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Introducing an effective model of developing production strategies and techniques on a global scale: A case study of the West African market

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Abstract

This study aimed to provide an effective model for developing production strategies and techniques on a global scale in the West African market. The criteria weights were determined using Shannon's entropy after collecting the opinions of West African market experts through questionnaires. The main and sub-components and production indicators were identified on a global scale and prepared and compiled in the form of a scoring checklist using the ISM model and examining the theoretical foundations of the research. Then, the indicators and components of the study were confirmed through the Delphi method. The causes of influence on production strategies and techniques on a global scale were designed based on structural-interpretive modeling. Further, the technique of analyzing the mutual effects of Mic Mac was used to investigate the impact of factors on each other in global scale production in the West African market. The research population was experts and specialists active in production on a global scale in the West African market. According to Saaty, ten experts were selected as the statistical population of this research. The ISM results showed that all 28 leading indicators were finally approved by experts and were ranked from 1 to 28. The index of non-creation of waste from the sub-component of cost reduction was ranked first with an agreement coefficient of 0.798. In addition, reducing set-up time from the sub-component of cost reduction with an agreement coefficient of 0.782 was ranked second, and lean production from the sub-component of lean production with an agreement coefficient of 0.611 was ranked 28th. The second-round results of the Delphi indicated that all the sub-indicator were confirmed based on a mean > 5, a low standard deviation, and an agreement coefficient > 0.5. The approved model was designed based on two Delphi steps based on experts' opinions, and the Mic Ma method showed that out of the 28 main factors, 12 were influential factors, nine were influential factors, and seven were independent factors. Finally, 10 of the main factors were determined as the key factors influencing production on a global scale in the West African market: 1) Cellular production, 2) Production without waste, 3) Activities with an environmental attitude, 4) Flexible system, 5) Field of operation, 6) No waste, 7) Operation improvement, 8) Communication with customers, 9) Clarity of business, 10) Participation and Companies relationship with suppliers.

Keywords: production on a global scale, supply chain on a global scale, competitive strategy in global scale production
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1 Introduction

Today's business has become international, and during the last decade, there has been a tremendous increase in international trade and foreign direct investment. Many markets are now completely globalized. The role of manufacturing companies has changed from supplying products for domestic markets through international markets to supplying international markets to local production. Therefore, research on international issues in production has evolved from global sales and marketing to global production. The process of globalization has changed the methods of providing products and services to customers and analyzing the affairs and production network or supply chain [19].

2 Research literature

Today, gaining a competitive advantage is not just a choice and guarantees the survival of companies in the national and international markets [2]. There are different approaches to formulating operational strategies, which explain the performance differences of companies and gain competitive advantage from different perspectives. These approaches are divided into three categories based on their emphasis. The first is the approaches that mainly focus on external factors, the second is on the company's internal resources and capabilities, and the third is on interface factors. Over time and facing different issues of each period, the attention of companies was turned from external and uncontrollable factors affecting the creation of competitive advantage to internal controllable resources and capabilities [5]. The development of operational strategies is one of the most common companies' internal controllable capabilities advantages. The strategy of specialization and division of labor in the assembly line of Ford for the mass production of cars or the production of various products at a reasonable price in the lean production system in Toyota is among the essential manifestations of operational strategies [3, 4, 30].

Production strategies affect gaining a sustainable competitive advantage as the companies' most common internal controllable ability. Developing these strategies requires a clear understanding of their role in gaining competitive advantage and their mutual effects on each other. Operational strategies express a set of roles, goals, and operational activities in a manufacturing company as part of the macro strategies of manufacturing companies. In other words, operational strategies serve as a model for strategic decisions and actions in manufacturing companies [14]. Operational strategies refer to a set of structural and infrastructural decisions that help to create and maintain a sustainable competitive advantage for companies. Production structure decisions primarily permeate design activities. However, sub-structural decisions affect planning and control, workforce organization, and improvement activities [12]. Companies can use operational strategies as an effective weapon to gain a sustainable competitive advantage [13] to maintain their unique features in front of their competitors [30].

Garrido-Vega et al. [10] evaluated production capability, strategy, and the parts manufacturers' performance. Nurcahyo and Wibowo [20] investigated the relationship between strategies and operational plans in manufacturing industries. Göleç [11] examined aligning production strategies with the export performance of small and medium-sized companies, and Singh and Mahmoud [27] assessed a suitable production strategy framework for small and medium enterprises. Löfving et al. [16] classified production strategies in Irish manufacturing companies.

Today, companies face intense challenges in the competitive market, including globalization, competition, cooperation, diversity of customer needs, and short product life cycle. As a result, the supply chain as an important principle has been noticed by company managers. In addition to focusing on the company's internal activities, top managers pay special attention to appropriate and timely communications and interactions with their suppliers and customers and try to manage the supply chain related to their products effectively and efficiently. In other words, optimizing organizational processes without considering suppliers and customers seems useless, and organizations that work together towards common goals have better performance [26].

Today, the role of supply chain seems necessary for producing a world-class supply chain. Because nowadays, the world is moving towards a global village more than in the past. Countries are opening their markets to each other by removing tariff and protection barriers. There is global industry competition due to the fundamental changes created in the competitive environment of industries, such as the process of globalization of trade, shortening the life of products, rapid changes in technology, and increasing the number of competitors [8, 18]. For this purpose, the issue of world-class manufacturing was raised. Schonberger [24] first introduced the concept of world-class manufacturing and enumerated the world-class manufacturing system, broad agreement on continuous improvement of quality, cost, waiting time, and customer service. As a result of world-class manufacturing (WCM), flexibility is the first goal of a part of the system as a level of organizational performance that enables competition in the global arena and can respond appropriately to today's needs of the business world [8]. Therefore, global competition is the fundamental and main reason for changing the competitive environment of manufacturing industries [22]. In most industries, a method is used to ensure the organization's survival in the turmoil of these changes. Considering the industry's importance and role in economic development and globalization, it is necessary to take measures to synchronize the organization with the existing global conditions. Khaled et al. [15] and Farsijani and Hosseini [9] stated that the best strategy for competing in the global arena is world-class manufacturing, which focuses on continuous improvement and is a suitable way to respond quickly to the environment.

Based on these studies, world-class manufacturing needs a proper supply chain and internal and external resources to speed up customer response. Hosseini and Solukdar [26] considered competitive boundaries (delivery, quality, cost, flexibility, innovation, sales, and after-sales services) as the essential factors affecting globalization and competition in the world market. Many world-class service providers and manufacturers are trying to provide their goods and services more efficiently and effectively in the least amount of time. The vital element of this effort is the coordination of internal and external resources, that is, activities related to the supply chain [9, 15, 25]. According to the results, companies alone cannot face the competitive environment and the realization of world-class manufacturing principles [1, 21]. The supply chain equips the organization with a competitive resource at the global and domestic levels. De Feliece et al. [6] consider the flow of materials and information and the cooperation and communication between the company and its suppliers to be the first condition of world-class manufacturing research. Based on this study, strengthening the supply chain leads to product development in the world-class [17].

Mir habibi et al. [18] improved the integration of the supply chain to achieve World-class manufacturing using Performance Importance Analysis (IPA) in Iran's home electronics industry and stated that today, organizations and industries are facing competition at the international level. The requirement for success in global competition is the production of world-class products. Industries need more integration at the level of the organization and their partners at the supply chain level to achieve World-class manufacturing indicators, competitiveness, and quick response. Mir habibi et al. [18, 17] explained the role of an integrated supply chain in achieving World-class manufacturing in home electronics industries and stated that in today's dynamic and complex environment, organizations and industries compete internationally. World-class product production is an essential category for successful global competition. Integration should be created at the chain of industries, organizations, and partners to achieve World-class manufacturing indicators and competitiveness.

Petrillo et al. [22] measured the performance of world-class manufacturing: a model for the Italian automotive industry. The continuous increase in competition forces each company to review its production processes to minimize costs and maximize customer service. Ebrahimi et al. [7] investigated the evolution of World-class manufacturing towards Industry 4.0 to increase the level of global competition and improve the performance of the production system. Many manufacturing companies have implemented the World Class Manufacturing (WCM) approach, which was developed based on the third industrial revolution and the need for mass production. Sandeep et al. [23] investigated the identification of barriers to implementing World Class Manufacturing Methods (WCM). World-class manufacturing methods are increasingly used by manufacturing organizations to achieve world-class performance, enabling them to remain in the current global competition. This organization tries to implement these methods successfully, but it always faces different obstacles, which should be solved more effectively.

3 Method

This applied and heuristic study aimed to understand more about world-class manufacturing in the West African market.

4 Data analysis

The results of this research can be classified as developmental research because it aims to develop a model of structural-interpretive analysis that can explain the factors affecting production in the world-class. At first, the critical factors identified by reviewing the research literature and interviewing World-class manufacturing experts were determined through questionnaires, and the criteria weights were selected using Shannon's entropy. Then, the ISM model was introduced, and the collected data was analyzed to investigate the complex relationship between the elements of a system. Mutual effects were examined to analyze the variables collected from experts' opinions using MIC MAC software, and the results of each research phase were explained.

4.1 The weight of data using Shannon's entropy

After collecting the opinions of West African market experts through questionnaires, the criteria weights were determined using Shannon's entropy:

Entropy is fundamental in social sciences, physics, and information theory. When the data of a decision matrix is fully specified, the entropy method can be used to evaluate the weights. The greater the dispersion in the values of an index, the more critical that index is. P_i entropy in information theory is a measure of uncertainty with a probability distribution:

$$E_i = S(P_1, P_2, ..., P_n) = -K \sum_{i=1}^{n} [P_1 * \ln P_i] \tag{4.1}$$

K is a constant value applied when E_i is between zero and one. E_i is calculated from the probability distribution of P_i based on a statistical mechanism, and its value is the maximum possible value if the $P_i s$ are equal to each other (i.e., $= \frac{1}{n} P_i$), which is calculated as follows:

$$-k \sum_{i=1}^{n} pi - \ln pi = -k\{\frac{1}{n} \ln \frac{1}{n} + \frac{1}{n} \ln \frac{1}{n} \ln \frac{1}{n} + ... + \frac{1}{n} \ln \frac{1}{n}\} = -k \left\{ \frac{1}{n} \ln \frac{1}{n} \left(\frac{n}{n}\right) \right\} = -k * \ln \frac{1}{n} \tag{4.2}$$

As a constant value, it is calculated as follows:

$$k = \frac{1}{\ln(m)} \tag{4.3}$$

The decision matrix contains information that can be used as a criterion for its evaluation. The following steps can be taken to obtain the weights of the indicators:

4.2 Forming a decision table for the weights of indicators

Each dimension of World-class manufacturing is evaluated based on different criteria. The results of the decision matrix are presented in Table 1.

Table 1: Decision matrix of experts based on weights of indicators

	Lean Production	**Human resource management**	**Environmental practices**	**Cellular production**	**Cost reduction**	**Flexibility**	**Marketing integration aspect**
Weights related to criteria	0	0	0				0
Expert 1	7.5	3.3	5.8	8	2.5	2.2	4.2
Expert 2	8.5	6.8	6.3	7	1.9	2.3	2.9
Expert 3	7.5	5.3	5.8	7	3.8	3.5	4.6
Expert 4	6.5	6.8	5.3	5.6	1	2.2	3.5
Expert 5	7.6	4.8	5.3	5.1	7	3.5	3.3
Expert 6	7	6.8	5.3	4.9	2.3	5.1	5.1
Expert 7	7.3	6.8	4.6	4.3	3.5	4.6	5.1
Expert 8	5.6	5.3	5.5	4.7	4.9	3.8	4.1
Expert 9	7.7	4.3	3	3.5	3.1	2	5.1
Expert 10	4.4	4.3	4	5.1	3.2	2.5	3.5
Total	69.5	54.5	45.6	55.2	54.1	31.7	41.4

The first stage of calculation: P_{ij}

Equation (4.4) is used to calculate P_{ij}:

$$P_{ij} = \frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}} \tag{4.4}$$

$$P_{ij} = \frac{7.5}{69.5} = 0.107 \simeq 0.11$$

Equation (4.4) was used to calculate the rest of the indicators, and the results are shown in Table 2:

Second step: calculating the E_{ij} entropy value

In this step, the E_{ij} value (confidence value) is obtained using the following equation:

$$-k = \ln \frac{1}{n} \tag{4.5}$$

$$\longrightarrow -k = \frac{1}{\ln 10} = 0.492$$

Table 2: Calculation of indicators

	Lean Production	**Human resource management**	**Environmental practices**	**Cellular production**	**Cost reduction**	**Flexibility**	**Marketing integration aspect**
Weights related to criteria	0	0	0		0	0	0
Expert 1	0.11	0.060	0.12	0.14	0.046	0.069	0.010
Expert 2	0.12	0.12	0.11	0.12	0.035	0.072	0.07
Expert 3	0.11	0.097	0.10	0.12	0.070	0.11	0.011
Expert 4	0.093	0.12	0.11	0.094	0.018	0.069	0.084
Expert 5	0.11	0.081	0.11	0.092	0.12	0.11	0.079
Expert 6	0.10	0.12	0.11	0.088	0.042	0.016	0.12
Expert 7	0.10	0.12	0.11	0.077	0.064	0.014	0.12
Expert 8	0.080	0.097	0.10	0.085	0.090	0.12	0.010
Expert 9	0.11	0.078	0.055	0.063	0.057	0.063	0.12
Expert 10	0.063	0.078	0.070	0.092	0.059	0.078	0.084
Total	0.996	0.683	0.995	0.971	0.601	0.721	0.708

$$E_j = S(P_1, P_2, ..., P_n) = -K\sum_{i=1}^{n}[P_1 * \ln P_i] \tag{4.6}$$

$$E_{11} = -0.4920[0.11\ln(0.11) + 0.12\ln(0.12) + 0.11\ln(0.11) + 0.093\ln(0.093) + 0.11\ln(0.11) + 0.1\ln(0.1) + 0.1\ln(0.1) \\ +0.080\ln(0.080) + 0.1\ln(0.1) + 0.063\ln(0.063)] = 0.1$$

Equation (4.6) was used to calculate the rest of the criteria (Table 3).

Table 3: Results of confidence values

E_1	E_2	E_3	E_4	E_5	E_6	E_7
0.2	0.13	0.07	0.09	0.080	0.080	0.11

We get d_j according to the following Equation:

The third step: the amount of uncertainty

$$d_j = 1 - E_j \tag{4.7}$$

$$1 - 0.2 = 0.8$$

Equation (4.7) was used to calculate the rest of E_j and their results are shown in Table 4:

Table 4: Results of confidence values of d_j

d_j	d_1	d_2	d_3	d_4	d_5	d_6	d_7	$\sum d_j$
$1 - E_j$	0.8	0.9	0.9	0.9	0.9	0.9	0.8	6.1

The fourth step: the weight of the indicators is obtained using the following equation:

$$w_j = \frac{d_j}{\sum d_j} \to w_1 = \frac{0.8}{6.1} = 0.47 \tag{4.8}$$

For the rest of the weights of the indicators, Equation (4.8) was used, and the results are shown in Table (Momini, 2010): w_{js} are equal to 1. According to Table 5, the indicator weight of the ten experts was obtained at the end of

Table 5: Weight of indicators

w_1	w_2	w_3	w_4	w_5	w_6	w_7
0.16	0.13	0.13	0.13	0.13	0.13	0.16

the fourth stage. After determining the weight of the indicators obtained from the collected questionnaires by ten experts, the sub-components are calculated.

$$CVR = \frac{19 - \frac{20}{2}}{\frac{20}{2}} = 0.9 > 0.42$$

According to the above calculations, out of a total of ten people who evaluated the questionnaire, ten people consider the presence of these components necessary for production on a global scale. The obtained coefficient is more than 0.42, so these sub-components in the questionnaire are confirmed in terms of validity.

Table 6: Production indicators on a global scale

Main component	**Sub-component**	**Sub-component indicators**	**Proportion coefficient of indicators**			
			Unnecessary	Useful but not necessary	Necessary	Result
Production on a global scale	Lean production	Cell production	–	–	20	1
		Control and ensure innovation	–	–	20	1
		Lean production	–	–	20	1
		Just-in-time production	–	–	20	1
		Comprehensive quality control	–	–	20	1
	Human resources management	The field of industrial culture	–	–	20	1
		The company's partnership and relationship with suppliers	–	–	20	1
		Customer service quality	–	–	20	1
		Communication with the customer	–	–	20	1
		Customer field	–	–	20	1
	Environmental practices	Environmentally friendly activities	–	–	20	1
	Cell production	Area of operation	–	–	20	1
		Upgrade operations	–	–	20	1
		Quality	–	–	20	1
		Material flow	–	–	20	1
	Cost reduction	Comprehensive preventive maintenance	–	–	20	1
		Reduced waiting time	–	–	20	1
		Reducing the time to reach the market	–	–	20	1
		Not creating waste	–	–	20	1
		Reduced setup time	–	–	20	1
		Reduce waiting time	–	–	20	1
	Flexibility	Flexible system	–	–	20	1
		Information	–	–	20	1
		Industry development field	–	–	20	1
	Marketing integration aspect	Strategic planning problems	–	–	20	1
		Political lobbying	–	–	20	1
		Business transparency	–	–	20	1
		Market	–	–	20	1

4.2.1 Part I: Qualitative analysis

Delphi analysis of the first round for determining the causes and influential factors

Data were collected through a literature review based on internet studies, information from articles on various sites, library studies, and interviews with experts. The following checklist was prepared for Delphi analysis after extracting the factors affecting production in the world-class and given to ten experts in the world-class manufacturing. As shown in Table 7, one main component, seven sub-components, and 28 case indicators were provided to experts in the form of a scoring checklist. In this section, a checklist is compiled using experts' scores. The parameters are approved or removed to be included in the final model according to the mean, standard deviation, and agreement coefficient.

Based on the first round of Delphi, all indicators were approved out of a total of 28. The coefficient of agreement obtained about these standards is above 0.05, and their standard deviation is high. The mean obtained from the research variables is also greater than 5 due to the 5-option Likert scale. Therefore, these standards can be effective in World-class manufacturing based on the opinion of elites.

Table 8 is sorted into sub-components according to the agreement coefficient, and the panel members give points. Participating experts consider human resource management a secondary component and an essential factor in World-

Table 7: Checklist of research component score (first round of Delphi)

Main component	Sub-component	Proportion importance coefficient, Subcomponents					The ratio of the indicators		
		Standard deviation	Mean	Coefficient of agreement	priority	Subcomponent indicators	Mean	Coefficient of agreement	Confirmation/ removal
Production on a global scale	Lean production	3.88	14.8	0.926		Cell production	4.1	0.866	Confirmed
						Control and ensure innovation	4.4	0.816	Confirmed
						Lean production	2.0	0.866	Confirmed
						Just-in-time production	2.2	0.866	Confirmed
						Comprehensive quality control	2.1	0.894	Confirmed
	Human resources management	3.26	2	0.935		The field of industrial culture	3.9	0.816	Confirmed
						The company's partnership and relationship with suppliers	4.1	0.816	Confirmed
						Customer service quality	4.1	0.816	Confirmed
						Communication with the customer	3.8	0.816	Confirmed
						Customer field	4.1	0.816	Confirmed
	Environmental practices	0.674	4.3	0.816		Environmentally friendly activities	4.3	0.816	Confirmed
	Cell production	1.63	17.3	0.894		Area of operation	4.3	0.707	Confirmed
						Upgrade operations	4.2	0.816	Confirmed
						Quality	4.5	0.707	Confirmed
						Material flow	4.3	0.816	Confirmed
	Cost reduction	3.32	24.8	0.935		Total preventive maintenance	3.9	0.816	Confirmed
						Reduced waiting time	4.1	0.816	Confirmed
						Reducing the time to reach the market	4.2	0.816	Confirmed
						Not creating waste	4.1	0.707	Confirmed
						Reduced setup time	4.2	0.816	Confirmed
						Reduce waiting time	4.3	0.816	Confirmed
	Flexibility	2.04	11.8	0.894		Flexible system	4.3	0.816	Confirmed
						Information	4.3	0.816	Confirmed
						Industry development field	3.2	0.816	Confirmed
	Marketing integration aspect	2.44	12.8	0.935		Strategic planning problems	3.2	0.816	Confirmed
						Political lobbying	3.3	0.866	Confirmed
						Business transparency	3.2	0.866	Confirmed
						Market	3.1	0.816	Confirmed

Table 8: Prioritization of sub-components according to agreement coefficient

Main component	Subcomponents	Coefficient of agreement	Prioritization
World Class Manufacturing	Lean production	0.926	Fourth
	Human resources management	0.935	First
	Environmental practices	0.816	Seventh
	Cell production	0.894	Fifth
	Reduce costs	0.935	Second
	flexibility	0.894	Sixth
	Marketing integration aspect	0.935	Third

class manufacturing. They believe that formulating appropriate strategies can play a significant role in increasing approaches based on World-class manufacturing. While outside of the researcher's prediction, environmental practices as one of the fundamental causes and factors of World-class manufacturing were placed in the last priority of this scoring.

Delphi analysis of the second round for determining the effective causes

The second round of Delphi among the panel members was conducted again based on the excluded indicators to confirm the final components.

Table 9: The second round of Delphi

Main component	Sub-component	Sub-component indicators	The ratio of the indicators			
			Unnecessary	Useful but not necessary	Necessary	Result
Production on a global scale	Lean production	Cell production	2.6	0.734	seventh	Confirmed
		Control and ensure innovation	2.5	0.725	thirteenth	Confirmed
		Lean production	3.6	0.611	twenty eighth	Confirmed
		Just-in-time production	3.3	0.621	Twenty seventh	Confirmed
		Total quality control	2.6	0.734	Eighth	Confirmed
	Human resources management	The field of industrial culture	3.3	0.678	twenty second	Confirmed
		The company's partnership and relationship with suppliers	3.4	0.683	Twenty first	Confirmed
		Customer service quality	2.4	0.707	fifteenth	Confirmed
		Communication with the customer	2.6	0.734	ninth	Confirmed
		Customer field	3.2	0.761	sixth	Confirmed
	Environmental practices	Environmentally friendly activities	3.1	0.707	sixteenth	Confirmed
	Cell production	Area of operation	2.8	0.712	fourteenth	Confirmed
		Upgrade operations	2.6	0.734	tenth	Confirmed
		Quality	3	0.668	twenty fifth	Confirmed
		Material flow	3.7	0.768	Fourth	Confirmed
	Cost reduction	Total preventive maintenance	3.2	0.734	Eleventh	Confirmed
		Reduced waiting time	2.5	0.707	seventeenth	Confirmed
		Reducing the time to reach the market	3.2	0.674	twenty third	Confirmed
		Not creating waste	3.3	0.798	First	Confirmed
		Reduced setup time	3.1	0.782	Second	Confirmed
		Reduce waiting time	3.2	0.700	eighteenth	Confirmed
	Flexibility	Flexible system	3	0.674	Twenty fourth	Confirmed
		Information	3.1	0.700	nineteenth	Confirmed
		Industry development field	3.5	0.766	fifth	Confirmed
	Marketing integration aspect	Strategic planning problems	3	0.668	twenty sixth	Confirmed
		Political lobbying	3.4	0.731	twelfth	Confirmed
		Business transparency	3.1	0.692	twentieth	Confirmed
		Market	2.8	0.769	Third	Confirmed

According to the results of the first round of Delphi, all indicators were approved out of a total of 28. The coefficient of agreement obtained about these standards is above 0.05, and their standard deviation is high. The mean of the research variables is also greater than 5 due to the 5-option Likert scale. According to the opinion of elites, these standards can be effective in World-class manufacturing.

4.2.2 The second part of the quantitative analysis

Formation of structural self-interaction matrix

As shown in Table 11, the indicators approved by the experts have been set in the form of abbreviations to form the structural self-interaction matrix. First, the opinions of 10 World-class manufacturing experts were compared regarding the relationship between indicators. Therefore, the mode index was used to include the relationship with the highest frequency in the final table among the four possible relationships between the indicators. According to this issue, the last structural self-interaction matrix was calculated.

Table 10: Abbreviations of indicators

Index	**Abbreviation**	**Index**	**Abbreviation**
Cell production	D1	Material flow	D15
Control and ensure innovation	D2	Total preventive maintenance	D16
Lean production	D3	Reduce waiting time	D17
Just-in-time production	D4	Just-in-time production	D18
Total quality control	D5	Not creating waste	D19
The field of industrial culture	D6	Reduced setup time	D20
The company's partnership and relationship with suppliers	D7	Reduce waiting time	D21
Customer service quality	D8	Flexible system	D22
Communication with the customer	D9	Information	D23
Customer field	D10	The field of industry development	D24
Environmentally friendly activities	D11	Strategic planning problems	D25
Area of operation	D12	Political lobbying	D26
Upgrade operations	D13	Business transparency	D27
Quality	D14	market area	D28

Table 11: SSIM matrix

—	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	D15	D16	D17	D18	D19	D20	D21	D22	D23	D24	D25	D26	D27	D28
D1		V	V	V	V	A	X	X	X	X	V	A	A	A	A	V	V	V	V	V	V	V	X	X	X	O	A	A
D2			V	V	V	A	X	X	X	X	X	V	V	V	V	V	V	V	V	V	V	V	X	X	V	O	X	X
D3				X	X	V	V	V	V	V	X	V	V	V	V	V	V	V	V	V	V	V	X	X	A	X	X	X
D4					X	A	V	V	V	V	X	X	X	X	X	X	X	X	X	X	X	X	X	X	A	O	X	X
D5						V	A	A	A	A	X	V	V	V	V	V	V	V	V	V	V	V	V	A	A	O	X	X
D6							V	V	V	V	X	V	V	V	V	V	V	V	V	V	V	V	V	A	A	O	X	X
D7								X	X	X	V	X	X	X	X	X	X	X	X	X	X	X	X	V	V	O	X	X
D8									X	X	V	X	X	X	X	X	X	X	X	X	X	X	X	A	V	O	X	X
D9										X	V	X	X	X	X	X	X	X	X	X	X	X	X	V	V	O	X	X
D10											V	X	X	X	X	X	X	X	X	X	X	X	X	A	A	O	X	X
D11												V	V	V	V	V	V	V	V	V	V	V	V	A	A	O	X	X
D12													X	X	X	X	X	X	X	X	X	X	X	V	A	O	X	X
D13														X	X	X	X	X	X	X	X	X	X	A	A	O	X	X
D14															X	X	X	X	X	X	X	X	X	A	A	O	X	X
D15																X	X	X	X	X	X	X	X	V	V	O	X	X
D16																	X	X	X	X	X	X	X	A	V	O	X	X
D17																		X	X	X	X	X	X	A	A	O	X	X
D18																			X	X	X	X	X	A	A	O	X	X
D19																				X	X	X	X	A	A	O	X	X
D20																					X	X	X	A	A	O	X	X
D21																						X	X	A	A	O	X	X
D22																							X	A	A	O	X	X
D23																								X	A	O	X	X
D24																									A	X	X	X
D25																										V	X	X
D26																											V	V
D27																												V
D28																												

This matrix has the dimensions of the variables mentioned in the first row and column, respectively. Then the two-by-two relationships of the variables are specified by symbols [29]. The structural self-interaction matrix is formed based on the discussion and opinions of the group of experts [28]. The opinion of experts based on various management techniques, including brainstorming and nominal group technique, was used to determine the type of relationships [27]. The following symbols can be used to determine the kind of relationship:

Table 12: Conceptual relationships in forming the structural self-interaction matrix

Symbol	Symbol concept
V	i leads to j (row leading to column)
A	j leads to i (column leads to row)
X	There is a two-way relationship between i and j.
O	There is no valid relationship.

Achievement matrix

At this stage, the availability matrix can be formed by converting the relationship symbols of the SSIM matrix to zero and one based on the table below. The conversion of these symbols is shown in Table 13 [28].

Table 13: How to convert conceptual relationships into numbers

Symbol	Convert conceptual symbols to quantitative numbers.
V	The entry related to this pair in the access matrix is number 1, and its corresponding entry is number 0.
A	The entry related to this pair in the access matrix is number 0, and its corresponding entry is number 1.
X	The entry related to this pair in the access matrix is number 1, and the corresponding entry is number 1.
O	The entry related to this pair is placed in the access matrix of the number 0, and the entry of the ninth counterpart of that number is 0.

The power of influence (score 1 obtained from the row) and the strength of dependence (score 1 obtained from the column) should be determined to separate the obtained results from the opinion of research experts:

Table 14: Separation of driving and dependent forces

Index	Abbreviation	Power of influence	Power of dependence	Index	Abbreviation	Power of influence	Power of dependence
Cell production	D1	20	27	Material flow	D15	26	22
Control and ensure innovation	D2	25	26	Comprehensive preventive maintenance	D16	25	22
Lean production	D3	25	6	Reduce waiting time	D17	23	20
Just-in-time production	D4	24	9	Just-in-time production	D18	12	22
Comprehensive quality control	D5	21	13	Not creating waste	D19	23	19
The field of industrial culture	D6	24	27	Reduced setup time	D20	21	20
The company's partnership and relationship with suppliers	D7	26	27	Reduce waiting time	D21	21	23
Customer service quality	D8	24	26	Flexible system	D22	21	22
Communication with the customer	D9	26	25	Information	D23	9	20
Customer field	D10	24	24	The field of industry development	D24	13	24
Environmentally friendly activities	D11	24	22	Strategic planning problems	D25	23	20
Area of operation	D12	24	20	Political lobbying	D26	12	21
Upgrade operations	D13	23	20	Business transparency	D27	12	22
Quality	D14	22	20	market area	D28	15	19

4.3 Determining the relationships between the variables and forming the conical matrix

In this section, the output set, input set, and common elements should be identified first to determine the relationships between the variables. The level determination vote, the priority of the variables, the achievement set, and the prerequisite set are determined for each variable. The access set of each variable includes the variables that can be reached through this variable, and the prerequisite set consists of the variables. Then, the contributions of the set of availability and prerequisites of all factors are determined. If the access set is equal to the subscription set, that factor (factors) is considered the level. The previous levels should be separated from the matrix, and the process should be repeated to obtain other levels. After determining the levels again, the received matrix is arranged, and the new matrix is called a conical matrix.

4.3.1 Level division

The set of output and input for each variable is obtained using the final access matrix. The set of output and input for a variable is defined as follows. The output set for a particular dimension/component consists of that variable and others affected and reached through this variable. Each variable's input set includes that variable and other influencing variables. Finally, the common elements refer to the shared dimensions of the output set and the inputs of the variables in the ISM hierarchy as high-level variables. In other words, these variables are ineffective in creating other variables. The components of the next highest system level are removed in the mathematical calculations of the related table to find the constituent components. The operation related to determining the components of the next level is performed in the same way as the method of determining the components of the highest level. This operation is repeated until the constituent components of all system levels are identified.

5 MicMac method

The MicMac method for structural analysis is one of the mutual effect analysis methods, which uses tables of mutual relations, but it is not probabilistic, unlike other methods. Therefore, this method does not calculate the effective probability of one variable on another variable but gives the intensity and existence of the relationship between two variables. The power of the relationship between two variables in the collective thinking stage is based on the collective opinions of experts, and the analytical stages are developed for summarizing the results.

Experts first provide a list of critical variables in focus groups based on their experience and knowledge to carry out the above steps. Then, the houses of the $n \times n$ matrix of influential variables are scored depending on the number of critical variables. This matrix is called the matrix of direct effects, and each entry represents the effect of variable i on variable j, and its value can be 0, 1, 2, 3, or 4 (P), depending on the effect. In this method, 1 suggests weak results, 2 indicates moderate effects, and 3 indicates severe or intense effects. The number 4 suggests that, according to research experts, the impact of two variables on each other is possible, and there may or may not be influence or impression. Changing the four or P codes in the software analysis stage can also identify possible effects. Then, in the third step, it was possible to determine the degree of influence using one of the two direct or indirect methods.

In the direct method, the direct effect of variable K on other variables is the sum of all the values of row K of the matrix M. The influence of variable k on other variables is the sum of the values of column k. In this way, a ranking of δ_D^M and δ_I^M is obtained for each variable, and the importance of each variable is calculated by sorting these values. The following formulas show the mathematical algebra of this process:

$$D = \sum_{j=1}^{n} m_{ik} \qquad (K = 1, 2, ..., n) \tag{5.1}$$

Then, indirect effects can be identified with the help of the MicMac method. Indirect influence in this method means spreading the effect of one variable on another variable through an intermediate variable. In the literature on social network analysis, this topic is called the calculation of first-degree distances or the identification of paths between two variables or nodes. First-order intervals mean that the spread of the effect of one variable on another variable passes through only one mediating variable and no more. Second-degree indirect effects are moderate or weak effects. For this reason, the system approach can ignore the calculation of multi-order effects (for example, the indirect propagation of the effect of one variable through two or more mediating variables). However, other related information can be obtained in the network analysis literature by calculating multiple paths and different network analysis indicators.

Initialization: In the first step, the values calculated from the direct method are assigned to δ_D^M and δ_I^M, and A is the matrix of direct effects or M.

Iteration: A is multiplied by $A \times M$, and δ_I^A and δ_D^A is calculated. Then, δ_I^A is compared to with δ_I and δ_D^A with δ_D. If the values are identical, the process is ended. Otherwise, stage 2 is repeated by $\delta_I^A = \delta_I$ and $\delta_I^D = \delta_D$.

M^δ matrix resulting from the last iteration was set equal to Mr, which is called the indirect effect matrix. The indirect effect of K on other variables is obtained from the sum of all row values of the Mr matrix. In the same way, the indirect influence (dependency) of the K variable is calculated by summing all the values of the K column of the Mr matrix. In this way, two different criteria calculated by Mr and related to each variable are obtained.

$$\acute{I}_k = \sum_{j=1}^{n} \acute{m}_{ij}, \quad k = 1, 2, ..., n \tag{5.2}$$

$$\acute{D}_k = \sum_{j=1}^{n} \acute{m}_{ij}, \quad k = 1, 2, ..., n \tag{5.3}$$

It is possible to calculate the mutual effects of the influencing variables of a brake system by performing the above calculations. The relative position of the variables can be drawn concerning each other in the two-dimensional space by obtaining the number related to influence and impression (dependency). In the MicMac software, the horizontal axis indicates the degree of influence (dependency), and the vertical axis shows the degree of influence.

The variables were ranked by mutual influence analysis after determining the influential factors to enter their matrix. The mutual impact analysis was provided to the experts after compiling the standard questionnaire. Then, the average answers collected are prepared to enter MicMac software as follows:

First step:

First, world-class manufacturing in the West African market was extracted for future analysis by reviewing the research background and interviewing 28 key factors. Then, these factors were distributed among the experts in a questionnaire to determine the importance of each factor.

Table 15: List of critical factors extracted from expert questionnaires

No.	**Variable**
1	Cell production
2	Control and ensure innovation
3	Industrial culture
4	The company's partnership and relationship with suppliers
5	Customer service quality
6	Flexible system
7	Area of operation
8	Communication with the customer
9	Strategic planning problems
10	Comprehensive preventive maintenance
11	Political lobbying
12	Environmentally friendly activities
13	Reducing waiting time
14	Information
15	Reducing the time to reach the market
16	Industry development
17	Lack of creating waste
18	Business transparency
19	Market
20	Operation upgrade
21	Reducing setup time
22	Lean production
23	Just-in-time production
24	Quality
25	Material flow
26	Reducing waiting time
27	Customer
28	Comprehensive quality control

Second stage

The variables are entered into the interaction analysis matrix to rank the influential factors. The mutual impact analysis was provided to the experts by compiling a standard questionnaire. The average of the collected responses to enter the Mic Mac software is as follows.

Table 16: Matrix of mutual effects of critical factors

	1: Reduce st	2: Set cell p	3: Red-wor-ma	4: Lean-Pro	5: Jit	6: To-Qu-Ma	7: To-Pre-Ma	8: Ind-cu-fi	9: Mark-Fiel	10: pro-dev-fi	11: Cust-Field	12: Opeer-Fied	13: Cu-Ser-qua	14: Co-As-In	15: Poli-Lobb	16: Flex-Syst	17: St-Pl-Pro	18: Quali	19: Fl-Ma	20: Info	21: RE-Co-Sup	22: Up-opr	23: Non-Sc	24: Co-Re	25: Act-App-En	26: Red-Wi-Ti	27: Bu-tr	28: Re-ar-go
1: Reduce st	0	0	2	2	1	0	2	0	3	1	0	0	0	0	0	0	0	0	0	3	0	0	2	0	0	0	3	2
2: Set cell p	2	0	2	0	1	1	2	0	1	1	0	3	3	3	3	3	3	3	3	3	0	0	0	0	0	0	2	0
3: Red-wor-ma	3	2	0	3	2	0	3	0	1	0	0	0	0	0	0	0	0	0	0	3	0	0	2	1	0	1	2	0
4: Lean-Pro	2	3	2	0	0	4	3	0	1	0	0	0	0	0	0	0	0	0	0	3	0	0	2	0	0	0	0	3
5: Jit	2	0	0	0	0	0	3	0	2	0	1	0	0	0	0	0	0	0	0	2	0	2	2	1	0	O	2	2
6: To-Qu-Ma	2	1	0	1	0	0	1	0	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7: To-Pre-Ma	3	2	0	0	0	0	0	0	2	0	0	2	2	2	2	2	2	2	0	3	0	0	3	0	0	0	1	2
8: Ind-cu-fi	1	0	1	0	0	0	0	0	1	1	1	1	1	0	2	2	2	0	0	0	0	1	2	2	2	2	2	0
9: Mark-Fiel	0	0	0	0	0	0	0	0	0	2	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
10: pro-dev-fi	0	2	0	1	0	0	2	1	1	0	0	1	1	1	1	1	1	0	0	0	0	0	0	0	2	0	0	0
11: Cust-Field	1	0	2	2	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
12: Opeer-Fied	0	1	0	0	0	0	0	0	2	3	0	0	3	1	2	2	2	0	2	4	3	3	0	2	0	3	0	0
13: Cu-Ser-qua	0	1	0	0	0	0	1	4	2	3	0	2	0	2	2	2	2	1	0	2	3	3	2	3	3	3	1	0
14: Co-As-In	0	1	2	1	1	0	1	0	2	3	2	2	3	0	2	0	0	4	0	3	3	0	3	0	0	0	0	
15: Poli-Lobb	0	1	0	0	0	0	0	2	1	1	0	1	1	1	0	3	3	0	0	0	0	1	0	0	2	2	3	0
16: Flex-Syst	0	1	2	0	0	0	2	2	1	1	2	1	1	0	3	0	3	0	2	2	0	2	0	0	2	2	3	0
17: St-Pl-Pro	0	1	1	0	0	0	0	2	1	1	0	1	1	0	3	3	0	0	0	0	0	3	3	2	2	2	3	0
18: Quali	0	0	0	0	0	0	0	1	0	1	1	0	2	0	0	0	3	0	0	0	0	2	2	0	1	1	3	0
19: Fl-Ma	0	0	1	1	0	0	0	0	0	0	0	2	3	0	1	1	0	0	0	3	0	3	0	0	0	0	3	0
20: Info	0	0	1	0	0	0	3	0	2	0	0	4	3	4	0	0	0	0	1	0	3	3	0	1	0	1	0	0
21: RE-Co-Sup	0	0	0	0	0	0	0	0	0	0	1	2	2	2	0	0	2	0	3	0	0	3	2	2	0	2	0	2
22: Up-opr	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
23: Non-Sc	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	3	2	2
24: Co-Re	0	0	3	0	0	0	3	1	0	0	0	0	2	2	2	2	2	1	2	0	0	0	3	0	0	3	0	2
25: Act-App-En	0	0	3	2	0	0	2	0	0	2	0	0	0	0	0	0	0	0	0	0	0	3	3	3	0	3	3	1
26: Red-Wi-Ti	0	0	0	0	0	0	2	0	0	2	2	1	1	1	0	0	2	0	0	2	0	0	0	0	3	0	3	0
27: Bu-tr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	3	3	0	0	2	0	0	1
28: Re-ar-go	2	0	0	3	0	0	2	0	2	1	0	0	0	0	0	0	0	0	0	0	2	0	2	2	0	0	1	0

The third step (analyzing the outputs of the Mic Mac software)

The key factors of World-class manufacturing were calculated directly and indirectly after the questionnaire data were entered into the software. The effects of World-class manufacturing were shown directly and indirectly, and the score of each factor was established in the column and row of the matrix. Calculations and numbers based on mathematical equations are calculated by the software and are mainly used to compare factors relatively and do not give real value.

MicMac software gives a new form of the hierarchy of variables with each repetition of the relationship between the variables. The comparison between the number of I variable permutations and I-I repetitions shows the stability in percentage. For example, 100% means that the number of permutations necessary to categorize the repetition of variable I in the repetition of variable I-I is essential and stable in use. The results can be in the range of 100%.

The software ranks the factors directly and indirectly in two influencing and influencing modes (Figure 1).

In Figure 1, "Operation Improvement" and "Business Clarity" are in first and second place in direct influence and

Table 17: The direct impact matrix of World-class manufacturing factors in the West African market

No.	Variable	Total number of rows	Total number of columns
1	Reduce Set Time	6715	5854
2	Set cellular production	19072	6800
3	Reduction Workflow Materials	9712	8423
4	Lean Production	8820	5478
5	Just in Time	5909	2834
6	Total Quality Management	3287	345
7	Total Preventive Maintenance	13658	13318
8	Industrial culture fields	10217	4201
9	Market Fields	1442	10443
10	Product Development Field	8885	10326
11	Customer Field	5113	4533
12	Operation Field	13733	8695
13	Customer Service Quality	16739	12546
14	Control and Assurance of Innovation	14672	7313
15	Political lobbying	10598	10317
16	Flexibility System	13849	10317
17	Strategic Planning Problem	12032	11812
18	Quality	6337	3367
19	Flow Material	7655	7596
20	Information	8028	12314
21	Relationship between company and suppliers	9893	8813
22	Upgrade Operation	1132	17602
23	Non Scarpe	2487	12077
24	Customer Relationship	13699	9675
25	Activities appropriate to the environment	9211	9943
26	Reduce waiting time	8616	14668
27	Business transparency	4275	15621
28	Reducing the time of arrival of the goods to the Market	6571	7126
	Total	585	585

Table 18: Matrix of indirect effects of World-class manufacturing factors in the West African market

No.	Variable	Total number of rows	Total number of columns
1	Reduce Set Time	21	18
2	Set cellular production	39	16
3	Reduction Workflow Materials	23	22
4	Lean Production	22	16
5	Just in Time	19	7
6	Total Quality Management	9	4
7	Total Preventive Maintenance	30	34
8	Industrial culture fields	24	12
9	Market Fields	4	28
10	Product Development Field	15	24
11	Customer Field	10	11
12	Operation Field	32	22
13	Customer Service Quality	41	29
14	Control and Assurance of Innovation	34	18
15	Political lobbying	22	23
16	Flexibility System	32	23
17	Strategic Planning Problem	29	27
18	Quality	17	7
19	Flow Material	18	19
20	Information	24	31
21	Relationship between company and suppliers	23	17
22	Upgrade Operation	3	38
23	Non Scarpe	10	30
24	Customer Relationship	28	24
25	Activities appropriate to the environment	25	19
26	Reduce waiting time	19	30
27	Business transparency	13	37
28	Reducing the time of arrival of the goods to the Market	17	17
	Total	585	585

Table 19: The degree of compatibility of the direct effects of World-class manufacturing factors in the West African market

Iteration	Influence	Dependence
1	99%	93%
2	97%	102%

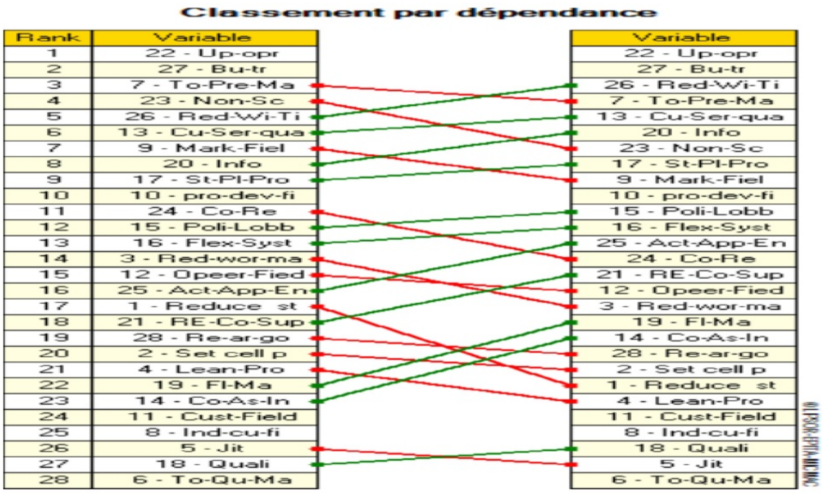

Figure 1: Classification of variables based on their direct and indirect influence

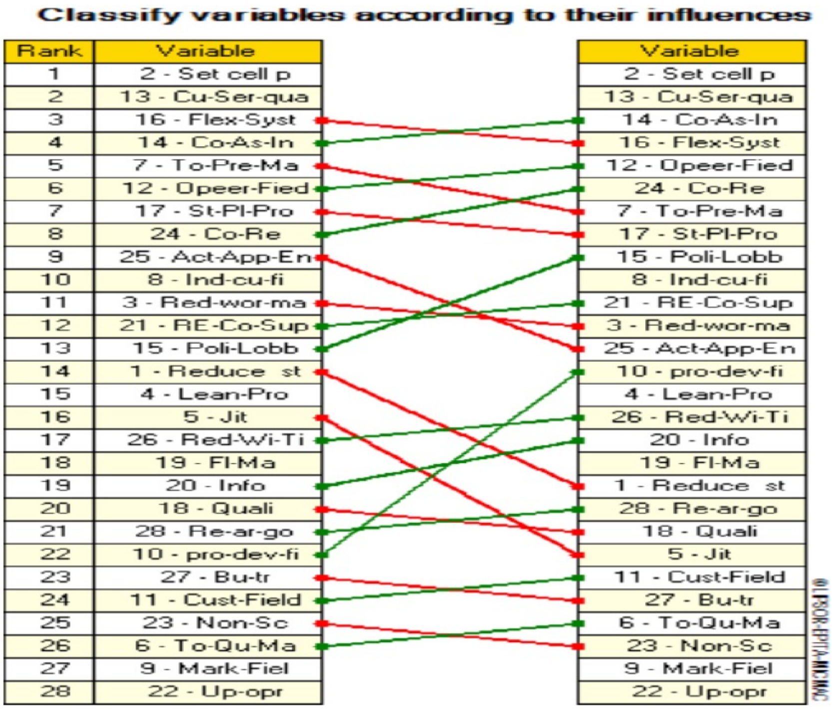

Figure 2: Classification of variables based on their direct and indirect influence

"Operation Improvement" is in the first place, and "Business Clarity" is in the second place in the indirect effect of this comparison is also evident for other variables. In Figure 2, "cell production" and "customer service quality" were ranked first and second in direct influence and ranked first and second in indirect effect, respectively. The software calculates the relationship and finally considers a numerical score for each factor based on the questionnaire, completed in the form of a matrix. In this case, the factor level with the most points, their influence, and their impression also change accordingly. Tables 20 and 21 rank the influential factors in world-class manufacturing based on direct and indirect effects.

Table 20: Impression and influence score of factors directly

Rank	Label	Direct influence	Label	Direct dependence	Label	Indirect influence	Label	Indirect dependence
1	Set-cell-p	666	Up-pr	649	Set-cell-p	755	Up-opr	697
2	Cu-ser-qua	649	Bu-tr	632	Cu-ser-qua	663	Bu-tr	619
3	Flex-Syst	547	To-er-ma	581	Co-Is-In	581	Red-Wi-Ti	581
4	Co-Is-In	529	non-sc	512	Flex-Syst	548	To-per-ma	527
5	To-per-ma	512	Red-Wi-Ti	512	opeer-fied	544	Cu-ser-qua	497
6	opeer-fied	495	Cu-er-qua	495	Co-Re	542	Info	487
7	St-pl-pro	495	Mark-fiel	478	To-per-ma	541	non-sc	478
8	Co-Re	478	Info	478	St-pl-pro	476	St-pl-pro	468
9	Act-App-En	427	St-pl-pro	461	Poil-lobb	419	Mark-fiel	413
10	Ind-cu-fi	410	pro-dev-fi	410	Ind-cu-fi	404	pro-dev-fi	409
11	Red-wor-ma	393	Co-Re	410	RE-Co-Sup	392	Poil-lobb	408
12	RE-Co-Sup	393	Poil-lobb	393	Red-wor-ma	384	Flex-Syst	408
13	Poil-lobb	376	Flex-Syst	393	Act-App-En	364	Act-App-En	394
14	Reduce-set	358	Red-wor-ma	376	pro-dev-fi	352	Co-Re	383
15	Lean-pro	324	opeer-fied	324	Lean-pro	349	RE-Co-Sup	349
16	Jit	324	Act-App-En	324	Red-Wi-Ti	341	opeer-fied	344
17	Red-Wi-Ti	324	Reduce-set	307	Info	318	Red-wor-ma	333
18	Fl-Ma	307	RE-Co-Sup	290	Fl-Ma	303	Fl-Ma	301
19	Info	307	Re-ar-go	290	Reduce-set	266	Co-Is-In	289
20	Quali	290	Set-cell-p	273	Re-ar-go	260	Re-ar-go	282
21	Re-ar-go	290	Lean-pro	273	Quali	251	Set-cell-p	269
22	pro-dev-fi	256	Fl-Ma	273	Jit	234	Reduce-set	231
23	Bu-tr	222	Co-Is-In	256	Cust-field	202	Lean-pro	217
24	Cust-field	170	Cust-field	188	Bu-tr	169	Cust-field	179
25	non-sc	170	Ind-cu-fi	153	To-qu-ma	130	Ind-cu-fi	166
26	To-qu-ma	153	Jit	119	non-sc	98	Quali	133
27	Mark-fiel	68	Quali	119	Mark-fiel	57	Jit	112
28	Up-opr	51	To-qu-ma	17	Up-opr	44	To-qu-ma	13

5.1 Interpreting the impression and influence of variables

The location of the variables in the output of MicMac software is based on the influence and impression of the variables. Based on the definition and interpretation of the variables in the MicMac chart, the position and status of the production factors in the world-class were examined based on the placement of the variables in the West African market (Figure 3).

The relationships between these factors were analyzed in the Mic Mac software after determining the status of each of the production factors in the world-class. The relationships between the effects of the factors are shown directly and indirectly in the following figures. The relationships of the factors affecting production in the world-class were shown at five levels:

- Very weak to very strong effects
- Weak to very strong effects
- Relatively strong to very strong effects
- Strong to very strong effects
- Very strong effects

The five levels of the effects in the form of a chart are due to the Mic Mac software, which is suitable for analysis and can be changed by the user. The obtained matrices can be displayed with the corresponding diagram of that requirement. The chart shows the direction of influence of each other load by "arrows," and the amount of influence is displayed numerically above the arrow. Finally, this software can extract key factors and rank them based on the

Table 21: Impression and influence score of factors indirectly

Rank	Label	Potentiel direct influences	Label	Potential direct dependence	Label	Potential indirect influence	Label	Potential direct dependence
1	Cu-ser-qua	679	Up-opr	630	Set-cell-p	745	Up-opr	680
2	Set-cell-p	646	Bu-tr	613	Cu-ser-qua	689	Bu-tr	583
3	Co-Is-In	563	To-per-ma	563	Co-Is-In	596	Red-Wi-Ti	560
4	opeer-fied	530	Info	514	opeer-fied	577	Info	513
5	Flex-Syst	530	non-sc	497	To-per-ma	536	To-per-ma	501
6	To-per-ma	497	Red-Wi-Ti	497	Flex-Syst	529	Cu-ser-qua	496
7	St-pl-pro	480	Cu-ser-qua	480	Co-Re	515	non-sc	450
8	Co-Re	464	Mark-fiel	464	Info	461	St-pl-pro	450
9	Act-App-En	414	St-pl-pro	447	St-pl-pro	445	Mark-field	409
10	Ind-cu-fi	398	pro-dev-fi	398	Poil-lobb	395	opeer-field	408
11	Info	398	Co-Re	398	Red-wor-ma	385	pro-dev-fi	405
12	Red-wor-ma	381	Poil-lobb	381	Ind-cu-fi	379	Poil-lobb	401
13	RE-Co-Sup	381	Flex-Syst	381	RE-Co-Sup	378	Flex-Syst	401
14	Lean-pro	364	Red-wor-ma	364	Lean-pro	366	Co-Re	380
15	Poil-lobb	364	opeer-fied	364	Act-App-En	343	Act-App-En	373
16	Reduce-set	348	Fl-Ma	315	Red-Wi-Ti	337	RE-Co-Sup	349
17	Jit	315	Act-App-En	315	pro-dev-fi	334	Co-Is-In	349
18	Red-Wi-Ti	315	Reduce-set	298	Fl-Ma	316	Fl-Ma	338
19	Fl-Ma	298	Co-Is-In	298	Reduce-set	272	Red-wor-ma	322
20	Quali	281	RE-Co-Sup	281	Re-ar-go	246	Re-ar-go	261
21	Re-ar-go	281	Re-ar-go	281	Quali	236	Set-cell-p	259
22	pro-dev-fi	248	Set-cell-p	265	Jit	233	Ind-cu-fi	221
23	Bu-tr	215	Lean-pro	265	Cust-field	192	Reduce-set	220
24	Cust-field	165	Ind-cu-fi	199	Bu-tr	172	Lean-pro	206
25	non-sc	165	Cust-field	182	To-qu-ma	123	Cust-field	176
26	To-qu-ma	149	Jit	116	non-sc	92	Quali	124
27	Mark-fiel	66	Quali	116	Mark-fiel	53	Jit	107
28	Up-opr	49	To-qu-ma	66	Up-opr	42	To-qu-ma	42

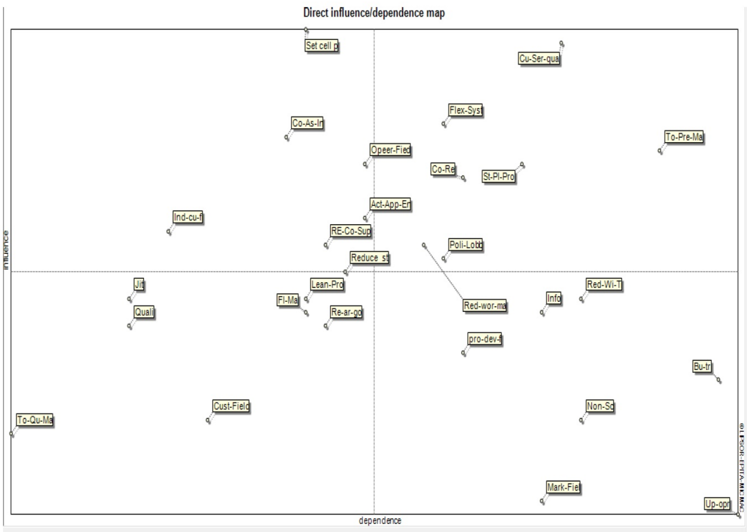

Figure 3: The state of critical factors in the output of the Mic Mac software

topology of drivers. The diagram related to the level of direct effects of factors and indirect factors from very weak to very strong relationships between variables in the output of MicMac software is presented below.

Table 22: Status of the variables based on the analysis in MikMak software

No.	Variable	Variable
1	variable	Cell production
2	variable	Control and ensure innovation
3	variable	Industrial culture
4	variable	The company's partnership and relationship with suppliers
5	variable	Customer service quality
6	variable	Flexible system
7	variable	Area of operation
8	variable	Communication with the customer
9	variable	Strategic planning problems
10	variable	Comprehensive preventive maintenance
11	variable	Political lobbying
12	variable	Environmentally friendly activities
13	variable	Reducing waiting time
14	variable	Information
15	variable	Reducing the time to reach the market
16	variable	Industry development
17	variable	Not creating waste
18	variable	Business transparency
19	variable	Market
20	variable	Upgrade operations
21	variable	Reducing setup time
22	Independent	Lean production
23	Independent	Just in time
24	Independent	Quality
25	Independent	Material flow
26	Independent	Reduce waiting time
27	Independent	Customer
28	Independent	Total quality control
29	Regulative	——
30	Secondary leverage	——

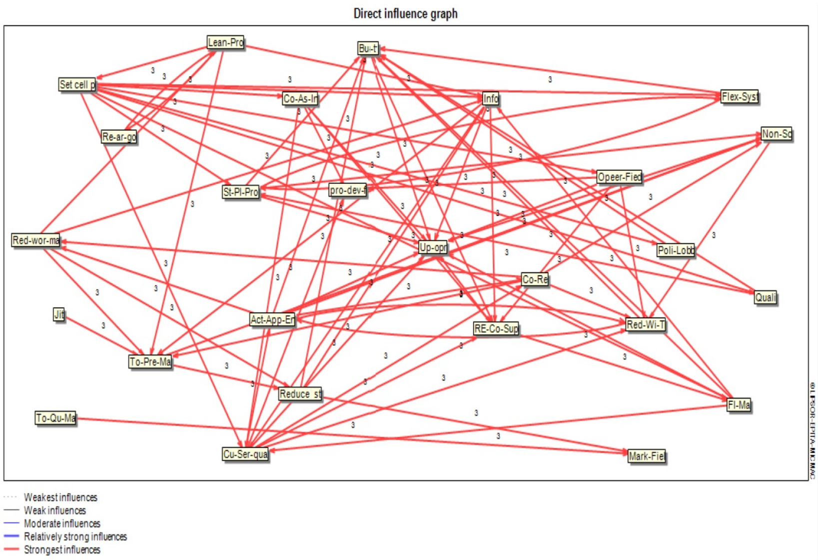

Figure 4: Direct effects of factors (very weak to very strong effects)

Ten key factors, including:

1. Cell production
2. Production without waste
3. Activities with an environmental attitude
4. Flexible system
5. Area of operation
6. No waste

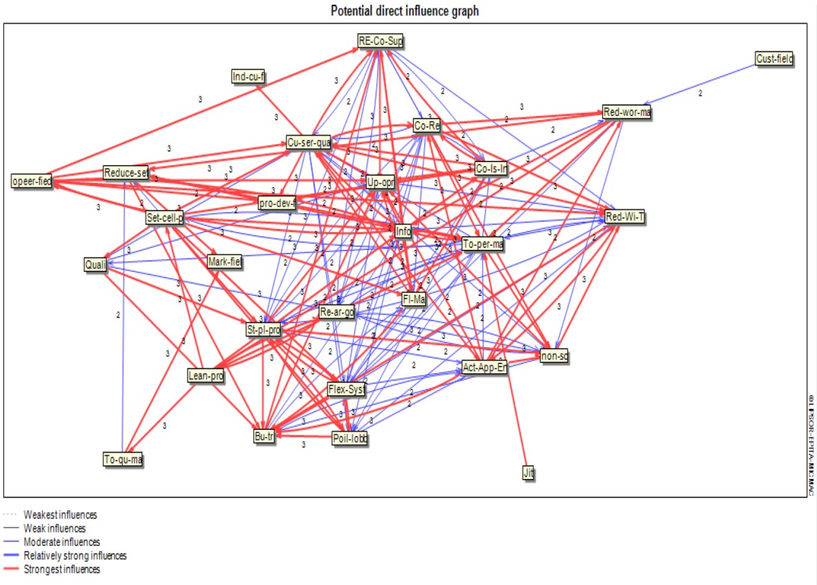

Figure 5: Indirect effects of factors (very weak to very strong effects)

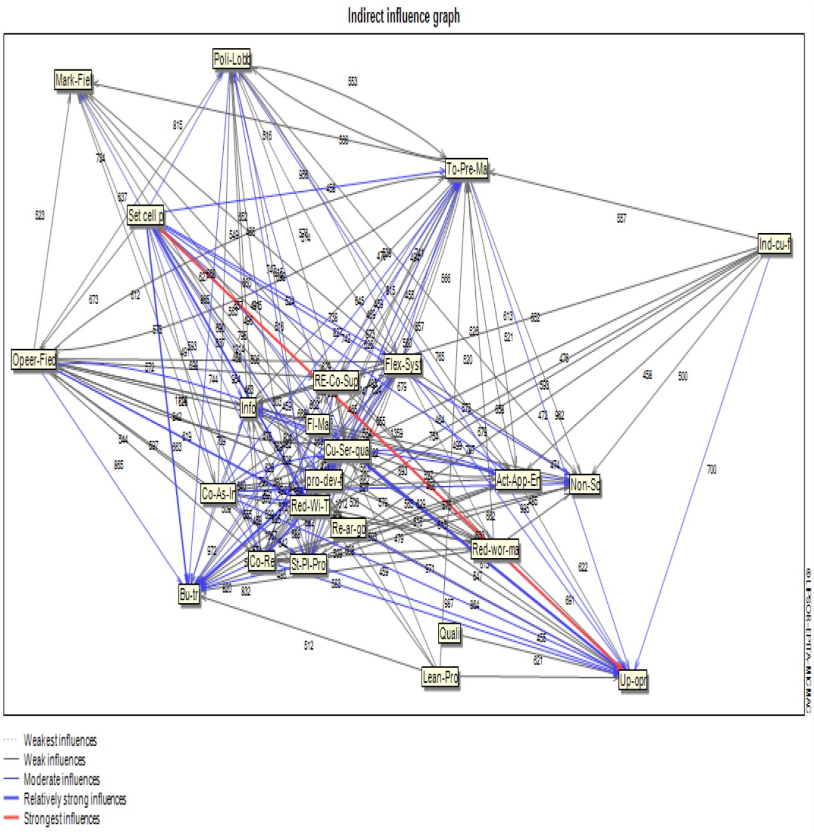

Figure 6: Indirect effects of factors (very weak to very strong effects)

7. Improvement of operations
8. Communication with customers
9. Business transparency
10. The company's partnership and relationship with suppliers

were identified by the Mic Mac software as key influencing factors in World-class manufacturing in the West African market.

6 Conclusion

Today, organizations and industries face international competition. The requirement for success in global competition is the production at world-class manufacturing. Industries need more integration at the level of their organization and partners at the level of the supply chain to achieve World-class manufacturing indicators, competitiveness, and quick response. Today's organizations are undergoing a revolutionary change from the industrial to the information age. Entering the world markets is one of the country's important issues that has occupied the minds of industry managers. The West African market is essential for Iran to provide an effective model for developing strategies and production techniques on a global scale. Therefore, world-class management in the 21st century and presence in the global business environment make producing world-class manufacturing inevitable. This research used the questionnaire method and interviews with World-class manufacturing experts in the West African market to collect information. The criteria weights were determined using Shannon's entropy after collecting the opinions of West African market experts through questionnaires. The main and secondary components and production indicators were identified on a global scale and in the form of a scoring checklist using the ISM model, first by examining the theoretical foundations of the research. Based on the empirical approach, it tried to confirm the indicators and components of the research through the Delphi method. Based on the structural-interpretive modeling method, important causes and influences on production strategies and techniques should be designed globally. This method examines the order and direction of the complex relationship between the elements of a system. In addition, the interaction analysis technique is also used for analysis. Questionnaires were completed only with World-class manufacturing specialists and experts in the West African market surrounded by this production method and were conducted using interviews. The mutual influence analysis matrix method was used to investigate the influence of factors on each other in World-class manufacturing in the West African market. For this purpose, first, one main component, seven sub-components, and 28 case indicators were provided to experts in the form of a scoring checklist. A checklist was prepared using the experts' score, and the criteria' mean, standard deviation, and agreement coefficient were confirmed or removed in the final model. The prioritization of the sub-components according to the agreement coefficient in Table 23 was obtained as follows:

Table 23:

Main component	Subcomponents	Coefficient of agreement	Prioritization
World-class manufacturing	Lean production	0.926	Fourth
	Human resources management	0.935	First
	Environmental practices	0.816	Seventh
	Cell production	0.894	Fifth
	Reduce costs	0.935	Second
	Flexibility	0.894	Sixth
	Marketing integration aspect	0.935	Third

In the second round of Delphi, all 28 leading indicators were finally approved by experts' opinions and ranked from 1 to 28. The index of non-creation of waste was ranked first from the sub-component of cost reduction with an agreement coefficient of 0.798. Reduction of start-up time from the sub-component of cost reduction was ranked as the second with a coefficient of agreement of 0.782, and lean production was ranked as the twenty-eighth rank from the sub-component of lean production with a coefficient of agreement of 0.611. Based on the results of the second round of Delphi, all the sub-indices were confirmed based on a mean > 5, a low standard deviation, and an agreement coefficient above 0.5. The approved model is designed based on two Delphi steps based on the opinions of elites as follows. In addition, the interaction affects analysis technique was used for analysis. The mutual influence analysis matrix method was used to investigate the influence of factors on each other in World-class manufacturing in the West African market, and the results obtained are as follows:

First, the seven main factors obtained from the world-class manufacturing matrix, including lean production, human resource management, environmental practices, cellular production, cost reduction, flexibility, and the marketing integration aspect, were provided to the experts for weighting through the designed questionnaire before conducting data analysis using the Shannon entropy. The results of the factor weights were obtained, and the data were entered into the software for final analysis using the Mic Mac software, and the following general results were obtained:

Table 22 shows the status of the variables in terms of influence, effectiveness, and independence from communication. Of the 28 primary factors, 12 are influential factors, 9 are influential factors, and 7 are independent factors.

Finally, ten of the main factors were determined as the key factors affecting world-class manufacturing in the West African market in the following order:

1) Cellular production 2) Waste-free production 3) Activities with an environmental attitude 4) Flexible system 5) Area of operation 6) No waste 7) Promotion of operations 8) Communication with customers 9) Business transparency 10) The company's partnership and relationship with suppliers.

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