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# Presenting a model based on artificial intelligence in the reverse supply chain of the home appliance industry in Tehran province by fuzzy genetic algorithm

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**Abstract**

The purpose of this study is to identify the indicators affecting the improvement of the reverse supply chain in the home appliance industry in Tehran province. Preliminary indicators were obtained using theme analysis method and during in-depth and semi-structured interviews with 14 experts of the reverse supply chain in the home appliance industry in Tehran province. The final indicators of the research were identified using fuzzy Delphi method and A model for optimizing indicators in the form of objective function and constraints is presented. To achieve this goal, the researcher has used qualitative and quantitative methods and research has mixed research in terms of type. In order to analyze the data, in the first place, with the help of ten experts, the final indicators were introduced and then, using the opinions of 36 people related to the issue of supply chain, the indicators were prioritized. The results of this study showed that the managerial dimension, including senior management's special attention to some links in the chain and consumer feedback to the manufacturer in the chain, is a key factor in accepting new change and entering the issue of reverse supply chain. Knowledge dimension, including continuous improvement in the field of learning and education, etc., after management indicators and in the same initial stages, can be a determining criterion for improving the reverse supply chain in the industry. Finally, a model was designed using a model that shows the output of the status of indicators and using genetic algorithm (along with model testing in Gomz program) in MATLAB software, analysis was performed and the results were introduced by introducing optimal values and An improved model was presented.



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## Introduction

Lack of resources in nature and increasing environmental concerns have made the issue of reverse . closed-loop supply chain a lot of attention in the last two decades, which can include many changes in different parts of the chain. To manage these changes, implementing flexibility options can be a good approach. Flexibility while managing change helps to improve supply chain responsiveness and customer satisfaction.

A supply chain can be thought of as an integrated process in which a group of several organizations such as suppliers, manufacturers, distributors and retailers work together to turn raw materials into finished products. It reaches the customers, while the flow of materials from the source to the end users in a supply chain through the so-called leading chain. Given the recent interest of researchers in supply chains, the debate lies in the recovery or after-sales service of products, which are usually referred to as reverse chain activities through processes such as repair, reconstruction, separation and recycling. ( Filip, Duta, 2015).

In recent years, the importance of reverse supply chain management has increased with increasing environmental concerns and reduced costs. In the past, producers did not feel much responsibility for the effects of their products on the environment and how the customer used them after distribution, but today, high production volumes will have irreversible effects on the environment, making both producers and consumers willing. Pay the costs related to the collection of wastes and wastes from their products, or have the least wastes and wastes from their products, or reduce their wastes to a minimum (silva et al, 2017) On the other hand, the existence of a reverse supply chain for a company will make the customer feel more secure and satisfied. Because the customer knows that the company feels responsible for it after selling the product and considers the possible problems caused by parts and components of the product solved. The product of defective parts will be delivered to the customer again with replaced healthy parts. If more attention is paid to this issue, it can be understood that this will also cause high profit for the manufacturer, because in the absence of this possibility, the company must pay the total cost of the reference product. To bear. The existence of these benefits as well as the new government laws have caused the producers to pay more attention to this issue. In a reverse supply chain, chain components can be very uncertain and difficult to manage. This proves the importance of making the supply chain flexible. (Zhou, Cao, Cao, & Meng, 2015).

The issue of reverse logistics (reverse supply chain) is a topic that is discussed in every industry that deals with after-sales service, and especially considering that organizations have entered a field full of competition, such issues and improving the way back. Defective products are a priority for organizations in the industry; That is, organizations that aim to attract customer attention and improve product delivery without the least waste and harm to the customer.

Optimization is the same as satisfying constraints. If a set of constraints is assumed together, the goal is to satisfy all constraints and minimize the objective function if it is a cost and maximize it if it is a profit . Many vendors, such as the Watson supply chain, offer logistics and supply chain software that uses artificial intelligence. Pricing used to be done by individuals, but now this software does it by considering different conditions. Management disorders are one of the important tasks that artificial intelligence can manage in the best possible way.

Bankruptcy, employee strikes, etc. have the potential to cause serious damage to the logistics business. According to experts, by predicting these disorders by artificial intelligence and through possible programs created by humans, corrective actions are taken automatically when needed and there is no need to worry (rostami, 2015)

According to the background of this research and the studies that were done in this field and as it was mentioned in the stages of their analysis, all these researches were reviewed and evaluated based on a static and fixed model, while meta-innovative issues and data type The collected data, if it is dynamic, can give us a more accurate answer, and also another summary in this research can be the unreality and non-applicability of research that based its work only on the scientific and ideal state. , Is. Therefore, in this study, we tried to cover this gap by using tangible variables.

Over the past two decades, many companies and industries, including the electronics industry in developed countries, have begun to look at product return policies with fast response response times, customer service, and a greater emphasis on return management, reshaping, and Re-stockpiling of expired goods. New government laws and green laws related to the disposal and disposal of electronic waste and other hazardous materials also force managers and senior logistics experts in supply chain processes to take a closer look at the reverse logistics process [6]. Also, the home appliance industry in Tehran province is no exception to this rule. The reverse supply chain is actually the use of return products, typically at the end of a product life, for repair or referral. The reverse supply chain has created a great opportunity for companies to control costs and material consumption, which should be seen as a positive context. Effective management of reverse supply chain operations increases the profitability of recycling processes, the discussion of reverse chains is more important for manufacturers and the development of new and appropriate tools and methods to support decision-making in applied management is necessary (min, 2010)

With more than six decades of history, the Iranian home appliance industry is on the verge of entering a new era and understanding a new reality. This industry, like most domestic industries, has been adapted from developed countries, but due to the lack of readiness to accept it, the lack of a proper industrial culture in the country and the lack of appropriate structures, unfortunately has not developed in accordance with the historical status and civilization of Iran. A review of this industry shows that despite global developments, Iran is stagnant in the situation of the fifties and is at a low level in terms of technology, technical knowledge and trained manpower (Duta , Zamfirescu & Filip, 2014)

One of the most important steps in managing and improving a situation is to evaluate and identify the factors that are influential and involved in a process; Because by identifying the effective local factors, the optimized model based on the specified indicators; In contrast to other models, it is clear and as a result, the decision maker can plan about the amount of available resources to optimize that situation. In other words, by identifying these factors and subsequently the optimized model, the managers of these firms will gain the necessary preparation to achieve the optimal model by allocating sufficient budget and time. Therefore, the purpose of the optimization phase, in the first stage, is to identify native indicators based on real timing or real constraints. With these interpretations and by stating the dimensions and aspects under consideration and explanations regarding the weakness in

the reverse supply chain of the home appliance industry, this plan is done in order to answer the questions that can be expressed in the form of the following questions?

• What is the required model or program required to optimize the reverse supply chain in the home appliance industry in Tehran province and what is its status?

## Material and methods

The aim of this study is to present a reverse supply chain optimization model through the use of advanced artificial intelligence based algorithms. To achieve this goal, the researcher has used a qualitative and quantitative method. Therefore, research is a mixed research in terms of type. Mixed research methods are performed using a combination of closed and open data sets and quantitative and qualitative variables and using a scientific method (Khalili Shourini, 2010). Therefore, first qualitative research and then quantitative research has been designed through the analysis of findings. The present study is a combination-exploratory research.

The present study has used three techniques to achieve the main goal of the research. In the first stage, by studying the theoretical literature and using the method of qualitative content analysis and open questionnaire, the effective components on reverse supply chain optimization were identified. In the second stage, by reviewing the literature and related theoretical foundations, reverse supply chain optimization was identified through application and based on that, the initial conceptual model of the research was presented. Then, using fuzzy Delphi technique, the conceptual model of the research (factors affecting the optimization of the reverse supply chain) was questioned and the factors that were not mentioned in the literature, but in the opinion of experts on the optimization of the reverse supply chain, were questioned. located. Finally, after analyzing the findings of fuzzy Delphi technique and inductive content analysis, the final conceptual model of the research was presented. In the third stage, based on the data and information obtained from the previous two stages, which are considered as a kind of real components, it was compiled in the form of meta-heuristic algorithms and evaluated and analyzed.

The present study is applied-developmental based on the purpose, because it seeks to investigate the factors affecting the optimization of reverse supply chain and its analysis using real indicators and meta-algorithm. In this study, the results of the analyzed model are a model for chain optimization. The present study also develops a new conceptual model in topics related to reverse supply chain optimization and introduces new factors affecting reverse supply chain optimization and the dimensions of reverse supply chain optimization based on the characteristics of the reverse supply chain. The industry has localized. Therefore, it can be considered a development. In terms of nature, the present study is among the descriptive-survey researches. Descriptive research includes a set of methods that aim to describe the conditions or phenomena under study. Among the types of descriptive research, the present study is correlational and field research.

Targeted sampling is used in this approach; This means that units are selected instead of random selection according to their characteristics to the phenomenon under study. In qualitative research, the researcher starts collecting data without any theory or hypothesis from the imagined PAP, but there is probably some information related to the research problem that determines the direction of the research. In the present study, a number of members related to the supply chain of the home appliance industry in Tehran province are selected as

a sample answering the interview questions. Among the issues that determine the direction of this research and the interview questions are the literature related to the reverse supply chain and the factors affecting its improvement (such as supply chain components, etc.).
In the second part, which has a small approach, hyperbaric methods are used. The meta-heuristic methods were based on artificial intelligence and in this research it is supposed that some restrictions are applied on it and it is a model based on real scheduling.
The home appliance industry in Tehran province, which operates under the title of home appliance industry in the country, constitutes the statistical population of the research.
The sample of the quality section is selected as an expert and specialized. In this method, the researcher refers to a group of experts and thinkers to obtain opinions and opinions on the research topic, both basic and applied. (Al-Ibrahim,2011) Therefore, first, the home appliance industry in Tehran province, considering the level of activity And the ease of access of the researcher is selected. Then, in order to collect qualitative and quantitative data, a number of experts related to the field of reverse supply chain in that factory are selected as a sample. It should be noted that this sample is selected randomly or selectively if necessary and will include as many different levels of the organization as possible..

Results
The findings of the article are analyzed in three sections and each question is answered separately:
Significance coefficients of indicators
The findings of this section are to answer the above question, ie what are the important indicators in improving the reverse supply chain?

**Table1:** ranking of reverse supply chain

| Criterion | Criterion symbol | criterion weight | Criterion rank | under the criteria | symbol | Weight in criteria | Rank in criteria | Final weight | Final ranking |
|---|---|---|---|---|---|---|---|---|---|
| Management indicators | A | 0.1757 | 1 | Senior management pays special attention to some links in the chain, | A1 | 0.1114 | 1 | 0.01957 | 26 |
| | | | | Management support, | A2 | 0.0997 | 6 | 0.01752 | 39 |
| | | | | Consumer feedback to the manufacturer in the chain, | A3 | 0.1109 | 2 | 0.01949 | 29 |
| | | | | Upgrading and improving the mental image of customers of the company, | A4 | 0.1036 | 4 | 0.01820 | 36 |
| | | | | Quick response to customer needs, | A5 | 0.0964 | 7 | 0.01694 | 40 |
| | | | | Outsourcing activities to contractors, | A6 | 0.0931 | 8 | 0.01636 | 42 |
| | | | | Win-win look at suppliers, | A7 | 0.0897 | 9 | 0.01576 | 43 |
| | | | | The need for a systemic approach in improving the reverse supply chain, | A8 | 0.0880 | 10 | 0.01546 | 44 |
| | | | | Reduce the distance between the links in the chain, | A9 | 0.1067 | 3 | 0.01875 | 33 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Relationship with suppliers, | A10 | 0.1004 | 5 | 0.01764 | 38 |
| Indicators related to the structure of the organization | B | 0.1650 | 4 | Coordination of the business unit with some links in the chain, | B1 | 0.1489 | 2 | 0.02457 | 7 |
| | | | | Supply chain integrity, | B2 | 0.2019 | 1 | 0.03331 | 3 |
| | | | | Emphasis on chain agility, | B3 | 0.1287 | 4 | 0.02124 | 15 |
| | | | | Availability of collection centers, | B4 | 0.1119 | 7 | 0.01846 | 35 |
| | | | | Culture of teamwork and system, | B5 | 0.1326 | 3 | 0.02188 | 12 |
| | | | | The relationship of the order unit with the whole chain, | B6 | 0.1284 | 5 | 0.02119 | 16 |
| | | | | Number of retail options, | B7 | 0.1130 | 6 | 0.01865 | 34 |
| | | | | Organization size | B8 | 0.1094 | 8 | 0.01805 | 37 |
| Indicators related to organizational knowledge | C | 0.1736 | 2 | Intellectual and technical excellence of employees, | C1 | 0.1337 | 3 | 0.02321 | 9 |
| | | | | Continuous improvement, | C2 | 0.2084 | 1 | 0.03618 | 1 |
| | | | | Smart warehouse system, | C3 | 0.1161 | 6 | 0.02015 | 22 |
| | | | | Purchasing Engineering, | C4 | 0.1114 | 8 | 0.01934 | 31 |
| | | | | Demand forecast, | C5 | 0.1176 | 5 | 0.02042 | 21 |
| | | | | Providing specialized manpower, | C6 | 0.1214 | 4 | 0.02108 | 17 |
| | | | | The degree of flexibility, | C7 | 0.1125 | 7 | 0.01953 | 28 |
| | | | | Training for important device operators. | C8 | 0.1682 | 2 | 0.02920 | 5 |
| Indicators related to underlying factors | D | 0.1696 | 3 | Compliance with the return method, | D1 | 0.0910 | 5 | 0.01543 | 45 |
| | | | | Availability of reverse logistics companies, | D2 | 0.0813 | 7 | 0.01379 | 47 |
| | | | | Supply chain needs assessment, | D3 | 0.0998 | 4 | 0.01693 | 41 |
| | | | | Infrastructure readiness to implement reverse supply chain, | D4 | 0.0862 | 6 | 0.01462 | 46 |
| | | | | Competitive pressure (competitors' pressure), | D5 | 0.1831 | 1 | 0.03105 | 4 |
| | | | | The positive impact of new technologies on intra-organizational communication, | D6 | 0.1146 | 3 | 0.01944 | 30 |
| | | | | Return without customer intervention, | D7 | 0.0740 | 8 | 0.01255 | 48 |
| | | | | Reduce resistance to change in staff, | D8 | 0.0684 | 10 | 0.01160 | 50 |
| | | | | Convenient transportation, | D9 | 0.1294 | 2 | 0.02195 | 11 |
| | | | | Lack of some basic facilities due to economic and political issues. | D10 | 0.0728 | 9 | 0.01235 | 49 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Indicators related to technology and technology | E | 0.1646 | 5 | Access to the latest technology in the world, | E1 | 0.1357 | 2 | 0.02234 | 10 |
| | | | | Strong information platform and information technology, | E2 | 0.2126 | 1 | 0.03499 | 2 |
| | | | | Flexibility in accepting alternative goods from suppliers, | E3 | 0.1260 | 4 | 0.02074 | 18 |
| | | | | Form of supply of essential parts, | E4 | 0.1189 | 7 | 0.01957 | 26 |
| | | | | Equipment maintenance, | E5 | 0.1258 | 5 | 0.02071 | 19 |
| | | | | Analysis of all failures, | E6 | 0.1294 | 3 | 0.02130 | 14 |
| | | | | Quality criteria in production, | E7 | 0.1204 | 6 | 0.01982 | 25 |
| | | | | Commodity standardization. | E8 | 0.1159 | 8 | 0.01908 | 32 |
| Indicators related to financial and physical resources | F | 0.1509 | 6 | Recycling cost, | F1 | 0.1620 | 2 | 0.02445 | 8 |
| | | | | The Impact of Financial Constraints on Update and Innovation, | F2 | 0.1424 | 3 | 0.02149 | 13 |
| | | | | financial costs, | F3 | 0.1322 | 6 | 0.01995 | 24 |
| | | | | The role of financial constraints in not compensating for mistakes, | F4 | 0.1363 | 4 | 0.02057 | 20 |
| | | | | Not paying attention to the price, | F5 | 0.1296 | 7 | 0.01956 | 27 |
| | | | | Physical asset management, | F6 | 0.1642 | 1 | 0.02478 | 6 |
| | | | | Strategic costs. | F7 | 0.1330 | 5 | 0.02007 | 23 |

As mentioned in the table above, the management dimension is introduced as the most important criterion that shows that the results of this study confirm the findings of other studies that have been in the field of implementing a new discussion in the organization, which confirms and supports senior management. The basics for accepting the new change have been introduced as a key factor and it is further stated that the knowledge dimension can be introduced after the management dimension as a determining criterion for implementing the reverse supply chain. Therefore, after ranking the dimensions, it can be concluded that if in this organization we first facilitate the approval of management and then the knowledge components and finally the underlying components, we can see the correct implementation of the reverse supply chain in this industry. In the sub-components, the components of continuous improvement, strong information platform and information technology and supply chain integration are the determining sub-components that managers and policymakers by creating and establishing it facilitate the reverse supply chain to improve performance. .

The mathematical model derived from the answer to the first question is as follows:

$$Max\ (z) = 0.1757A + 0.1650B + 0.1736C + 0.1696D + 0.1646E + 0.1509F$$
$$Constraint\ (A) = 0.01957a1 + 0.01752a2 + 0.01949a3 + 0.01820a4 + 0.01694a5 + 0.01636a6 + 0.01576a7 + 0.01546a8 + 0.01875a9 + 0.01764a10$$

$$Constraint\ (B) = 0.02457b1 + 0.03331b2 + 0.02124b3 + 0.01846b4 + 0.02188b5 + 0.02119b6 + 0.01865b7 + 0.01805b8$$
$$Constraint\ (C) = 0.02321c1 + 0.03618c2 + 0.02015c3 + 0.01934c4 + 0.02042c5 + 0.02108c6 + 0.01953c7 + 0.02920c8$$
$$Constraint\ (D) = 0.01543d1 + 0.01379d2 + 0.01693d3 + 0.01462d4 + 0.03105d5 + 0.01944d6 + 0.01255d7 + 0.01160d8 + 0.02195d9 + 0.01235d10$$
$$Constraint\ (E) = 0.02234e1 + 0.03499e2 + 0.02074e3 + 0.01957e4 + 0.02071e5 + 0.02130e6 + 0.01982e7 + 0.01908e8$$
$$Constraint\ (F) = 0.02445f1 + 0.02149f2 + 0.01995f3 + 0.02057f4 + 0.01956f5 + 0.02478f6 + 0.02007f7$$
All criteria ≥ 0

4-2- Results of genetic algorithm analysis:
This section was analyzed in two parts; In the first part, the research model was tested first to check whether the model can be tested or not.

4-2-1- Model test:
The model is modeled as follows:

eq1 =E= objective function
(۵)eq1.. - 0.1757*x(1) - 0.165*x(2) - 0.1736*x(3) - 0.1696*x(4) - 0.1646*x
x(6) + z =E= 0 ; (LHS = 0)*۰/۱۵۰۹ -
eq2 =E= constraints ----
(۱'۴)eq2(1).. 0.01957*y(1,1) + 0.01752*y(1,2) + 0.01949*y(1,3) + 0.0182*y
(۱'۸)y(1,5) + 0.01636*y(1,6) + 0.01576*y(1,7) + 0.01546*y*۰/۰۱۶۹۴ +
; y(1,9) + 0.01764*y(1,10) =E= 0.1757*۰/۰۱۸۷۵ +
(**** LHS = 0, INFES = 0.1757)
(۲'۴)eq2(2).. 0.02457*y(2,1) + 0.033331*y(2,2) + 0.02124*y(2,3) + 0.01846*y
=y(2,5) + 0.02119*y(2,6) + 0.01865*y(2,7) + 0.01805*y(2,8) =E*۰/۰۲۱۸۸ +
(**** LHS = 0, INFES = 0.165) ; ۰/۱۶۵
(۳'۴)eq2(3).. 0.02321*y(3,1) + 0.03618*y(3,2) + 0.02015*y(3,3) + 0.01934*y
=y(3,5) + 0.02108*y(3,6) + 0.01953*y(3,7) + 0.0292*y(3,8) =E*۰/۰۲۰۴۲ +
(**** LHS = 0, INFES = 0.1736) ; ۰/۱۷۳۶
REMAINING 3 ENTRIES SKIPPED

The results obtained for the decision variables will be as follows:
VARIABLE x.L objective----
ALL 0.000
VARIABLE y.L cpnstraints1----
۸/۹۷۸ ۱
۶/۷۱۶ ۲
۷/۴۸۰ ۳
۱۰/۹۹۲ ۴
۷/۳۶۸ ۵
۶/۱۷۲ ۶
VARIABLE z.L = 0.000 objective function-----

**Discussion**
According to the obtained results as well as the values on the right for each constraint, it can be said that the search for an exact solution for the model is inefficient and as a result, an acceptable optimal answer has not been obtained. In general, the reason for this can be considered the equality of the constraints used in the model, which will significantly reduce the response space. In

such cases, two approaches will be applicable and implementable. In the first step, it is possible to solve the model and analyze the obtained answers by using meta-heuristic algorithms whose basis is based on searching for the answer space to reach the optimal local or final solution. This issue is considered in the continuation of this research. In the second approach, and if the use of meta-heuristic algorithms does not lead to acceptable results, it is necessary to consider changes in the model and assumptions, which is also applicable if the results obtained in the second phase. And not interpretation, is on the agenda. Using the genetic algorithm, the following problem has been coded in MATLAB software and the results will be discussed later.

Analysis of genetic algorithm results
In this section, we try to examine the results of the genetic algorithm based on each dimension and in each dimension based on each variable and understand the importance of each variable. For this purpose, in the comparison we make, the final weight values will also be important so that we can measure the importance of the variables as a whole.
Management indicators:
The table below shows the variables in the management dimension and the final weight and the value obtained from the genetic algorithm for each variable and finally the total value of the effect of each variable on the objective function.

**Table2:** Criterion rank

| Criterion rank | Weight in criteria | Final weight | Optimal values | The total amount of the effect |
|---|---|---|---|---|
| Senior management pays special attention to some links in the chain, | 0.1114 | 0.01957 | 0.3603 | 0.0070 |
| Management support, | 0.0997 | 0.01752 | 0.1958 | 0.0034 |
| Consumer feedback to the manufacturer in the chain, | 0.1109 | 0.01949 | 1.5627 | 0.0304 |
| Upgrading and improving the mental image of customers of the company, | 0.1036 | 0.01820 | 0.1265 | 0.0023 |
| Quick response to customer needs, | 0.0964 | 0.01694 | 1.3039 | 0.0220 |
| Outsourcing activities to contractors, | 0.0931 | 0.01636 | 1.9051 | 0.0311 |
| Win-win look at suppliers, | 0.0897 | 0.01576 | 1.3446 | 0.0212 |
| The need for a systemic approach in improving the reverse supply chain, | 0.0880 | 0.01546 | 0.7349 | 0.0113 |
| Reduce the distance between the links in the chain, | 0.1067 | 0.01875 | 1.3564 | 0.0254 |
| Relationship with suppliers, | 0.1004 | 0.01764 | 1.2029 | 0.0212 |

According to the table above, outsourcing activities to contractors in the management dimension is of the highest importance in the optimization of the result, and also in this dimension, the promotion and improvement of customers' mental image of the company is of the least importance.

The general diagram of the management dimension against the optimization function is drawn as follows, which shows a linear and positive relationship between the improvement of the management dimension and the objective function.

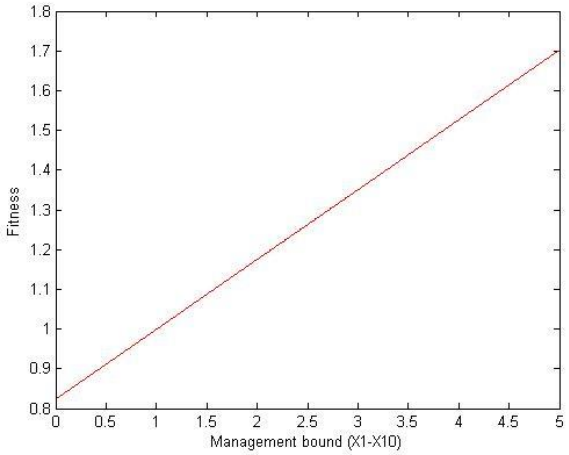


**Figure 1:** optimization function of Management indicators

## Conclusions

Indicators related to the structure of the organization:

The table below shows the variables in the structural dimension and the final weight and the value obtained from the genetic algorithm for each variable and finally the total value of the effect of each variable on the objective function

.

**Table 3:** ranking of Indicators related to the structure of the organization

| Criterion rank | Weight in criteria | Final weight | Optimal values | The total amount of the effect |
|---|---|---|---|---|
| Coordination of the business unit with some links in the chain, | 0.1489 | 0.02457 | 1.5878 | 0.0390 |
| Supply chain integrity, | 0.2019 | 0.03331 | 1.3621 | 0.0453 |
| Emphasis on chain agility, | 0.1287 | 0.02124 | 0.2896 | 0.0061 |
| Availability of collection centers, | 0.1119 | 0.01846 | 1.6492 | 0.0304 |
| Culture of teamwork and system, | 0.1326 | 0.02188 | 0.0154 | 0.0003 |
| The relationship of the order unit with the whole chain, | 0.1284 | 0.02119 | 0.4317 | 0.0091 |
| Number of retail options, | 0.1130 | 0.01865 | 1.5907 | 0.0296 |
| Organization size | 0.1094 | 0.01805 | 0.2698 | 0.0048 |

According to the table above, supply chain integration in the structural dimension is of the highest importance in the optimality of the function and also in this dimension of team and system work culture is of the least importance. The general diagram of the structural dimension against the optimization function is drawn as follows, which shows a linear and positive relationship between the improvement of the structural dimension and the objective function.

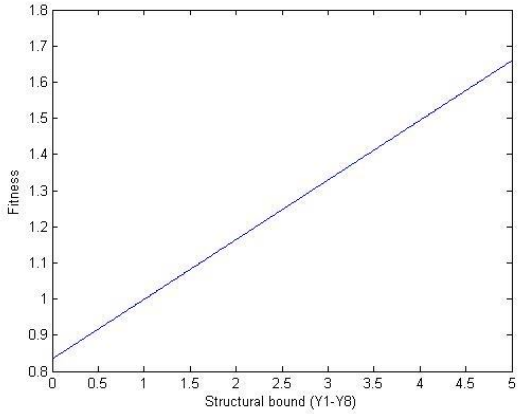


**Figure 2:** optimization function of structural dimension

Indicators related to organizational knowledge:

The table below shows the variables in the final knowledge and weight dimension and the value obtained from the genetic algorithm for each variable and finally the total value of the effect of each variable on the objective function.

**Table 4:** Indicators related to organizational knowledge

| Criterion rank | Weight in criteria | Final weight | Optimal values | The total amount of the effect |
|---|---|---|---|---|
| Intellectual and technical excellence of employees, | 0.1337 | 0.02321 | 0.1870 | 0.0043 |
| Continuous improvement, | 0.2084 | 0.03618 | 0.1034 | 0.0037 |
| Smart warehouse system, | 0.1161 | 0.02015 | 1.1508 | 0.0201 |
| Purchasing Engineering, | 0.1114 | 0.01934 | 0.0077 | 0.00001 |
| Demand forecast, | 0.1176 | 0.02042 | 1.8609 | 0.0376 |
| Providing specialized manpower, | 0.1214 | 0.02108 | 1.3767 | 0.0290 |
| The degree of flexibility, | 0.1125 | 0.01953 | 1.8176 | 0.0354 |
| Training for important device operators. | 0.1682 | 0.02920 | 1.3583 | 0.0396 |

According to the table above, training the operators of important devices in the knowledge dimension is of the highest importance in the optimization of the function and also in the same dimension of purchasing engineering is of the least importance. The general diagram of knowledge dimension versus optimality function is drawn as follows, which shows a linear and positive relationship between knowledge dimension improvement and goal function.

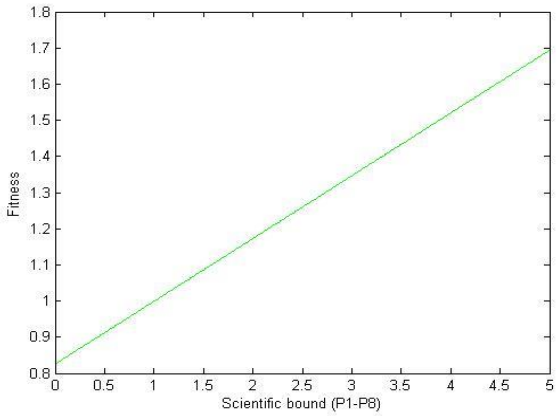


**Figure 3:** optimization function of organizational knowledge

Indicators related to underlying factors:
The table below shows the variables in the background dimension and the final weight and the value obtained from the genetic algorithm for each variable and finally the total value of the effect of each variable on the objective function
.

**Table 5:** Indicators related to underlying factors

| Criterion rank | Weight in criteria | Final weight | Optimal values | The total amount of the effect |
|---|---|---|---|---|
| Compliance with the return method, | 0.0910 | 0.01543 | 1.4088 | 0.0217 |
| Availability of reverse logistics companies, | 0.0813 | 0.01379 | 0.3510 | 0.0048 |
| Supply chain needs assessment, | 0.0998 | 0.01693 | 0.3335 | 0.0056 |
| Infrastructure readiness to implement reverse supply chain, | 0.0862 | 0.01462 | 1.8624 | 0.0272 |
| Competitive pressure (competitors' pressure), | 0.1831 | 0.03105 | 1.0819 | 0.0335 |
| The positive impact of new technologies on intra-organizational communication, | 0.1146 | 0.01944 | 0.0728 | 0.0014 |
| Return without customer intervention, | 0.0740 | 0.01255 | 0.9003 | 0.0113 |
| Reduce resistance to change in staff, | 0.0684 | 0.01160 | 1.4717 | 0.0170 |
| Convenient transportation, | 0.1294 | 0.02195 | 1.4474 | 0.0317 |
| Lack of some basic facilities due to economic and political issues. | 0.0728 | 0.01235 | 1.2146 | 0.0150 |

According to the table above, competitive pressure (competitors' pressure) in the field dimension has the highest importance in function optimization and also in this dimension the positive impact of new technologies on intra-organizational communication is the least important. The general diagram of the background dimension against the optimization function is drawn as follows, which shows a linear and positive relationship between

the improvement of the background dimension and the objective function.

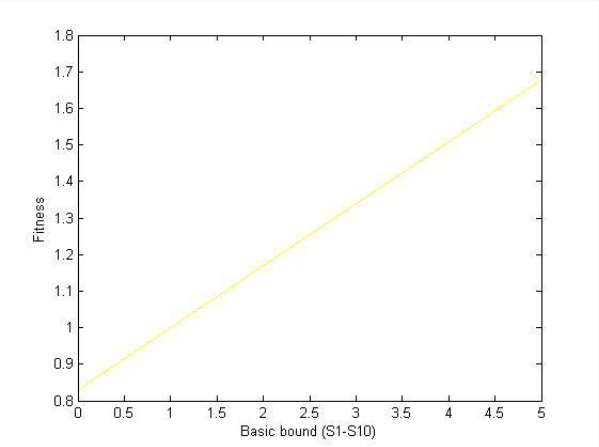


**Figure 4:** optimization function of underlying factors

Indicators related to technical and technological factors:
The table below shows the variables in the technical and technological dimension and the final weight and the value obtained from the genetic algorithm for each variable and finally the total value of the effect of each variable on the objective function.

**Table 6:** Indicators related to technical and technological factors

| Criterion rank | Weight in criteria | Final weight | Optimal values | The total amount of the effect |
|---|---|---|---|---|
| Access to the latest technology in the world, | 0.1357 | 0.02234 | 1.4048 | 0.0313 |
| Strong information platform and information technology, | 0.2126 | 0.03499 | 0.4404 | 0.0154 |
| Flexibility in accepting alternative goods from suppliers, | 0.1260 | 0.02074 | 0.3822 | 0.0079 |
| Form of supply of essential parts, | 0.1189 | 0.01957 | 0.8059 | 0.0157 |
| Equipment maintenance, | 0.1258 | 0.02071 | 1.4763 | 0.0305 |
| Analysis of all failures, | 0.1294 | 0.02130 | 1.3331 | 0.0283 |
| Quality criteria in production, | 0.1204 | 0.01982 | 1.4142 | 0.0280 |
| Commodity standardization. | 0.1159 | 0.01908 | 0.3726 | 0.0071 |

According to the table above, competitive pressure (competitors' pressure) in the technical and technological dimension is the highest importance in the optimization of the function and also in this dimension the positive impact of new technologies on intra-organizational communication is the least important. The general diagram of the technical and technological dimension against the optimization function is drawn as follows, which shows a linear and positive relationship between the improvement of the technical and

technological dimension and the objective function.

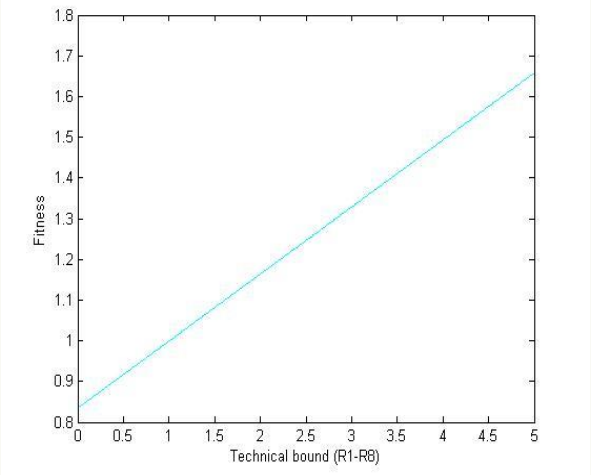


**Figure 5:** optimization function of technological factors

Indicators related to financial and physical resources:

The table below shows the variables in the physical and financial dimensions and the final weight and the value obtained from the genetic algorithm for each variable and finally the total value of the effect of each variable on the objective function.

**Table 7:** Indicators related to financial and physical resources

| Criterion rank | Weight in criteria | Final weight | Optimal values | The total amount of the effect |
|---|---|---|---|---|
| Recycling cost, | 0.1620 | 0.02445 | 0.0290 | 0.0007 |
| The Impact of Financial Constraints on Update and Innovation, | 0.1424 | 0.02149 | 1.5222 | 0.0327 |
| financial costs, | 0.1322 | 0.01995 | 0.0017 | 0.00003 |
| The role of financial constraints in not compensating for mistakes, | 0.1363 | 0.02057 | 1.8321 | 0.0376 |
| Not paying attention to the price, | 0.1296 | 0.01956 | 1.2506 | 0.0244 |
| Physical asset management, | 0.1642 | 0.02478 | 1.0493 | 0.0260 |
| Strategic costs | 0.1330 | 0.02007 | 1.4596 | 0.0293 |

According to the table above, the role of financial constraints in not compensating for physical and financial errors is of the highest importance in the optimality of the function and also in this dimension, financial costs are of the least importance. The general diagram of the physical and financial dimension against the optimization function is drawn as follows, which shows a linear and positive relationship between the improvement of the physical and financial dimension and the objective function.

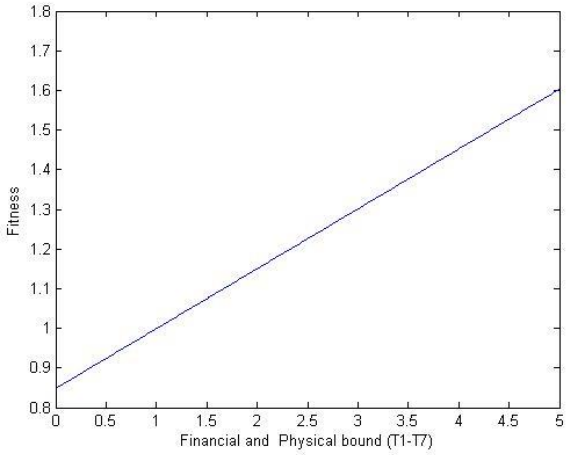


**Figure 6:** optimization function of financial and physical resources

Examine the whole objective function
The optimal value of the whole objective function is also reported from this algorithm 0.9993. In the previous section, we examined the importance of each criterion at the level of each dimension, and in this section we try to identify the degree of importance of each dimension in the whole objective function, the results of which are summarized in the table below.

**Table 8:** Examine the whole objective function

| dimension | Criterion weghit | Total effect of later criteria | The overall impact of each dimension |
|---|---|---|---|
| Management indicators | 0.1757 | 0.1753 | 0.0308 |
| Indicators related to the structure of the organization | 0.1650 | 0.1646 | 0.0271 |
| Indicators related to organizational knowledge | 0.1736 | 0.1697 | 0.0294 |
| Indicators related to technology and technology | 0.1696 | 0.1692 | 0.0286 |
| Indicators related to underlying factors | 0.1646 | 0.1642 | 0.0269 |
| Indicators related to financial and physical resources | 0.1509 | 0.1507 | 0.0227 |

According to the table above, it is inferred that the same importance that the standard weight has given to the studied dimensions, the algorithm has considered the degree of importance of each dimension as the standard weight, so that the most important dimension is the managerial dimension and then the knowledge dimension. The lower ranks are in the underlying dimension, structural dimension, technical and technological dimension, and physical and financial dimension, respectively. The general diagram of the optimization problem considering the dimensions is as follows:

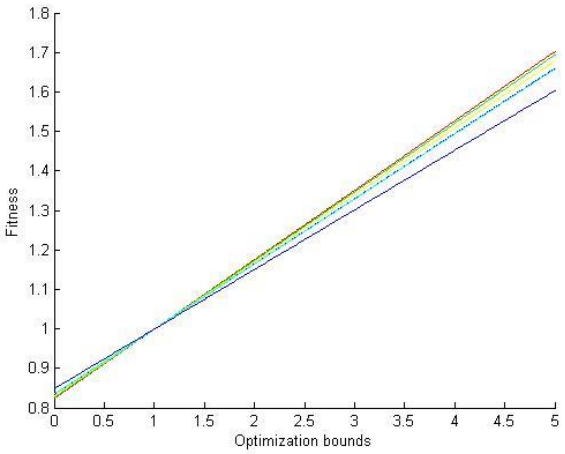


**Figure 7:** general diagram of the optimization problem

Which is a function of infinite optimal space and unique optimal answer. A point with a width of 0.9993 is where all the constraints intersect and create a corner point that is also the optimal solution to the problem.

## Conclusion:

The existence of uncertainties and the increase of influential factors in the supply chain and the complexity of production systems have made it difficult for managers to achieve their goals. Each organization faces different levels of risks and hazards depending on the type of activity and the sensitivity of its assets. Due to the limitations of organizations in accessing sufficient resources, providing solutions and allocating the necessary resources to deal with risk factors in the reverse supply chain will be done based on priorities. Reverse supply chain is an issue that can overcome these risks and create and revive a flexible and competitive organization. The home appliance industry, considering the competitive market and the large number of companies active in this field, considers the reverse supply chain necessary for itself, and according to the definitions and concepts expressed in previous chapters for industries such as the home appliance industry, the most essential topic is implementation. Making is something that can keep the company in this area.

In this study, first, in an interview with industry experts, indicators were introduced to identify the factors affecting the reverse supply chain, and then using the fuzzy Delphi method (and adding the indicators referred to by experts). Not, but it was mentioned in the articles done), effective indicators were introduced, which finally, due to the overlap of some indicators, the number of final indicators were introduced and identified. Then, based on the classification in the form of dimensions, they were determined and presented. Then, the weight of each index was obtained by methods related to the logic of the dissertation, and finally in the last section, by obtaining the optimal values of the improved model

This study provides some management tips for organizations. Organizations need to be constantly looking for new approaches to solving supply chain issues. Implementing exploitative strategies that emphasize existing capabilities is easier than looking for new opportunities. Organizations that seek out new opportunities in the supply chain are more likely to be able to cope quickly with difficult situations.

Organizations are interested in focusing on stronger capabilities in existing supply chain processes, and the importance of search. Ignore the current reverse supply chain technology. To reap the benefits of a reverse supply chain, including reducing the harm of reverse supply chain disruptions and increasing corporate performance, organizations must continually look for creative ways to respond to new market needs and adapt quickly to changing business environments. Finally, reverse supply chain strategies must be implemented at the right time. From a complementary perspective, organizations need to mobilize their business processes and resources to keep pace with different combinations of strategies.

According to the research and background study, it can be stated that the reverse supply chain, considering that after-sales service and maintenance and the name and reputation of the company as a vital factor in creating a competitive advantage in different periods and in different periods has been considered. Various factors and criteria are the basis of this evaluation.

Practical suggestions that can be presented in this section include the following:

1. In the management dimension, it is suggested that by holding symposiums and coordination between supply chain managers and senior management, an appropriate strategy to achieve an improved reverse supply chain and its consolidation and continuous improvement be formulated and extended to all parts of the home appliance industry To be notified. It should be mentioned that this process should be implemented first at the level of each factory in the industry and then at the level of national management. The development of the mentioned strategy should include long-term goal setting, provision and allocation of financial and human resources, setting priorities, determining performance evaluation indicators, and so on.

2.Due to the prevailing culture of large organizations such as home appliance industry factories, it is recommended to inform all departments and individuals about the short-term conclusion, strategies and operational strategies to achieve an improved reverse supply chain by senior management. During periodic meetings, management chain support for the process of activities should be announced to individuals.

3. It is suggested that a committee called the reverse supply chain be formed from the middle managers of each of the elements of the supply chain in this industry. The members of this committee can reach operational solutions (technical and partial) to establish and consolidate a reverse supply chain by holding regular meetings.

4.It is suggested that a training course be held to teach the concept of reverse supply chain and especially to reverse supply chain improvement at different levels of the home appliance industry and to ensure the transfer of this knowledge to the members of the organization.

5.It is suggested that an appropriate incentive system, such as a quality award, be defined and implemented to discuss the reverse supply chain. In this way, periodically and according to the evaluation criteria set in the reverse supply chain improvement strategies, the top departments and individuals in the field of achieving an improved reverse supply chain are encouraged.

6. It is suggested that in each part of the supply chain, a part called innovation management be added to the structure and one of the people working in the same sector be selected as the custodian of innovation. This approach seems necessary to balance the exploration component with the exploitation component in different parts of the supply chain. It should be noted

that those in charge of the innovation department can also be members of the reverse supply chain committee.
7.It is suggested that a comprehensive information and communication system called the integrated supply chain system of this industry be set up and information such as the current performance status of different parts of the supply chain be provided to all employees. This system can also create an environment for presentation. To help creative ideas and solutions of department staff.
8. It is suggested that with the help of technicians, professors and experts, the concept of improvement in the reverse supply chain and its related components be included in the job descriptions of all managers and employees in the home appliance industry. This job description should include clauses that cover each of the effective components and fulfill the executive guarantee of each. Employees should be familiar with the culture of continuous improvement from the first moment of employment and by studying their job descriptions.

Research suggestions:
1-Considering the importance of reverse supply chain in this industry, it is recommended to the country's home appliance industry to prepare the research priorities required in the supply chain specifically for universities and scientific-research centers.
2-Analyzing the findings of this research and comparing it with the models presented in this field and in other researches as a comparative analysis research.
3-Analyzing the process of doing work in a normal and definite state.
4-Presenting another method based on artificial intelligence and based on the obtained indicators to improve the existing conditions of the home appliance industry.
5- Prioritizing the dimensions of the reverse supply chain based on the effectiveness of the introduced indicators.

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