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Examining the electronic supply chain management to achieve world-class home appliance industry

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Abstract

The present research aimed to design an electric supply chain management model to achieve a world-class home appliance industry. Firstly, the effective indicators in the electronics supply chain in the home appliance manufacturing industry were identified. After that, the identified effective indicators in the supply chain in this industry were prioritized. Then, the relationships between the indicators and their effectiveness and impression are determined. Ultimately, the intensity of the relationships between the variables is determined through the fuzzy dimetal method. Supply chain management brings about world-class development since the first condition for the realization of world-class manufacturing is defined by the flow of materials, information, association, and communication between the company and suppliers. As the home appliance industry is one of the country's most remunerative industries, the current study's significance is that it devotes wider attention to world-class supply chain management, which is rarely investigated. For instance, some of the important dimensions of these industries are (1) The very high volume of world trade: After energy carriers, the largest volume of international trade is for the equipment of this production sector. (2) The low level of pollution and energy consumption means that most of the sub-sectors of these industries are included in the scope of green industries. (3) The ability to make soft power that can turn Iran into a technology hub at the regional and global level in this industry. The findings indicate that it ought to review its production processes to diminish costs as much as conceivable and maximize customer service. The prioritization of the indicators shows that the electronic infrastructure is the top priority. The electronic infrastructure is the primary step in the electronicization of the supply chain. Technocentrism holds the second priority, so customer and supplier technocentrism success infrastructures should be developed. Electronic procurement is placed as the third priority. Electronic procurement has been issued as a new strategic approach to supply chain management to increase performance. Regarding the relationships obtained, it can be stated that electronic infrastructure has the highest intensity of influence on other factors.

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1 Introduction

Companies and organizations face many challenges in the turbulent era of changes and the current competitive environment. One of the challenges is the new manufacturing philosophies and technologies that supersede the old technologies. Another challenge is the customers who demand new products and services in a short time. To deal with these challenges, organizations must take quick measures for their survival [8]. The growth of information technology in diverse structures of society in today's world has caused an increase in the speed of manufacturing services as one of the important and fundamental factors and issues in customer retention and customer relationship management [1].

Research among Asian countries showed that Asian countries, namely China and India, are growing faster among the world economies. China, Japan, and India account for over 30% of the world's Gross domestic product (GDP). The share of Asian economies in the world's GDP exceeds that of the European Union and the United States. The GDP growth rate in China and India is more than 70% compared to the growth rate of GDP in the world. Thus, Asia has become a center of attraction for global trade. This indicates more capital inflow and capital formation in China and India, which has increased the scope of creating goods and services and narrowed the competition for other Asian countries [5].

This pervasive expansion throughout business has, in fact, fundamentally changed the way supply chains are designed, operated, and maintained. The companies of these countries understood the role that supply chain management plays in the success of their market. Many companies have realized that automation in supply chain management processes, such as transportation and warehouse fulfilment and management, can reduce costs and improve efficiency quickly [13]. Over the last few decades, improved coordination activities, business reimbursements, and operational flexibilities have led to increasing integration and greater synchronization in supply chains. With the establishment of e-commerce, the conditions for the emergence of electronic supply chains have become more favourable. However, some companies still use both traditional and virtual supply chain flows. To enumerate one of the reasons, the diversity and complexity of the supply chain and electronic commerce fields can be noted, referring to diverse and interconnected issues such as the formation of new and untested business models. Recent research [10] in the beverage products group found that e-SCM technology has many advantages, such as optimizing the registration of goods data, distribution of goods, and facilitating the audit of goods from upstream to downstream. The philosophy of this system remains in the lack of integrity of the traditional supply chain used in this industry under conditions of uncertainty.

Another study underscored that e-commerce sales in Indonesia will reach 219 trillion pounds in 2022, a growth of 13.5% compared to its previous years since 2017. Furthermore, this study stated that between 13% and 75% of the costs of traditional supply chains concern coordination and logistics issues, which have been reduced to much smaller amounts in recent years. In the field of the clothing industry, an investigation considered electronic supply chain management as the product of electronic transportation, electronic distribution, enterprise resource planning, and warehouse management systems. High-speed, low-cost communication and interactions between suppliers and customers are key factors in improving management, all realized under electronic supply chain management [9].

The first condition for realizing world-class manufacturing is the flow of materials, information, association, and communication between the company and suppliers. Strengthening the supply chain leads to the development of world-class manufacturing [3]. According to domestic researchers, the philosophy of world-class production and world-class organizations is associated with strategic planning challenges, and new methods and technologies are developing every day [6]. Iranian companies can succeed in the global market if they design their supply chains in an efficient and world-class method [7]. However, this will not be achieved unless this design is done in the social and economic background of e-commerce.

Due to the real and hidden conflicts in the opinions and findings of the researchers and the importance and role of industry in economic development and economic globalization, domestic industries must take measures to adapt to the existing global conditions. This important goal will not be achieved unless, due to the complexity in supply chain networks and for effective management of these complexities, companies always consider new technologies as a potential factor in improving their supply chain performance. Companies seek to gain competitive advantages through these technologies and information circulation, and improve their supply chain management performance. The research "Effects of Supply Chain Collaboration on Customer Loyalty for Home Electronics in Vietnam" unravelled that collaboration in the electronic supply chain will increase productivity and customer satisfaction. It also showed that competitive advantage can be increased through sharing information, synchronizing decision-making, and aligning incentives.

Another research entitled "The Impact of e-Supply Chain Management Systems on Procurement Operations and Cost Reduction in the Electronics Manufacturing Services Industry" demonstrated that companies' profits have increased due to electronic supply chains and have also improved internal communication [2]. The research has also

shown how social media and the Internet impact business models of electronic services by improving communication and operations in the overall supply chain. According to the research findings, electronic supply chains have many technical issues in supply chain data transfer.

Another study titled "Multi-product and multi-period closed-loop supply chain network design under take-back legislation" underscores the problem of designing a closed-loop supply chain for durable products, considering take-back legislation [4]. This study proposes a multi-product multi-period mixed integer (MIP) model assuming a 100% recovery target. In this study, sensitivity analysis is performed to obtain how some model parameters affect the decision made and to integrate the reverse supply chain and its structure when there is no regulatory constraint on the returns.

The home appliance manufacturing industry is not excluded from the current research. The significance of the present research concerns the wide importance of supply chain management of these industries in the world-class web space and e-commerce, which has not yet been the focus of academic research as it should be. For example, some of the important dimensions of these industries are included: (1) High volume of world trade that after energy carriers, the largest volume of international trade is for the equipment of this production sector. (2) The low level of pollution and energy consumption means that most of the sub-sectors of these industries are included in the scope of green industries. (3) The ability to make soft power that can turn Iran into a technology hub at the regional and global level in this industry. (4) Ability to empower other industries of the country in terms of the extensive relationship that these industries have with other sectors, such as transportation, communication and information technology, electricity industry, industrial equipment, and machinery, set forth.

Reviewing the related literature in the field of this industry shows that despite the global progress, Iran is not in a good competitive situation and is at a low level in terms of its ability to compete with other competing countries. Due to sanctions, foreign brands have been removed from the local market, and there is a good opportunity to invest in and regenerate domestic industries with quality and global standards; supply chain management can also be part of this strategy.

Most of the electronic supply chain management research has been formed at the tactical, operational, and logistical levels. In addition, there is a lack of a holistic view at the strategic level to realize a world-class structure in the supply chain context. Therefore, regarding the noted issues, problems, and strengths, the current research is intended to bridge this gap in the academic area and provide a solution based on scientific knowledge by designing an electronic supply chain management model to achieve world-class.

2 Materials and methods

This is developmental-applied research in terms of purpose since the researcher seeks to provide a model for developing electronic supply chain management to achieve world-class with an integrated interpretive and fuzzy Dimetal structural modelling approach. A mixed method was used in the present research, including the historical method (data collection) and the survey method (questionnaire distribution). Also, the articles, books, and reliable sources available to the researcher are used for the theoretical foundations of the research.

The research analysis method includes six steps, which are:

1. Identifying indicators related to the problem
2. Forming the structural self-interaction matrix (SSIM): In this step, the variables (indicators) are checked together two by two, and the respondent determines the relationships.
3. Creating the initial access matrix
4. Creating the final access matrix
5. Level segmentation: The access matrix is categorized into different levels in this step. The input and output sets for each variable are obtained using the final access matrices.
6. Drawing the model: According to the levels of the variables and the final matrix, the ISM model is drawn.

Prioritizing factors affecting electronic supply chain management to achieve world-class: To categorize the influencing factors, the fuzzy Dimetal method will be used.

The research statistical population and sample are the experts in the home appliance manufacturing industry, and professors and researchers in world-class production. The sampling method is purposeful.

Then, the categories calculated from the research literature are validated. A total of 47 indicators have been identified for designing the electronic supply chain model to achieve world-class performance in the home appliance

industry. The Delphi method has been used to screen and identify the final indicators. Delphi analysis is dependent on the viewpoints of nine experts. Although experts use their mental skills and abilities to make comparisons, it should be noted that the traditional process of quantifying people's points of view cannot fully reflect the human cognitive style. To put it simply, the use of fuzzy sets is more compatible with human linguistic and sometimes ambiguous explanations. Thus, it is better to deal with long-term forecasting and real-world decision-making with fuzzy sets (fuzzy numbers). The current study uses triangular fuzzy numbers to fuzzify the experts' points of view.

The viewpoints of nine experts about each index should be aggregated. Various methods have been proposed to aggregate the opinions of n respondents. As a matter of fact, these aggregation methods are experimental methods presented by different researchers. For example, a conventional method for aggregating a set of triangular fuzzy numbers is considered to be the minimum l, the geometric mean m, and the maximum u.

$$F_{AGR} = \left(\min\{l\}, \prod\{m\}, \max\{u\}\right) \tag{2.1}$$

$$F_{AGR} = \left(\min\{l\}, \left\{\frac{\sum m}{n}\right\}, \max\{u\}\right) \tag{2.2}$$

$$F_{AVE} = \left(\left\{\frac{\sum l}{n}\right\}, \left\{\frac{\sum m}{n}\right\}, \left\{\frac{\sum u}{n}\right\}\right) \tag{2.3}$$

Each triangular fuzzy number obtained by aggregating the viewpoints of the experts for the J^{th} index is shown below:

$$\begin{aligned} \tau_j &= (L_j, M_j, U_j) \\ L_j &= \min(X_{ij}) \\ M_j &= \sqrt[n]{\prod_{i=1}^{n} X_{ij}} \\ U_j &= \max(X_{ij}) \end{aligned}$$

The index i refers to the expert, so that:

X_{ij}: Evaluation value of the i^{th} expert from the j^{th} criterion

L_j: Minimum evaluation value for the j^{th} criterion

M_j: Geometric mean of the experts' evaluation value of the performance of the j^{th} criterion

U_j: Maximum evaluation value for the j^{th} criterion

In the current study, the fuzzy weighted average method (Relation (2.3)) is used.

3 Defuzzification of values

It is usually possible to sum up the average of triangular and trapezoidal fuzzy numbers by a definite value, the corresponding best average. This operation is called defuzzification. There are several methods for defuzzification. In most cases, the following simple method is used for defuzzification:

$$x_m^1 = \frac{L + M + U}{3} \tag{3.1}$$

Another simple method for defuzzifying the mean of triangular fuzzy numbers is as follows:

$$\begin{aligned} F_{ave} &= (L, M, U) \\ x_m^1 = \frac{L + M + U}{3}; \quad x_m^2 &= \frac{L + 2M + U}{4}; \quad x_m^3 = \frac{L + 4M + U}{6} \\ \text{Crisp number} = Z* &= \max(x_{\max}^1, x_{\max}^2, x_{\max}^3). \end{aligned} \tag{3.2}$$

The values of $x_{\max}^i$ do not differ much and are always close to the number M. M is the average of aggregating possible values of m from different triangular fuzzy numbers. However, the deterministic value of the largest calculated $x_{\max}^i$ is taken into account.

In the present study, the Center of Area (CoA) defuzzification method is used:

$$DF_{ij} = \frac{[(u_{ij} - l_{ij}) + (m_{ij} - l_{ij})]}{3} + l_{ij}. \tag{3.3}$$

The fuzzy average and the defuzzified output of the values related to the indices are shown in the table. The defuzzified value greater than 0.7 is acceptable, and any index with a score less than 0.7 is rejected.

4 Round two of the fuzzy Delphi method

Fuzzy Delphi analysis continued for the remaining indices in the second round. At this stage, 39 indices were evaluated based on the experts' points of view.

5 Round three of the fuzzy Delphi method

Although no new indices were removed or added in the second round, one more round was continued to ensure more certainty. In this stage, 41 indices were evaluated based on the viewpoints of the experts.

6 The end of the rounds of the Delphi method

In the second and third rounds, no question was removed, which indicates the end of the Delphi rounds. Generally, one approach to the end of Delphi is to compare the average scores of two consecutive rounds. The survey process stops if the difference between the two stages is smaller than the very low threshold (0.2).

7 Results and discussion

The statistical sample includes nine experimental and theoretical experts. The qualitative part of the present study is based on the viewpoints of experts in the field of study. Regarding gender, eight people are male, and one person is female. Regarding age, two people are less than 35, three people are between 35 and 45, and four people are over 45. In terms of education, seven of the experts have a master's degree, and two have Ph.D. Finally, five people have 10 to 20 years of work experience, and four have more than 20 years of work experience. In addition, four people were sales managers, three were vice presidents of commerce, and two were managers.

Table 1: Demographic characteristics of the experts

Demographic characteristics		**Frequency**	**Percent**
gender	Male	8	88.8%
	Female	1	11.2%
age	Less than 35 years	2	22.3%
	35 to 45 years	3	33.3%
	45 years and more	4	44.4%
education	Masters	7	78%
	Ph.D.	2	22%
Work experience	10 to 20 years	5	55%
	Over 20 years old	4	45%
Organizational background	Sales Manager	4	44%
	Vice President of Commerce	3	33%
	The manager	2	23%

The six steps of qualitative analysis of the theme are explained below.

Step one: Become familiar with the data

For the researcher to become familiar with the depth and scope of the content of the data, it is necessary to imvmerse himself in the data to some extent. Immersion in data typically involves "repeating rereading the data" and reading the data actively (i.e., looking for meanings and patterns). At this step, it is attempted to identify the indicators related to the research objective from the interview texts.

Step two: Generate initial codes

The second stage begins when the researcher has read and become familiar with the data. This step involves creating initial codes from the data. Codes introduce a feature of the data that the analyst finds interesting. Coded data are different from the units of analysis.

Step three: Search for themes

This step includes grouping different codes in the form of potential categories and sorting all coded data summaries in the form of specific categories. As a matter of fact, the researcher begins the analysis of the codes and considers how different codes can be combined to create a general category. At this step, the indicators extracted from the interview texts are categorized through screening, removing duplicate codes, and integrating synonymous codes.

Step 4: Review themes

The fourth step begins when the researcher creates and reviews a set of themes. This step includes two stages: reviewing and purifying themes. The first stage includes a review at the level of coded summaries.

In the second stage, the themes' validity is considered in relation to the data set. One can move on to the next step if the category map works well. However, if the map does not fit the data set well, the researcher should go back and continue coding until a satisfactory category map is created. At the end of this stage, the researcher should know the different categories, how they fit together, and the whole story they tell about the data. The indicators extracted from the interview texts are screened again after initial categorization, and additional indicators or those without lexical value are removed to design the research model.

Step 5: Define themes

The fifth step begins when there is a satisfactory category map. In this step, the researcher defines and revises the themes presented for analysis. Then, the included data are analyzed. Through defining and revising, the nature of what a category discusses is specified, and in effect, the aspect of data each category contains is determined.

Step 6: Write-up

The sixth step begins when the researcher has a set of final themes. This step includes the final analysis and report writing. Therefore, the present research has identified 60 themes by examining and categorizing the descriptive codes obtained from the interview texts.

8 Discussion and conclusion

In the qualitative part, effective indicators were identified in the electronics supply chain in the home appliance manufacturing industry to achieve world-class. Fifteen indicators were identified, including electronic infrastructure, technocentrism, electronic procurement, electronic supplier management (ESM), information flow, supply chain velocity, ability to resist threats, relying on internal capacity, cost, waiting time, flexibility, sales service, after-sales service, meeting customer expectations, and world-class quality (ISO 60335 home appliances). Organizations and industries face global competition. For organizations to produce their products at a world-class level and, in effect, become successful in global competition, it is necessary to be more integrated at the level of the organization's partners as well as the supply chain. Global supply chain companies never lose customer needs. They have effectively 1) identified key customers, 2) evaluated critical customer success factors, and 3) begun to establish processes in suppliers to deliver quality and accountability at the lowest possible cost. Reducing costs and increasing quality are highly important in the supply chain, moving towards globalization and customer satisfaction. The continuous increase in competitiveness compels any company to review its production processes to reduce costs as much as possible and maximize customer service. The pivotal keywords are "zero waste" and "zero damage".

There are many different methods necessary to achieve these objectives. The world-class practice provides a strategic vision of the relationship between the productive resources of the companies with each other and the environment. The best companies use customer-centric actions at the company level. These services include cost reduction for the customer, quality, time, and flexibility. There are sales services, after-sales services, and meeting customer expectations at the next level. Companies that seek to achieve world-class production must adopt a continuous improvement strategy in all dimensions of the organization to be the best in their industry. The requirement for continuous improvement is complete knowledge of customers, suppliers, performance of competitors, and their strengths and weaknesses.

Suppose the companies have relationships with other partners in the supply chain. In that case, they can have the opportunity to better understand customer needs, respond faster to market dynamics, deliver on time, lower costs, and earn more profit. A sustainable supply chain and using internal and external resources are needed to

accelerate responding to customers [12]. World-class production is the instant response to customers in a competitive environment, which requires proper and integrated communication with customers and suppliers [11]. Reviewing the literature on developing the electronic supply chain management model for the home appliance industry to achieve world-class showed that the research conducted using a grounded theory approach was not systematic.

That is, the causal factors, background conditions, intervening factors, strategies, and consequences have not been mentioned in this regard. On the other hand, this issue is not considered from all aspects, such as social, economic, political, cultural, physical, and set forth. While all the aspects above have been addressed in the current research, for each aspect, the concerned indicators and components have been identified. This shows the comprehensiveness of the model. However, generally, the research conducted in this field has somewhat confirmed the indicators and components obtained in the present research.

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