers by providing a positive experience and fostering trust. Given the unfamiliar virtual environment of social media, it is expected that customers will be aware of the risks associated with online interactions, making them more cautious when engaging with other users on social platforms. Therefore, companies must strive to build trust in their interactions with customers. In this regard, Saputra (2023) emphasizes that maintaining consumer trust and adhering to international privacy standards are critical aspects of successful digital marketing. Yadav & Rahman (2018) have also demonstrated that online buyers often make purchasing decisions based on the availability of sufficient and reliable information on e-commerce websites or social media platforms, in the form of product details, ratings, and reviews.

Research Limitations

In general, the researcher in this research has faced scientific and practical limitations in conducting the research, which are mentioned below:

1. This study used a cross-sectional survey to collect data from cosmetics exporting companies, it is expected that the generalization of these findings in terms of time or to other domestic and exporting companies should be done with caution.
2. Environmental and infrastructural factors such as social media filters or restrictions on internet speed and financial transactions with the target countries

have not been addressed in this study, while these factors can be effective in improving digital trade and developing exports.
3. One of the other limitations of this research is the uncertainty in the responses of the experts, which may influence the answers due to the different conditions and their responses.

Suggestions for future Research

1. According to the findings of this model, the marketing strategy in social media is one of the influential factors in the development of global trade, so it is suggested that researchers present a model for social media marketing strategy.
2. Also, according to the findings of this study, value creation for the customer is one of the influential factors that the success of the system depends on, which requires more studies in this field. Therefore, it is suggested that researchers provide a model for creating customer value in social media.
3. Advertising strategy in social media is one of the other effective factors that have been emphasized in this research. It is suggested that the researchers design the advertising strategy model and contact with the customer through emerging technologies such as artificial intelligence and their role.
4. In this research, the drivers of digital marketing have been discussed, considering that every system faces obstacles and challenges, so it is suggested that researchers analyze and investigate the challenges and obstacles of marketing in social media of international markets.

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RESEARCH ARTICLE **Open Access**

The Model of Culture Management in Islamic Azad University with an Emphasis on Reducing Tenure and Increasing the Role of Influencers (case study: Student Organizations in the Academic years of 2021-2022 and 2023-2024)

Farzad Jahanbin [1]

Abstract
Compilation and approval of the transformation and excellence document of Islamic Azad University and emphasizing the transformational turn from cultural and educational inefficiency to an educational, cultural and identity community in the document and emphasizing the role of influencers in this transformation, adopting a strategic and management model in line with creating a platform for education and has put social education in front of Islamic Azad University. In this regard, this article, which has been written by using a qualitative approach based on documentary studies and extracting statistical data from monitoring and buffer systems, aims to answer the question that the application of culture gardening model in Azad University How has Islamic been able to increase the role of influencers and reduce tenure in this university and in the process of social education? The results and findings of the present applied research, which is based on the evaluation and comparison of the influence status of student institutions (centers, Islamic organizations of academics and publications) in The cultural achievements of the academic years 2021-2022 and 2023-2024 have been obtained, indicating the increasing role of the influence pole of student institutions in branches of the Islamic Azad University and the reduction of tenure in this university, as this will provide the basis and necessary arrangements for the realization of the ministry stage in the process of social education and training. The entry of students into the field of participation and responsibility and special attention to their agency in cultural programs has been provided.
Keywords: *Pattern, Cultural Management, Tenure, Effective pole, Social education, Islamic Azad University*

Introduction

In Islamic traditions, the stages of education are divided into three periods of seven years. The period of the first seven years, which is the period of the child's sovereignty, and the period of the second seven years of the child's life, which is the period of obedience. The state of servitude and servitude of the child towards his parents is the result of the trust he has gained towards them in the first seven years of his life. and the third seven-year period (14 to 21 years old), which is the period of ministry and cooperation (Aamili, Wasal al-Shia, Vol. 21: 476). Minister, as a verb and as a subject noun, means that a person takes responsibility. But since he still cannot do this independently, in the narrations, the concept of being prepared and in other words preparing him for this work has been emphasized (Qurashi Banabi, Qur'an Dictionary, Vol. 7, 1992: 206).

The characteristics of this course are: respect and seeking opinions, criticizing and

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challenging, seeking participation, freedom and responsibility (Qasuri et al., 1402: 266). This period requires that he be consulted like a minister and that the tasks that arise from him be entrusted to him so that he becomes responsible. A part of this third period, from the age of 18 to the age of 21, is spent in the university, and if it is accepted after the age of 23, the undergraduate course can be considered a period of social education and preparation for entering the social environment. Meanwhile, the age of social maturity has increased from 18 to 24 (Sohrabzadeh and Hakim Javadi, 2019: 59-60). And this clearly shows that the university has not been able to fulfill its duty in this regard.

According to the document of the Islamic University, the mission of the university is based on four educational systems, research and technology, management and cultural-educational system, and certainly one of the tasks of the cultural system is social education. In other words, according to the concept of ministry and death, in the third seven years of life, he should be prepared to accept social responsibilities. Student institutions are among the platforms that can prepare young people to take charge of the future affairs of the country. In this regard, the document of the Islamic University states: "Building the ground and promoting the motivation and spirit of participation of academics and developing their social capabilities and communication and group skills" (Document of the Islamic University, 25/04/2013).

But in this direction, there are two basic challenges:

1 .Reducing culture to cultural affairs and activities, which has resulted in maximum 20% of students being the audience of cultural programs (Ramazani, 2024:3).

2 .The high share of the university's institutions in the management and implementation of programs has reduced the space for students to experience activities (ISKA News, April 18, 2024).

Considering the second challenge, the present article aims to answer the question of what model can be used in the Islamic Azad University, while overcoming this challenge, in relation to social education.

Research Background

Sadeghzadeh et al. (2021) in the article "Foundation data model of cultural transformation in Islamic Azad University" try to provide a model for the phenomenon of transformation by using a qualitative approach and purposeful sampling along with the extraction of variables and indicators of cultural transformation. achieve culture in South Tehran branch.

Mohammadreza Ansari et al. (2021) in the article "Presenting a cultural policy model with a transformation approach (a case study of Islamic Azad University, Tehran Science and Research branch)" are of the opinion that the category of culture and cultural policy has many hidden and obvious dimensions and angles. It is, that without proper policy, the realization of these goals is not possible. With the aim of designing a model of cultural policy making, with the approach of cultural transformation in higher education and using a qualitative approach, this research tries to analyze the policy making process of the Islamic Azad University and especially the Tehran Science and Research Branch by using a data-based strategy Examine and study.

Shahrakipour et al.(2021) in the article "Presenting a model for evaluating the indicators of cultural management in Islamic Azad Universities of Tehran and Alborz province" while highlighting Azad University as a symbol of higher education in the country and an effective institution in the society's culture, they try to adopt a qualitative approach based on The theme analysis method, which seeks the output of basic, organizing and comprehensive themes related to the research problem, answers the question of whether it is possible to identify indicators of culture that

cause the development of culture in the university.

A review of the presented articles shows that: first, instead of a strategic and long-term view on the category of culture and culture management in Islamic Azad University, most of the authors have had a partial, partial and unitary view of this issue. Secondly, most of the studies have not paid much attention to the religious foundations of culture, the document of transformation and excellence of Islamic Azad University, as well as the statement of education. Thirdly, most of the studies have paid attention to the pathological aspects of culture management in Islamic Azad University Branches. Fourthly, none of them have succeeded in presenting a macro, comprehensive and practical model in the field of culture management in Islamic Azad University or have not achieved it.

The governing model of culture management in Islamic Azad University

Culture and culture management

Culture has various meanings and concepts, and in its historical course, it has assumed various meanings, including: Literature, education, knowledge, knowledge, a collection of customs and scientific and literary works of a nation, a dictionary, goodness, cultivation of greatness, virtue, splendor, art, wisdom, tree horns that sleep under the ground and pour dirt on it, and also Education, education, school and ideology (Sahibi, 2005: 60)

Allameh Mohammad Taqi Jafari in the book "Follower Culture, Leading Culture" after examining the definitions of culture from the point of view of 24 famous dictionaries and encyclopedias among the important nations and languages of the world, writes: "Research on the definition of culture from the point of view of the most famous encyclopedias and some sociological sources, more To prove this truth, it is to show the existence of human evolution in the true meaning of culture among societies as a necessary and worthy quality or way of human life, guaranteeing and if some selfish, profiteers or nihilists want to reduce culture to the level of a paradise of vulgar phenomena and call it culture, it is not based on truth and has anti-human roots, but what has caused the appearance of multiple definitions is the variety of views of researchers and In the interpretation of the concept of culture, commentators have commented on its evolutionary principle" (Jaafari, 2013:11-13).

In 1871, Edward Taylor[2] defined culture as follows: "Culture is a tangled whole including knowledge, religion, art, law, morality, and any abilities and habits that a person acquires as a member of society." (Ashuri, 2010: 71).

From the point of view of Ayatollah Khamenei, which is the chosen definition of this article, culture can be considered as a social structure that is formed under the influence of various factors in the context of time and determines the space of movement and actions of humans and exists everywhere like air. (Khamenei, 17/10/2004 and 23/9/1999). In this definition, a central nucleus can be identified and it is a structure that has been formed in a society over time under the influence of various factors. From within this central core, the general attitude towards life and human life, along with the values governing economic, political, social relations, has a meaning and is manifested. In another part, there are examples that include ethics, social customs and behaviors, individual behaviors and temperaments and national characteristics. pointed out (Jahan Bin, 2018: 18-15).

Management is also the process of effective and efficient use of material and human resources in planning, organizing, mobilizing resources, directing and controlling, which is done to achieve organizational goals and based on the accepted value system (Rezaian, 2000: 179).

[2] E.B. Taylor

Based on this, culture management is a conscious effort to change the mentality and structure of the society in order to reach a desirable situation that has been determined in advance. It should be noted that "culture management" is different from "cultural management" which is dedicated to the management of cultural affairs and activities. In culture management, all factors affecting culture are taken into consideration (Jahan Bin, 2017: 53)

Pattern elements

The following model as a culture management model in the Islamic Azad University aims to create a platform for social education and training and prepare for the following Provide social times.

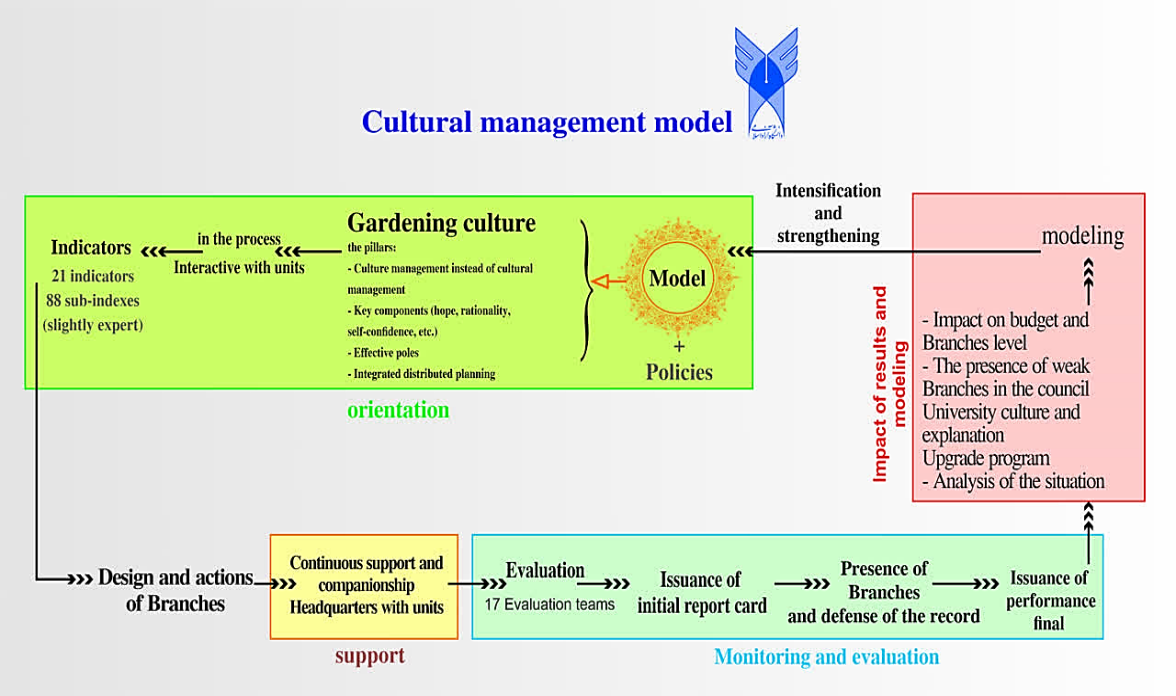


Figure 1. *Culture management model*

This model has elements that are explained as follows:

Culture gardening model

There are many models for managing culture in different schools. With an analytical review of the cultural positions of the supreme leader of the revolution in the process of culture management, a model can be presented that should be called "culture gardening" or "leading the excellence of culture in a hostile environment". By relying on this model, both culture is managed and freedoms and diversity are preserved (Jahanbin, 2018: 101)

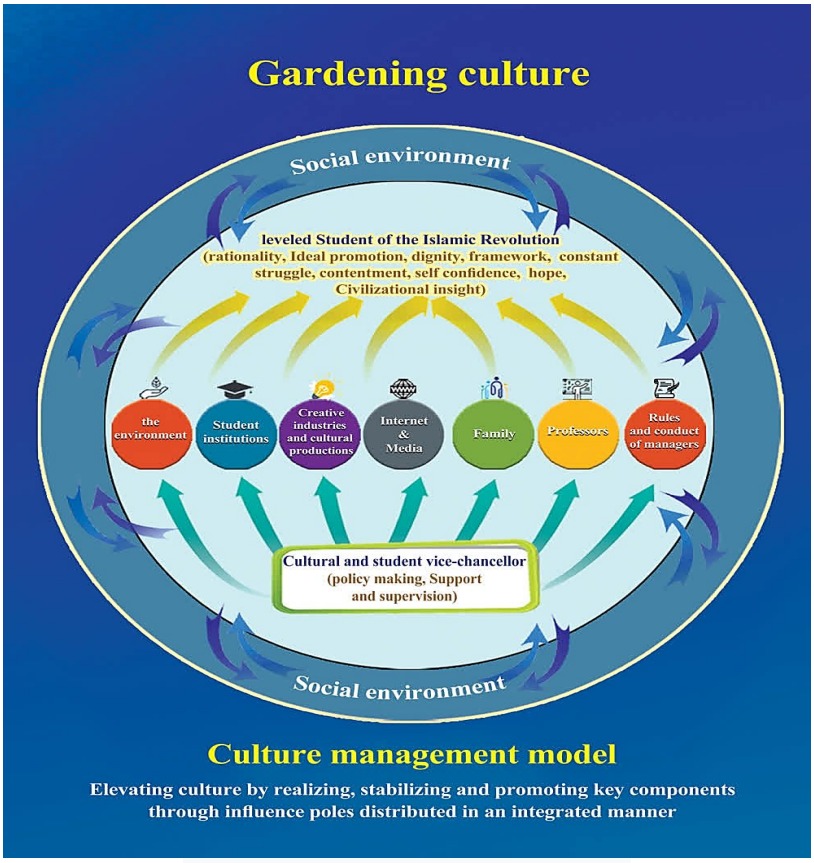


Figure 2. *Culture gardening model*

This model has three pillars: culture management instead of cultural management as explained; Affective poles and key components and integrated distributed planning (Jahanbin, 2018: 85)

Affective pole

In the process of culture management, the modification of a society's culture is possible through the poles that have the greatest impact on a society's culture and the advancement or decline of society's culture is directly related to them. These poles are:

1. The conduct of administrators is considered the first pole of cultural influence: according to this pole of influence, people are more similar to their leaders than their fathers; Therefore, any influence on the culture is related to the behavior of the managers of the culture of a society.

2. Professors are the second pole of cultural influence: the professor's silence, his words and actions, and the way he enters and leaves affect the students, and it is not the case that the professor says, "I am only doing my teaching and I am not concerned with any other issues." Education and subtleties can only be learned in the presence of a professor, and if this aspect is not paid attention to in the university, informal education will gradually replace formal education.

3 .The family is the third pole of cultural influence. The families of professors and students have a great influence on them.

4. Virtual space as the fourth and organizations, centers and student mobilization are the fifth pole of cultural influence, and any influence on the culture of a society is related to these five cultural poles. pp. 55-50).

In order for the culture of a society to be established, agents and managers work on the poles and the culture of the society is influenced on a large scale; Therefore, the optimal allocation of resources to the mentioned priorities forms the basis of the work of the cultural assistant in Islamic Azad University.

Key components

The requirement to achieve effectiveness in any field, including the cultural field, is the allocation of limited resources to key components and the convergence and concentration of different components with different special tasks on those components. In other words, in order to achieve convergence, instead of allocating the limited resources available to multiple subjects, and reducing the effectiveness in each subject and all the fields and dimensions of culture, a few core and key components that are the main branches should be selected and in the management of culture It focused on those components.

The question here is that focusing on which component or key components can help the Islamic system in carrying out its planning task, provide the ground for evacuation and resolution at the community scale, and at the same time, the differences in the field of culture should not be ignored, and freedom and People's right and real participation should not be denied. What are the key components that will provide the possibility of creating cultural resistance among the general public against invading cultures and pave the way towards the desired culture? (Jahan Bin, 2018: 71-83).

Based on what is stated in the Islamic Azad University document, which is based on the Islamic Azad University document, the key components are:

-strengthening moral virtues and religious beliefs and commitment to social responsibilities;

-Promotion of civilizational insight, revolutionary spirit, belonging to the ideals of the revolution and Iranian-Islamic identity

-Institutionalizing the culture of chastity and family-oriented

-The spread of the Islamic-Iranian lifestyle and the spirit of contentment and hard work

- Promoting rule of law, wisdom, self-confidence and the spirit of self-sacrifice and jihad (Transformation and Excellence Document of Islamic Azad University, 2021: 27)

Policies

The main policies emphasized in the culture management model are:

-Attention to human dignity in all interactions and the centrality of the law instead of administrative and personal tastes;

-Paying attention to the university as a platform for social education and preparing to accept great responsibilities;

-A scientific look at all activities as well as problem-oriented planning, limiting and focusing on key components and influencing factors;

-Paying attention to low-cost and high-yield programs and avoiding waste of resources and costs in non-priority cases, as well as avoiding wasteful, shallow and worrisome activities;

-Avoiding tenure as much as possible and focusing on the three principles of guidance, support and supervision;

-Maximum use of the capacities of culture assistant professors in the university's cultural mediation;

-Developing and attracting the participation of students, professors and employees and paying special attention to their agency in the programs;

- Using the capacity of art in culture management and paying special attention to virtual space and media (Sena Journal, 2023: 17)

Interactive process with units

In an interactive process with the units and after dialogue and understanding with cultural activists regarding the culture gardening model (in the first round of provincial trips, 8,900 people-hours were held with different groups of cultural activists, meetings and dialogues were held (educators,)) This model was operationally defined in the form of 21 indicators and 88 quantitative and qualitative sub-indices. After the initial definition by experts, indicators and sub-indices have been engraved and modified in several rounds with the units, and of course, this action is repeated annually.

According to this model, university units also try to be the platform for the role of those

influential poles to realize the key components with the same role of guidance, support and supervision by avoiding tenure except in a few cases.

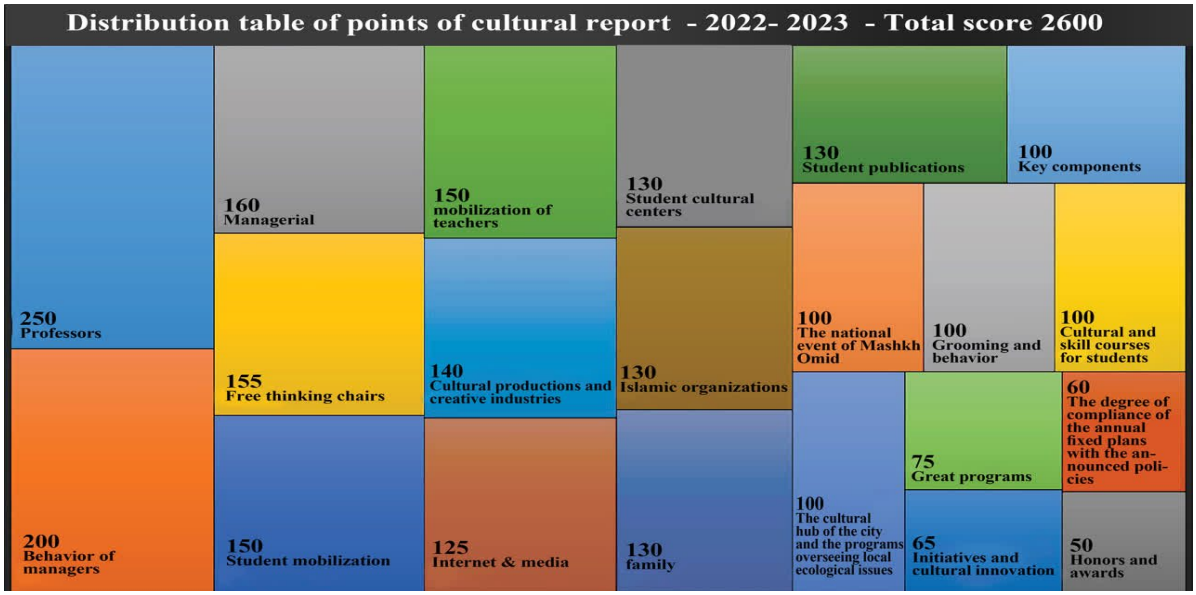
In another stage of this interactive process, the headquarters of the vice president is in continuous cooperation with the units and activists. All actions are recorded in a system called buffer system, which is an interactive platform for cultural actions. This system provides the possibility of observation, analysis and feedback of what happens in the university text. Of course, field visits and objective feedback also play an important role.

As one of the things that is regularly evaluated is the level of tenure and attention to influencers and obstacles to their roles and how to allocate resources to priorities.

Indicators

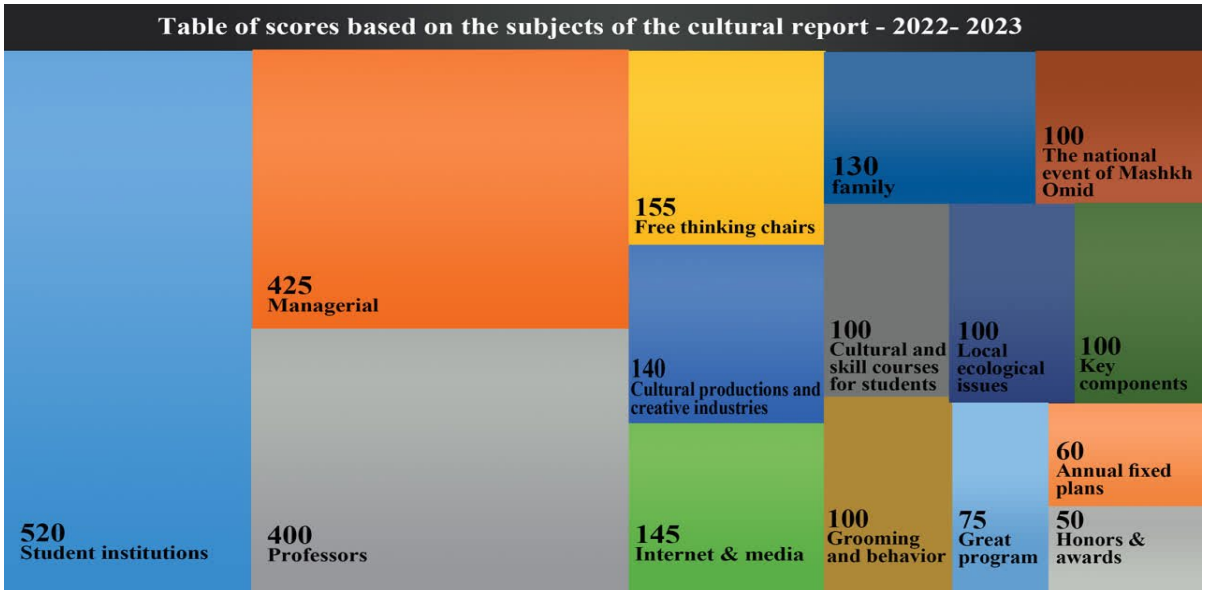
21 indicators of culture management model in the form of (management, student mobilization, professors mobilization, key components, student cultural centers, student publications, Islamic organizations, the national event Mashgh-e-Omid, decency and behavioral issues, the degree of compliance of annual fixed programs with policy announcements, free-thinking chairs, virtual space and media, honors and awards, cultural initiatives and innovation, prestigious programs, cultural and skill courses, cultural hub of the city, family, course knowledge enhancement and empowerment, professors' plan and cultural jihad, sacrifice and martyrdom) and 88 quantitative and qualitative sub-indices are defined operationally.

Table 1.
Indicators of culture management model



The distribution of points in the indicators was done in such a way that the weight of the work is towards the influential poles (in this article, student organizations are emphasized) and reduce the tenure

Table 2.
Distribution of points based on cultural management model indicators

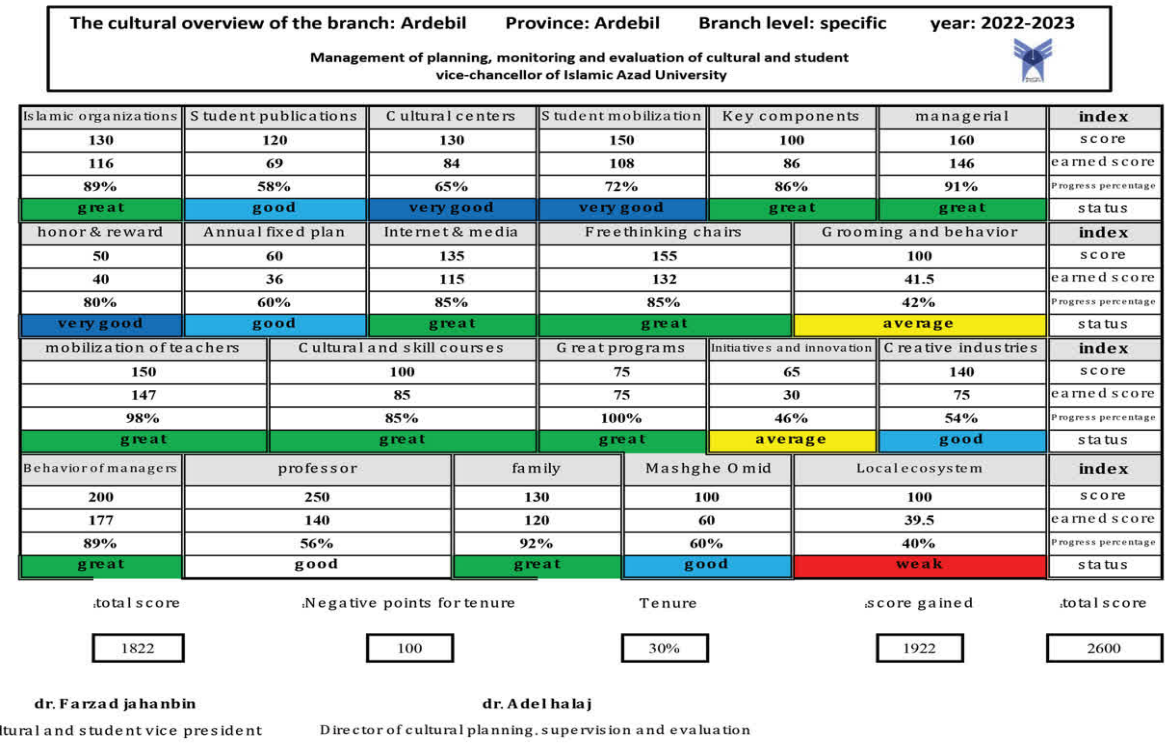


Issuance of cultural performance in line with evaluation

One of the most important measures in the management process of Islamic Azad University is to provide a performance that can both guide and evaluate the branches. Performance is important in three ways; First, it is a guide. That is, the indicators and sub-indices, with the amount of points given to those indicators, give a macro direction to the university branch. Second, the performance report shows an accurate, detailed picture of the branch's performance. In such a situation, the university branch can identify its strengths and weaknesses and try to correct its problems in the next step. The third point is that based on justice, according to the facilities of the branches and their level, the scoring for the branches is different.

Evaluation is considered in two ways: (Noe, Hollenbeck, Gerhart, & Wright, 2017: 32-33) evaluation of effort and functional evaluation. Evaluation of effort means how much the branches tried to prepare for the activity of polarization and reduction of tenure, and evaluation of performance means that what results have been achieved in practice in this regard?

Table 3.
Cultural record



The cultural overview of the branch: Ardebil Province: Ardebil Branch level: specific year: 2022-2023

Management of planning, monitoring and evaluation of cultural and student vice-chancellor of Islamic Azad University

Islamic organizations	Student publications	Cultural centers	Student mobilization	Key components	managerial	index
130	120	130	150	100	160	score
116	69	84	108	86	146	earned score
89%	58%	65%	72%	86%	91%	Progress percentage
great	good	very good	very good	great	great	status

honor & reward	Annual fixed plan	Internet & media	Freethinking chairs	Grooming and behavior	index
50	60	135	155	100	score
40	36	115	132	41.5	earned score
80%	60%	85%	85%	42%	Progress percentage
very good	good	great	great	average	status

mobilization of teachers	Cultural and skill courses	Great programs	Initiatives and innovation	Creative industries	index
150	100	75	65	140	score
147	85	75	30	75	earned score
98%	85%	100%	46%	54%	Progress percentage
great	great	great	average	good	status

Behavior of managers	professor	family	Mashghe O mid	Local ecosystem	index
200	250	130	100	100	score
177	140	120	60	39.5	earned score
89%	56%	92%	60%	40%	Progress percentage
great	good	great	good	weak	status

total score	Negative points for tenure	Tenure	score gained	total score
1822	100	30%	1922	2600

dr. Farzad jahanbin
Cultural and student vice president

dr. Adel halaj
Director of cultural planning, supervision and evaluation

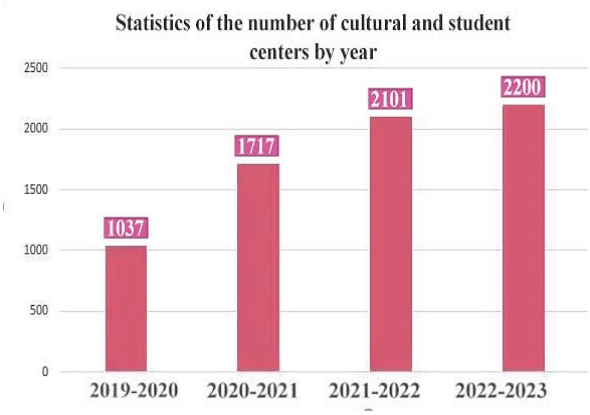
Analysis of Findings

The comparison of the cultural and social performance of the units in the academic years of 2021-2022 and 2023-2024 clearly shows that all the units of Islamic Azad University have taken steps towards reducing tenure and increasing the role of influencers.

Student cultural centers

Student cultural centers are student and voluntary institutions that are established in the framework of the rules of the Cultural and Student Vice-Chancellor of the Islamic Azad University in each of the religious fields (Islamology, prayer and supplication, enjoining what is good and forbidding what is bad, chastity and hijab, the approximation of religions) etc.), the Islamic Revolution (the achievements of the Islamic Revolution, the thoughts of the Imams of the Islamic Revolution, Martyr Motahari, Martyr Avini, the Second Step Document of the Revolution, etc.) Culture and Civilization (Introduction, cultural studies, culture of sacrifice and martyrdom, modern Islamic civilization, creative cultural industries, reading books, etc.) social (Jihad Yaori, Red Crescent, Iranology, tourism, environment, prevention and dealing with social harms, entrepreneurship, charity, Citizenship rights, etc.) Media and virtual space (virtual productions, media, radio, media literacy, etc.)), art and literature (revolutionary art of Shahid Avini, poetry and literature, playwriting, writing, film and photography, theater, documentaries, dubbing, performing arts, visual arts, handicrafts, etc.) are active. Chart number (3) shows the increase in the number of cultural and social centers as one of the influential poles in Islamic Azad University. As in the academic year 2019, about 1037 registered cultural centers were working in Islamic Azad University. This figure has increased to about 1717 cultural centers in the academic year of 2021-2022, to about 2101 in the academic year of 2023-2024, and to about 2200 cultural centers in the academic year of 1402-1403.

Diagram 1. *The growth rate of student centers*

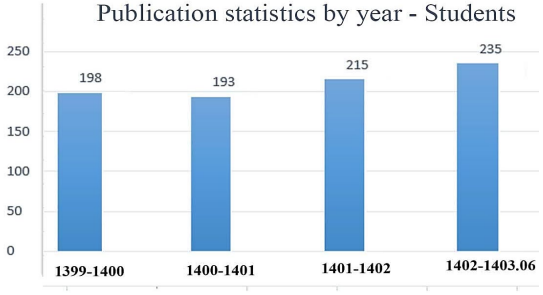


Islamic organizations of academics

The Islamic or ganization is a group composed of academics, which after receiving the official permission to operate from the competent authority of the university's supervisory board in order to realize the Islamic goals and the values of the revolution and the Islamic system, within the framework of the constitution and the regulations of the Islamic organizations of academics, approved by the meeting dated 6/9/1999 and subsequent extensions of the Supreme Council of Cultural Revolution.

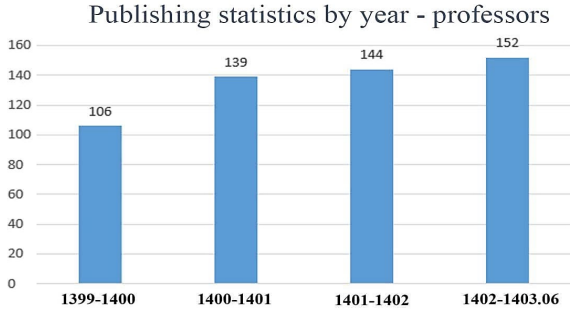
Diagram 2. shows the increase in the number of student Islamic organizations as one of the influential poles in Islamic Azad University. As in the academic year 2021-2022, about 193 registered student organizations were active. Meanwhile, this figure has increased to about 215 in the academic year 2023-2024 and to about 235 student organizations in the academic year 2023-2024.

Diagram 2. *Growth rate of student Islamic organizations*



Also, diagram 3. shows the increase in the number of Islamic organizations of professors as one of the influential poles in Islamic Azad University. As in the academic year 2019-1400, about 106 registered faculty organizations were working in Islamic Azad University. This is while this figure has increased to about 139 in the academic year of 2021-2022, to about 144 in the academic year of 2023-2024, and to about 152 in the academic year of 2023-2024.

Diagram 3. *Growth rate of Islamic teachers' organizations*



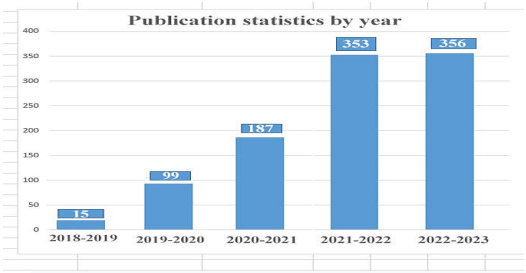
Publications

Student publications include all periodicals, periodicals or single issues as well as electronic publications with a fixed name and date of publication, in cultural, social, scientific, economic, artistic, literary and sports fields by each of the students, centers, It is said that university organizations and institutions, professors and faculty members or a group of them are published in universities and distributed within the boundaries of universities. These publications are considered as a forum for expressing the opinions and opinions of students and a speaker to express the issues and problems within the university and on a wider level and in the society. Publishing an academic journal is actually a suitable field for expressing the existence of a university, and the main mission of these publications is to promote rationality, guidance and guidance to eliminate problems and use collective wisdom. This type of activity is considered a type of meta-organizational activity.It is the work of a group that most of the active students are in some way connected with, therefore the activity of publications

should be facilitated in such a way that it acts as a tool of cultural excellence in the university. Diagram 4. shows the increase in the number of student publications as one of the influential poles in Islamic Azad University. As in the academic year of 2018-2019, about 15 student publications registered in Islamic Azad University were published, while this number was about 99 publications in the academic year of 2019-2019, in the academic year of 2019-2021 to about 187 publications, and in the academic year of 2011-21 to about 353. magazine and in the academic year 2022-2023 with the number 356 The publication has increased.

1402-1403 about 356 student publications registered in Islamic Azad University were published, while this figure was about 353 in the academic year 2022-2023, about 187 publications in the academic year 1401-1400, about 99 publications in the academic year 2020-2021, and in the academic year 2020-2021 There have been about 15 publications.

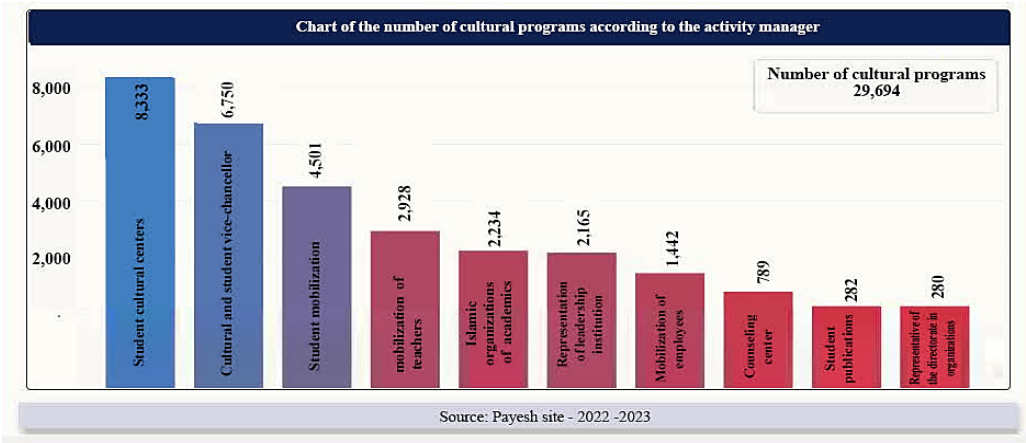
Diagram 4. *The rate of growth of Islamic teachers' organizations*



The frequency chart of the number of cultural programs in the academic year 2022-2023, by activity manager, shows that 29,694 programs were implemented, of which 6,750 programs were conducted by the cultural and student vice-chancellors of the units, and most of them are aimed at students. Out of this number, 8333 programs are provided by student associations, 6750 programs by the cultural and student vice-chancellor, 4501 programs by the Student Basij, 2928 programs by the professors' Basij, 2232 programs by the Islamic organizations of academics, 2165 programs by the Supreme Leader's representative body, 1442 programs by the Basij. employees, 789 programs by the counseling center, 282 programs by university publications and 280 programs by the representative of the university president in the supervisory board Organizations

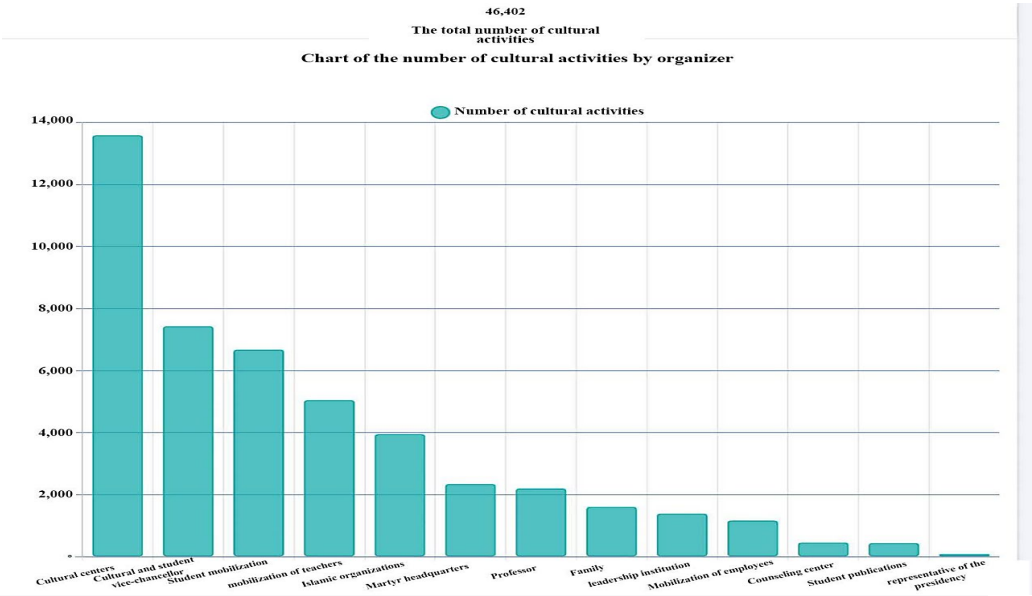
Enhancing the role of student institutions

Diagram 5. *The number of cultural programs in the academic year 2022-2023*



This is while the graph of the frequency of the number of cultural programs in the academic year 2023-2024, by activity manager, shows that 46,402 were implemented. Despite the increase in the number of programs, the share of the cultural and student vice-chancellor of the units has reached below 20% with 7000 programs. The important point is that an important part of these activities is effective for the elites, which does not include tenure, and with this calculation, the share of vice-chancellors of the units can be considered to be around 15%. Besides this, the share of student institutions has increased.

Diagram 6. *The number of cultural programs in the academic year 2023-2024*



The cost of cultural indicators according to the implementation of activities

Diagram 7. *The cost of cultural indicators according to the implementation of activities in the academic year 2022-2023*

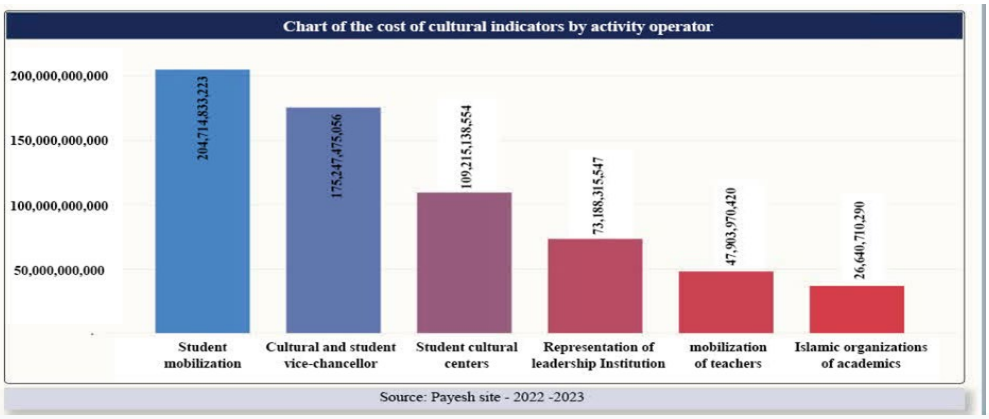


Diagram 8. *The cost of cultural indicators according to the implementation of activities in the academic year 2022-2023*

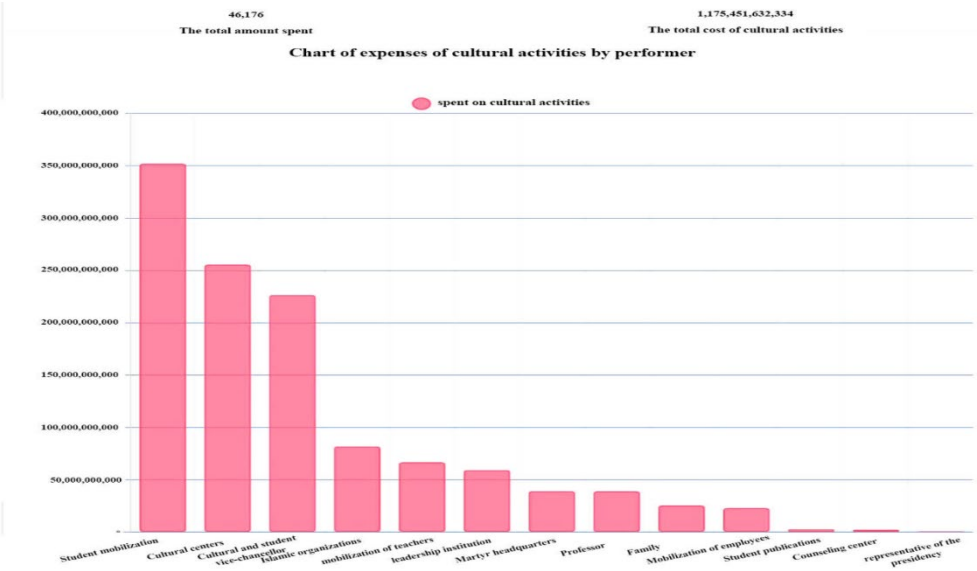


Diagram .8, the cultural cost chart by the activity manager in the academic year of 2023-2024, indicates the cost of 175.175/334/634 Rials for 46176. Of course, this part of the costs in the cultural field in the Islamic Azad University does not include the staff costs of the cultural and student field in the central organization, and programs such as Rahian Noor are not included in this chart. The share of the cultural and student vice-chancellor of the units in this chart is about 200 billion Rials (20 billion Tomans), which if the programs for the students are reduced from that, it reaches about 100 billion Rials (10 billion Tomans). In other words, the deputy's share of the tax cost is below 15%. This is despite the fact that in the academic year 2022-2023, the share of the Vice-Chancellor was 170 billion Rials (17 billion Tomans) from about 690 billion Rials (69 billion Tomans), and the share of student organizations has increased significantly due to the decrease in the share of the headquarters46176 programs by student organizations. This increase compared to the academic year of 2022-2023 has been an expression of the focus on the influence poles with emphasis on student organizations by university Branches.

Conclusion

A comparison of the influence status of student institutions (centers, Islamic organizations of academics and publications) in the cultural performances of the academic years 2021-2022 and 2023-2024 clearly shows that the total units of the Islamic Azad University are moving towards increasing the role of influence poles. The transition and reduction of tenure in the university are the basis of social education and the realization of the ministry stage in the process of education and training in Islamic Azad University.

Acknowledgments

In the end, I express my thanks and gratitude to God for the existence of the wise leadership, whose valuable opinions are our understanding of cultural gardening. I also declare that without the compassionate guidance, support and companionship of Dr. Mohammad Mehdi Tehranchi, the president of Islamic Azad University, as well as the companionship of the huge body of professors, staff, and student organizations, especially my colleagues in the staff and ranks, none of these events - which, of course, we are at the beginning of the journey - would have been possible. It did not happen.

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RESEARCH ARTICLE **Open Access**

Identifying and Ranking Obstacles to the Implementation of TQM in SMEs Using GMWM (Case study: Food Industry)

Mahnaz Zarei [1*], Mehdi Abbasi[2]

Abstract
This study identifies and ranks the obstacles to implement Total Quality Management (TQM) in small and medium-sized enterprises (SMEs) within the food industry. The aim is to determine the key barriers hindering TQM adoption and provide actionable insights to address these challenges. The research is applied and descriptive, using a survey-based methodology. Data were collected through structured questionnaires distributed to quality managers in food industry SMEs, selected via snowball sampling. The Group Best-Worst Method (GBWM) was employed to prioritize the identified barriers. Results reveal that "Lack of commitment and involvement of senior management" is the most significant obstacle, with an importance coefficient of 0.299, followed by "Senior management instability" and "High rate of employee turnover," each scoring 0.117. Also, consistency ratio values were close to zero, and the results were validated. This research contributes by offering practical recommendations for addressing TQM barriers and developing effective strategies tailored to SMEs in the food industry, especially in the context of developing countries.
Keywords: *Sized enterprises (SMEs), Food Industry, Group Best-Worst Method (GBWM)*

Introduction

Over the past three decades, organizations worldwide have witnessed the emergence and expansion of a diverse array of non-technological innovations designed to enhance management practices. In the face of increasing global competition, many organizations have been compelled to adopt appropriate technological strategies, skilled workforces, and managers equipped with the requisite expertise to navigate and coordinate these changes, with a sharp focus on quality and customer satisfaction (Aletaiby et al., 2021). TQM stands as a pivotal framework that underscores continuous improvement as a primary objective, thereby empowering organizations to attain commercial excellence. TQM encompasses a set of guiding principles and managerial practices aimed at fostering ongoing quality enhancement and ensuring the delivery of superior products to customers. To remain competitive in today's global market, organizations must effectively embed TQM principles throughout all their activities and operations (Muruganantham et al., 2018).

TQM serves as an efficient cost management system, driving quality improvement efforts across all levels of the organization, ensuring the provision of services and products that consistently satisfy customer expectations. The system seeks to cultivate a culture that improves the organization's ability to meet the evolving and diverse demands of customers. Moreover, successful TQM implementation can provide a formidable competitive edge. In the contemporary business environment, product quality has become one of the most significant tools for organizations to secure customer satisfaction, ultimately driving profitability. In general, organizations that

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successfully implement TQM enjoy numerous benefits. However, many organizations struggle with the effective execution of TQM, with research indicating that failure rates for implementation can reach as high as 41%. Two key factors often cited for these failures are the neglect of the crucial role of organizational culture in TQM implementation and a lack of understanding regarding the barriers that hinder its successful execution (Talapatra & Uddin, 2019).

The food industry, in particular, is currently experiencing a surge in global demand for food safety, higher product quality, and greater sustainability (Konstantinidis et al., 2023). Over recent years, food companies have seen significant growth on a global scale. In Iran, the food industry plays a critical role, particularly in ensuring food security and safeguarding public health, while also contributing substantially to the nation's exports. Among the various quality control methods employed in the food industry, the implementation of TQM has emerged as one of the most significant strategies. However, many companies face considerable challenges in the effective implementation and development of TQM. These barriers are not confined to any single domain; rather, they extend across all sectors of the organization, including production, services, and training. As such, it is crucial for organizations to identify these obstacles before and during the implementation process in order to mitigate their impact (Mohammadpour et al., 2024).

The problem of this study addresses is the difficulty in fully implementing TQM in SMEs within the food industry, particularly at Dadli Food Company. While TQM is recognized as an effective strategy for improving quality, customer satisfaction, and operational performance, many organizations, especially in the food sector, face substantial challenges in overcoming key barriers. Despite the company's efforts to implement TQM, these obstacles hinder the realization of its full potential, limiting improvements in product quality and customer satisfaction. Therefore, this research will focus on identifying and prioritizing these key obstacles to successful TQM implementation at Dadli Company, utilizing the Group Best-Worst Method (GBWM) to systematically analyze and rank these challenges.

Literature Review

Concept of Total Quality Management

Total Quality Management (TQM) is a continuous effort to meet and exceed customer expectations by improving the workforce and minimizing costs through a dedicated focus on organizational processes. TQM promotes a holistic approach to continuous improvement within an organization, addressing both internal and external customer needs while emphasizing the importance of timely actions. It is a structured method for planning and implementing processes to enhance product and service quality. TQM also involves rewards, resources, vision, philosophy, strategy, and organizational commitment (Akanmu et al., 2020). Overall, TQM is recognized as a major innovation in management, focusing on evaluating expectations, needs, and organizational cohesion through ongoing development at all organizational levels (Akanmu et al., 2023).

Food Industry

Food is a fundamental part of life, and the food industry is crucial for every nation. Quality and health-related issues are primary concerns. The industry covers a range of activities, including sourcing, production, processing, packaging, transportation, distribution, consumption, and disposal (Pereira et al., 2022). Food quality assurance is vital for compliance with standards. Neglecting quality can harm a company's survival and brand reputation. In the long run, investing in quality improves sales and export opportunities. The food industry uses internationally recognized quality assurance systems like HACCP, ISO, and BRC. However, studies show that TQM application in food distribution and supply is limited,

despite its importance in improving competitiveness (Ghasemi & Kiandokht, 2018).

Obstacles in Implementing TQM

Identifying barriers to TQM implementation offers valuable insights for developing strategies to enhance the success of TQM and business performance (Kaur et al., 2021). Many studies have explored these obstacles, with Table 1 highlighting the most common factors that prevent TQM adoption.

Table 1.
Common Obstacles in implementing TQM

No.	Barriers	References
1	Lack of commitment and involvement of senior management	Mohammadpour et al. (2024), Yadav et al. (2022), Attri et al. (2021), Kaur et al. (2021), Aletaiby et al. (2021), Kumar et al. (2020)
2	Senior management instability	Mohammadpour et al. (2024), Attri et al. (2021), Talapatra and Uddin (2019)
3	Low employee engagement and lack of interest	Attri et al. (2021)
4	Employee resistance to change	Mohammadpour et al. (2024), Yadav et al. (2022), Kaur et al. (2021), Kumar et al. (2020), Talapatra and Uddin (2019)
5	Poor infrastructure facilities	Mohammadpour et al. (2024), Yadav et al. (2022), Attri et al. (2021)
6	Insufficient tools and equipment	Attri et al. (2021)
7	Lack of utilization of TQM tools, techniques, and methodologies	Mohammadpour et al. (2024), Yadav et al. (2022), Attri et al. (2021)
8	High rate of organizational turnover	Mohammadpour et al. (2024), Yadav et al. (2022)
9	Lack of training programs	Mohammadpour et al. (2024), Yadav et al. (2022), Kumar et al. (2020), Talapatra and Uddin (2019)
10	Insufficient knowledge or understanding of TQM philosophy	Attri et al. (2021)
11	Lack of budget for investment	Mohammadpour et al. (2024), Yadav et al. (2022), Talapatra and Uddin (2019)
12	Inadequate skills and experience among employees	Yadav et al. (2022)
13	Organizational rigidity towards environmental sustainability and technological changes	Attri et al. (2021)
14	Lack of long-term planning and policies	Mohammadpour et al. (2024), Attri et al. (2021), Kaur et al. (2021), Kumar et al. (2020), Talapatra and Uddin (2019)
15	Lack of clarity in organizational policies regarding TQM programs	Mohammadpour et al. (2024), Yadav et al. (2022), Attri et al. (2021), Kaur et al. (2021)

Application of TQM in various industry

Fili et al. (2019) identified the key success factors of TQM and ranked them by using a combined approach based on fuzzy Decision making trial and evaluation laboratory (DEMATEL) and Fuzzy Analytic Network Process (FANP). The results indicated that the most influential factors for TQM success were senior management commitment and leadership, human resource management, and, finally, education and learning. On the other hand, supplier management and benchmarking had the least impact. Talapatra and Uddin (2019) examined the relative importance of various barriers to TQM in the apparel industry in Bangladesh, using the FAHP. The results of their study show that inappropriate planning for TQM implementation, lack of financial support, lack of employee training, lack of employee empowerment, and inadequate physical resources are among the most significant barriers to the successful implementation of TQM.

Sarbandi and gholizadeh (2020) examined the relationship between TQM, customer satisfaction, and customer loyalty, considering the mediating role of service quality in bank branches. They used structural equation modeling for data analysis. The results of their study showed a significant relationship between the application of TQM and both customer satisfaction and loyalty, with service quality acting as a mediator. Kumar et al. (2020) conducted a study to identify the key human and operational barriers to implementing sustainable TQM in Indian organizations using a fuzzy Interpretive Structural Modeling (ISM) approach. Their findings revealed that relational barriers, including a lack of teamwork, absence of performance measurement and evaluation criteria, untimely implementation of programs, and inadequate planning, play a significant role in hindering sustainable TQM.

Kaur et al. (2021) aimed to identify the main barriers to the synergy of TQM and Supply Chain Management (SCM) in medium and large manufacturing companies in India using the Vise Kriterijumska Optimizacija I Kompromisno Resenje (VIKOR) method. The results suggest that the synergy between TQM and SCM is still in its early stages in India. Attri et al. (2021) prioritized barriers to the successful implementation of TQM in Indian manufacturing companies using the Best-Worst Method (BWM). The ranking results show that the most significant deterrents to TQM implementation include lack of senior management commitment and involvement, absence of continuous training, and lack of employee engagement and indifference. The goal of the research by Dehghani et al. (2022) was to explore the barriers to implementing TQM in hospitals in Kerman city using statistical analysis. Their findings indicated that there is a significant relationship between cultural and workforce barriers, infrastructure-related barriers, and managerial barriers with the successful implementation of TQM, with a confidence level of more than 99%.

Yadav et al. (2022) analyzed the causal relationships between human-related and system-related barriers to TQM in the automotive industry using the fuzzy DEMATEL method. Their findings indicate that key obstacles include lack of senior management commitment, budget shortages, lack of advanced production facilities, and employee resistance to change. Hchaichi (2023) analyzed the critical success factors of TQM in public sector companies using multiple linear regression. The results confirm that the successful implementation of TQM requires a culture of trust, loyalty, good communication, and social cohesion. Akanmu et al. (2023) explored the relationship between TQM practices and sustainability aspects in Malaysian food and beverage manufacturing companies using Structural Equation Modeling (SEM). Their findings emphasize that effective continuous process improvement, benchmarking, quality assurance, service design, and information analysis have a significant positive impact on sustainability.

Sfakianaki et al. (2023) conducted an empirical study to examine the current status of TQM implementation in elementary education centers in Greece. They tested 37 components in seven major dimensions and found a positive impact between TQM and elementary education centers. Nguyen et al. (2023) applied Delphi and AHP techniques to identify the key factors and indicators for implementing a 4.0 industrial generation-based TQM model in manufacturing companies. Their findings showed that social factors were more significant than technical factors. Mohammadpour et al. (2024) investigated barriers to implementing TQM in the Solico Food and Beverage Production Group. The GBWM was used to prioritize these barriers. The results revealed that the most significant barriers were the lack of top management commitment and participation, high organizational burnout rate, and instability due to frequent changes in senior management.

Research gap and novelty

Despite the extensive body of literature on TQM implementation across various industries, several critical gaps remain. Studies, such as those by Talapatra and Uddin (2019), Kumar et al. (2020), and Attri et al. (2021), have identified key barriers to TQM implementation in service and manufacturing sectors. However, the majority of these investigations have focused on industries like apparel, automotive, and general manufacturing, leaving significant areas, such as the food industry, underexplored. The main novelty of this research lies in its focus on the food industry—a sector that remains largely underrepresented in TQM research, despite its unique challenges and requirements.

In addition, while methodologies such as AHP have been widely used to prioritize and analyze barriers, few studies have adopted novel decision-making methods like the BWM. BWM offers a distinct advantage over AHP. The method's primary strengths are its reduced number of pairwise comparisons. Also, by utilizing a non-linear model, BWM allows for the calculation of an optimal range of weights (Rezaei, 2015, Rezaei, 2016). In addition, the solution of the BWM can be obtained by solving the mixed integer linear programming model (Dehghani & Abbasi, 2022a), and the weights of the BWM criteria can be determined and estimated by solving linear programming or mixed integer linear programming models (Abbasi & Dehghani, 2025). Using other forms of BWM like the Trustable BWM Algorithm can be beneficial, too (Dehghani & Abbasi, 2022b). In the case of TQM barriers, the factors are often qualitative, which requires a method that can evaluate them effectively. As decision-making becomes more complex in advanced environments, making optimal decisions while considering all aspects of the issue becomes increasingly difficult. Therefore, it is essential to rely on the opinions of an expert committee. The experts can be selected using snowball sampling. Considering what has been stated, further novelty of this study is the application of the GBWM to identify and prioritize barriers to TQM implementation in the food industry, a sector that has been underexplored in the existing literature.

Research Methodology

The present study is applied in terms of its purpose and utilizes a survey research method for data collection. Data were collected using structured questionnaires, which were carefully designed based on a comprehensive review of the relevant literature. The GBWM was applied to analyze and rank the identified barriers. The target population comprises quality control and assurance managers from small and medium-sized enterprises (SMEs) within the food industry, with Dadli Food Company serving as the case study. Participants were selected using the snowball sampling method, which facilitated access to knowledgeable individuals actively engaged in quality management processes at Dadli Food Company. The data collection process commenced with a semi-structured interview with the company's CEO. Pre-prepared questions were provided to the interviewee in advance. At the conclusion of the interview, the CEO was asked to recommend additional suitable participants for the study. Subsequently, interviews were conducted with other experts. The expert committee was finalized as outlined in Table 2.

Table 2.
Expert Panel Information at Dadli Food Company

Row	Organizational Position	Experience (Years)	Code
1	CEO	18	E1
2	Compliance Manager (Quality Control)	12	E2
3	Senior Quality Assurance Manager	15	E3
4	Senior Audit and Standardization Expert	10	E4
5	Production Planning Expert	8	E5

The research began with an interview with the company's CEO. The interview was semi-structured, with pre-prepared questions provided to the interviewee beforehand. At the end of the interview, the CEO was asked to recommend additional suitable participants for the study. Similarly, interviews were conducted with other experts. Data collection utilized Delphi questionnaires and the GBWM.The proposed research process included the following stages:

1. Forming an expert team to collect data using the snowball sampling method.
2. Validating TQM implementation barriers identified from the literature review (Table 1) using the Delphi method.
3. Determining the importance coefficients of barriers by the GBWM (includes 3 steps).

Delphi Method

The process of finalizing the barriers to implementing TQM in the food industry, with a focus on Dadli Company, involved distributing questionnaires to the members of the expert panel. Each member was asked to evaluate the identified barriers to TQM implementation based on a binary scale of "agree" or "disagree." At the end of the questionnaire, respondents were also requested to suggest any additional barriers they deemed relevant. Barriers that received unanimous agreement from all experts were selected for inclusion. If no additional barriers were suggested by the experts, the screening and validation process concluded at this stage. However, if new barriers were proposed, the validation process proceeded to the next round. This iterative process continued until no new barriers were suggested in a given round, ensuring a comprehensive and consensus-driven final list of barriers.

The steps of GBWM

The steps of the GBWM are described as follows (Safarzadeh et al., 2018):

Step 1: Determining Initial Information

In this step, the required input information related to each decision-maker is collected. This includes the set of decision criteria, weighting coefficients of experts which reflect their subjective preferences based on their experience; best and worst criteria selected by the experts; Pairwise comparison vectors between the best and worst criteria and the other criteria.

It is important to note that best and worst criteria are considered equally significant for the group decision-making problem. To ensure that the best and worst criteria are consistent across all experts, the method of using expert weight coefficients is applied. In this study, linear normalization is used to calculate expert weight coefficients. In this method, each value in a set is divided by the total sum of the elements in that set. After normalization, the total sum of the elements will equal one. The index used to determine the expert weight coefficients is the work experience and expertise of the experts. This method is illustrated in Equation 1.

$$n_{ij} = r_{ij} / \sum_{i=1}^{m} r_{ij} \quad (1)$$

To explain how to achieve a consistent selection of the best and worst criteria for all experts using expert weight coefficients, a case example is provided as follows. For example, if a group decision-making problem involves three experts and four criteria (E, F, G, and H), the experts' opinions are aggregated as shown in Table 3, and the final best and worst criteria are determined accordingly:

Table 3.
Selection of best and worst criteria

Expert	Expert's weight	Initial best and worst criteria	Score	Final best and worst criteria
E_1	0.3	$(B:F, W:G)$	$\begin{cases} B = \begin{cases} E = 0.2 \\ F = 0.3 + 0.5 \end{cases} \\ W = \begin{cases} G = 0.3 \\ H = 0.2 + 0.5 \end{cases} \end{cases}$	$(B:F, W:H)$
E_2	0.2	$(B:E, W:H)$		
E_3	0.5	$(B:F, W:H)$		

Step 2: Calculating the criteria weights through solving the nonlinear programming model

The objective of this model is to minimize the total consistency deviations for all experts. Accordingly, the minimization model is formulated as follows in Equation 2:

$$\begin{aligned} & min \sum_{k \in D} w'_k Max_i \left\{ \left| \frac{w_B}{w_i} - a^k_{Bi} \right|, \left| \frac{w_i}{w_W} - a^k_{iW} \right| \right\} \\ & S.t. \\ & \sum_i w_i = 1 \\ & w_i \geq 0;\ \forall\, i \in C \end{aligned} \quad (2)$$

In the objective function of this model, w'_k represents the weight coefficient of the experts, which is adjusted as percentage values from [0,100]. By solving the above mathematical model, the optimal weights of the criteria $(W_1^*, W_2^*, \dots, W_n^*)$ are calculated. To simplify model 2, the term ξ_k is defined as in Equation 3:

$$\begin{aligned} & \xi_k \\ & = Max_i \left\{ \left| \frac{w_B}{w_i} - a^k_{Bi} \right|, \left| \frac{w_i}{w_W} - a^k_{iW} \right| \right\} \end{aligned} \quad \begin{matrix} \forall\, k \\ \in D \end{matrix} \quad (3)$$

Therefore, the proposed model 3 is transformed into the final model 4:

$$\begin{aligned} & min \sum_{k \in D} w'_k \xi_k \\ & S.t. \\ & \left| \frac{w_B}{w_i} - a^k_{Bi} \right| \leq \xi_k \\ & \left| \frac{w_i}{w_W} - a^k_{iW} \right| \leq \xi_k \\ & \sum_i w_i = 1 \\ & w_i \geq 0;\ \forall\, i \in C \end{aligned} \quad \begin{matrix} \forall\, i \in C; \forall\, k \in D \\ \forall\, i \in C; \forall\, k \in D \end{matrix} \quad (4)$$

Step 3: Obtaining consistency ratio of the problem to evaluate the results

In the next step of the GBWM, a consistency ratio is calculated to verify the reliability of the comparisons. After solving the mathematical model, the optimal values of ξ_k^* are used to compute the consistency ratio for each expert (CR_k) and for the overall group decision-making consistency ratio (CR^G). Generally, Equation 5 is used to represent the consistency ratio for the k-th expert, and Equation 8 is used to determine the group consistency ratio:

$$CR_k = w'_k \left(\frac{\xi_k^*}{CI^\theta} \right) \quad \forall\, k \in D \quad (5)$$

$$CR^G = Max_k \{CR_k\} \quad (6)$$

In this context, θ represents a non-negative value that indicates the sensitivity of the model. According to the research by Safarzadeh et al. (2018), this value is assumed to be 1 by default. Similar to the original version of the BWM, the consistency index values for a group decision-making problem are reported in Table 5. In this table, the maximum preferences of the experts are given by $a_{BW}^{max} = Max_k a^k_{BW}$.

Table 4.
Consistency index

a_{BW}^{max}	1	2	3	4	5	6	7	8	9
CI	0.00	0.44	1.00	1.63	2.30	3.00	3.73	4.47	5.23

Therefore, the closer the consistency ratio (CR) is to zero, the higher the consistency of the comparisons made. In fact, a lower CR indicates that the opinions and preferences of

the experts are more aligned and consistent with each other, which in turn increases the reliability and credibility of the group decision-making process.

Findings of the Study

Determining the Expert Weights

Considering that the issue under study in this research is a group decision-making problem and one of the input parameters for the proposed nonlinear programming model of the GBWM is the weight of the preferences and subjective judgments of each expert committee member, in this step, the expert weight for each member of the committee was determined using the linear normalization method (Equation 1). The weight for each committee member relative to the experience index is shown in Figure 1. The process works by dividing each committee member's years of experience by the total years of experience of all members.

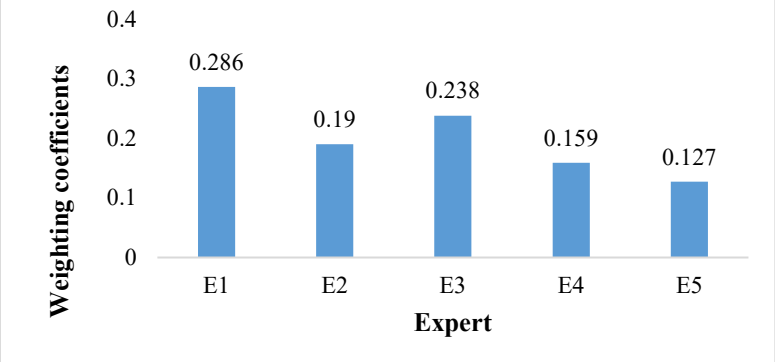

Figure 1. *Weighting coefficients of the expert committee*

According to the results obtained, the expert weights for CEO of the company, Senior Quality Assurance Manager, Compliance Manager (Quality Control), Senior Audit and Standardization Expert, and Production Planning Expert were found to be 0.286, 0.190, 0.238, 0.159, and 0.127, respectively.

Determining the Final Barriers

According to the literature review, an initial list of 15 barriers was identified and extracted, as shown in Table 1. A Delphi method questionnaire was then designed and distributed to the expert committee members, asking them to indicate their agreement or disagreement with each of the identified barriers. At the end, experts were also given the opportunity to suggest any additional barriers not included in the initial list. Afterward, all questionnaires were collected. The data collected from the questionnaires were then analyzed using the Delphi method. In general, after conducting the Delphi method over three rounds, the final list of barriers was determined, as shown in Table 5.

Table 5.
Finalized obstacles identified by Delphi method

Code	Description
B1	Lack of commitment and involvement of senior management
B2	Senior management instability
B3	Employee resistance to change
B4	Lack of utilization of TQM tools, techniques, and methodologies
B5	High rate of employee turnover
B6	Insufficient knowledge or understanding of TQM philosophy
B7	Lack of budget for investment
B8	Inadequate skills and experience among employees
B9	Organizational rigidity towards environmental sustainability and technological changes

Determining the Priority of Barriers

In this step, the most significant (best) and least significant (worst) barriers affecting the implementation of TQM were identified based on the opinions of the expert committee. The results are shown in Table 6.

Table 6.
Best and worst barriers identified by each expert

Barriers	Experts	
	Best	Worst
B1	E1, E3	
B2	E2, E5	
B3		
B4		E1
B5		
B6		E2
B7	E4	
B8		E3, E5
B9		E4

Subsequently, utilizing the expert weighting method, the opinions of experts regarding the identification of the most significant (best) and least significant (worst) barriers were aggregated, as presented in Table 7.

Table 7.
Final best and worst barriers based on expert opinions

Expert	w_k'	Best and worst criteria selected by experts	Final Score
E_1	0.286	$(B: B_1, W: B_4)$	$\begin{cases} B = \begin{cases} B_1 = 0.524 \\ B_2 = 0.317 \\ B_7 = 0.159 \end{cases} \\ W = \begin{cases} B_6 = 0.286 \\ B_6 = 0.190 \\ B_8 = 0.365 \\ B_{10} = 0.159 \end{cases} \end{cases}$
E_2	0.190	$(B: B_2, W: B_6)$	
E_3	0.238	$(B: B_1, W: B_8)$	
E_4	0.159	$(B: B_7, W: B_9)$	
E_5	0.127	$(B: B_2, W: B_8)$	

As shown in Table 7, the barrier of "Lack of commitment and involvement of senior management" (B1) was selected as the most important (best criterion) by expert E1 with a weight of 0.286 and expert E3 with a weight of 0.238. Therefore, the final weighted score for this barrier is 0.524. Additionally, the barrier of "Inadequate skills and experience among employees" (B8) was selected as the least important (worst criterion) by expert E3 with a weight of 0.238 and expert E5 with a weight of 0.127. Consequently, the final weighted score for this barrier is 0.365. Therefore, among the barriers, B1 is the most important, and B8 is the least important. In the next step, the priority of the best criterion relative to other criteria, as well as the priority of other criteria relative to the worst criterion, was determined by the experts based on a scoring range of {1, 2, ..., 9}. Finally, the pairwise comparison vectors of the best criterion with other criteria (Best-to-others), and other criteria with the worst criterion (Others-to-worst), for each expert are shown in Tables 8 and 9.

Table 8.
Best-to-others (BO) vectors

Expert	Best	Best-to-others vectors								
		B1	B2	B3	B4	B5	B6	B7	B8	B9
E1	B1	1	2	3	3	2	3	5	9	2
E2	B1	1	3	5	5	2	2	3	8	3
E3	B1	1	2	2	4	4	3	3	9	5
E4	B1	1	3	3	4	3	3	5	8	3

E5	B1	1	5	5	3	2	5	4	9	2

Table 9.
Others-to-worst (OW) vectors

Expert	Worst	Others-to-worst vectors								
		B1	B2	B3	B4	B5	B6	B7	B8	B9
E1	B8	9	5	3	3	5	3	2	1	4
E2	B8	8	2	3	3	5	2	3	1	3
E3	B8	9	3	5	4	3	4	2	1	4
E4	B8	8	2	3	2	5	2	3	1	3
E5	B8	9	4	5	3	3	2	2	1	2

After determining the priority of the barriers, a nonlinear programming model was developed to calculate the weights of the barriers according to Equation 4. The model was solved using GAMS software version 24.3 with the Baron solver. Based on the results, the barriers of "Lack of commitment and involvement of senior management" (B1), "Senior management instability" (B2), and "High rate of organizational turnover" (B5) were ranked first to third, with final weights of 0.299, 0.117, and 0.117, respectively, and were identified as the most significant barriers. The global weight and also priority of the barriers to the implementation of TQM at Dadli Food Company is presented in Table 10.

Table 10.
Final Prioritization of Barriers in TQM Implementation

No.	Barriers	Global weight	Rank
1	Lack of commitment and involvement of senior management (B1)	0.299	1
2	Senior management instability (B2)	0.117	2
3	Employee resistance to change (B3)	0.095	4
4	Lack of utilization of TQM tools, techniques, and methodologies (B4)	0.083	7
5	High rate of employee turnover (B5)	0.117	3
6	Insufficient knowledge or understanding of TQM philosophy (B6)	0.086	6
7	Lack of budget for investment (B7)	0.077	8
8	Inadequate skills and experience among employees (B8)	0.03	9
9	Organizational rigidity towards environmental sustainability and technological changes (B9)	0.095	5

After solving the model, the ξ* values associated with each expert are reported in Table 11. Considering θ=1, the consistency ratio (CR^G) for the group decision-making problem, calculated using relations 5 and 6, is the maximum value from the set {0.062, 0.079, 0.084, 0.066, 0.059}, which is 0.084. Since the consistency ratio is close to zero, the obtained results have acceptable validity.

Table 11.
Consistency ratio for the obtained weights

Expert	w_k'	ξ*	a_{BW}^{max}	CI	CR_k
E_1	0.286	1.140	9	5.23	0.062
E1	0.190	1.860	8	4.47	0.079
E2	0.238	1.860	9	5.23	0.084
E3	0.159	1.860	8	4.47	0.066
E4	0.127	2.446	9	5.23	0.059

To clarify how the consistency ratios are obtained, the calculations for expert E1 are explained. Since the priority degree of the best criterion over the worst criterion (a_{BW}^{max}) is 9, according to Table 5, the consistency index (CI) for the pairwise comparisons is 5.23. Therefore, the consistency ratio for expert E1, using the equation 5 ($CR_k = w'_k\left(\frac{\xi_k^*}{CI^\theta}\right) = 0.286 \times \frac{1.140}{5.23} = 0.062$), is calculated as 0.062. This indicates a very high consistency of the results for expert E1, as this value is close to zero. Similarly, the consistency ratios for other experts are reported in Table 11.

Discussion and Conclusion

The food industry today faces a myriad of challenges. To remain competitive, the sector must adopt advanced technologies and innovative approaches, as failing to do so risks falling behind. In the 19th century, the number of producers in the market was limited, and products were constrained in terms of volume, variety, and innovation. In contrast, today's market is highly competitive, demanding that food industries focus on various aspects such as cost efficiency, production speed, and timely delivery to customers.

The primary objective of this study was to identify and prioritize the barriers to implementing TQM in the food industry, specifically at Dadli Food Company, using GBWM. The initial stage involved reviewing existing research and focusing on highly cited articles to compile an initial list of barriers to TQM implementation, as detailed in Table 1. These barriers were then analyzed using the Delphi method in the second stage. Ultimately, nine significant barriers were identified as obstacles to implementing TQM at Dadli Food Company: lack of commitment and involvement of senior management, senior management instability, employee resistance to change, lack of utilization of TQM tools, techniques, and methodologies, high rate of employee turnover, insufficient knowledge or understanding of TQM philosophy, lack of budget for investment, inadequate skills and experience among employees, Organizational rigidity towards environmental sustainability and technological changes. Subsequently, these barriers were prioritized using GBWM in the third stage (includes 3 steps). The results, shown in Table 10, revealed that "Lack of commitment and involvement of senior management" ranked as the most significant barrier with an importance coefficient of 0.299, followed by "Senior management instability" (0.117) and "High rate of employee turnover" (0.117). Furthermore, the consistency ratio of the results, found in Table 11, was close to zero, demonstrating the high reliability of the weights assigned to the barriers.

Based on the findings of the study, the following key recommendations are made to overcome the barriers to TQM implementation at food industries, particularly at Dadli Food Company. These recommendations are framed in the context of existing research and provide managerial insights for overcoming the identified challenges:

This study identified of commitment and involvement of senior management as the most significant barrier to TQM implementation. This finding is consistent with several prior studies. Fili et al. (2019) and Attri et al. (2021) emphasize that senior management involvement is crucial for successful TQM adoption. Similarly, Kumar et al. (2020) and Mohammadpour et al. (2024) highlight that inadequate management commitment results in insufficient resource allocation and poor implementation of TQM strategies. To address this issue, it is essential for senior management to not only endorse but actively engage in the TQM process. This can be achieved by providing the necessary resources, such as advanced tools, machinery, and training programs. Moreover, it is important for senior management to lead by example, demonstrating their commitment to quality and fostering a culture of ownership among employees. Ensuring that senior management plays an active, visible role in TQM will

motivate employees and facilitate a more effective and sustainable quality management system.

The issue of senior management instability was another significant barrier highlighted in this study. This aligns with the findings of Mohammadpour et al. (2024), who also identify leadership instability as a challenge for TQM implementation. Instability in leadership creates inconsistency in decision-making, disrupts long-term strategic planning, and negatively impacts organizational performance. Research consistently shows that stable leadership is vital for the successful execution of quality improvement initiatives. To mitigate the impact of leadership instability, it is recommended that food companies consider extending the tenure of senior management positions and ensure smooth transitions in leadership. This stability allows for better continuity in implementing TQM strategies and ensures that long-term goals are maintained. Additionally, structured succession planning can help preserve institutional knowledge and maintain organizational consistency. A stable leadership team will be crucial in fostering a culture of quality and supporting continuous improvement.

High rate of employee turnover was identified as another barrier to TQM success in this study. This finding is corroborated by Mohammadpour et al. (2024), who also point out that high turnover negatively affects organizational cohesion and hinders TQM adoption. High turnover disrupts team dynamics and results in the loss of critical knowledge, which impedes the smooth execution of quality initiatives. To address this challenge, food companies should focus on aligning compensation, benefits, and incentives with employee skills, experience, and job responsibilities. Offering competitive, performance-based rewards will help attract and retain talent. Furthermore, fostering a positive work culture, providing opportunities for career growth, and implementing clear paths for advancement can reduce turnover and improve employee engagement. By creating a stable and motivated workforce, the company can improve operational efficiency, retain valuable knowledge, and foster a long-term commitment to TQM.

In conclusion, the study reveals that the success of TQM implementation at Dadli Food Company, and by extension, in the broader food industry, depends heavily on overcoming key barriers such as lack of senior management commitment, leadership instability, and high employee turnover. By focusing on management involvement, leadership stability, and employee retention, food companies can significantly improve their ability to implement TQM and enhance overall operational efficiency. The recommendations provided offer practical solutions that can help food companies, particularly SMEs like Dadli Food Company, to not only address these barriers but also build a sustainable competitive advantage in today's fast-evolving food market.

Conflict of Interest

The corresponding author declares that there is no conflict of interest regarding the authorship or publication of this article.

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