J. Basic. Appl. Sci. Res., 3(6)675-682, 2013
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ISSN 2090-4304
Journal of Basic and Applied Scientific Research
www.textroad.com

Introducing a Model to Determine the Optimum Amounts of Supply Indexes by Using Analytical Hierarchy Process (AHP) in Supply Chain Management

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ABSTRACT

In this article, the main aim is determination of the optimum amounts of major supply indexes of producers to the optimum supply of their consumption raw materials in supply chain management. The considered indexes in this article are: supply cost, supply time and supply quality status. In this article tried that with considering to amounts of each supply indexes in terms of producers and also maximum capacity of each suppliers in terms of each supply indexes, be calculated the optimum amounts of each supply index. In this model with the use of bipolar scale space technique, convert the qualitative values to numerical values and the use of Entropy technique to determination the weighted matrix and the use of Analytical Hierarchy process (AHP) to determine the supply optimum amounts for each supply indexes.
KEYWORDS: supply cost, supply time, supply quality status, supplier, supply chain management.

1. INTRODUCTION AND PROBLEM STATEMENT

These days, daily increasing of competitive conditions in markets, customer services and essential progress in information technology and communication industries caused satisfying the customers in appropriate quality of product or service, low price in comparison to other competitive and on time delivery of product or service, has the essential role in remaining of organizations at markets and getting the market's proportion. For this reason the concept of supplying chain management is posed during these two decades.

Supply process in a supply network, the supplier in next step as a customer for the supplier in current step. Each supplier is customers for some suppliers and supplier for some other suppliers during supply process and during supply steps and should be mention that supply chain strategies in terms of supply networks is studied.

The aim of this study is the main aim is determination the optimum amounts of major indexes of producers to the optimum supply of their consumption raw materials in supply chain management. The considered indexes in this article are: supply cost, supply time and supply quality status. In this article we tried that considering amounts of each supply indexes in terms of producers and also maximum capacity of each suppliers in terms of each supply indexes, be calculated the optimum amounts of each supply indexes. In this model with the use of bipolar scale space technique, convert the qualitative values to numerical values and the use of Entropy technique to determination the weighted matrix and the use of combined placement issues in the square of the Euclidean distance to determination the supply optimum amounts for each supply indexes.

Much research has been done in this issue, some of which that: with the aim of developing a phase multi-purposed model for equalizing the use of transportation machines in logistic system, have considered this issue (Ghazanfari, khalili-dizaj, 2004). Was choosing as case study with the purpose of decreasing the transportation costs in iran khodro Company (Asghari, Aghdasi, 2004). Have presented a model for determining the order point and optimizing the size of order considering the transportation costs (Teimouri, Ghiyami, 2004). Have presented some models for integrating the total logistic cost in supplying chain management (Ghazanfari, Seyed Hosseini, 2004). Have practiced to the development of a model for optimizing the total cost of logistic distribution in conditions of a producer and some distributed warehouses in supply chain management (Ghazanfari, Seyed Hosseini, 2004). by presenting a mathematical Mosel, have practiced to lowering the transportation costs and existence in a production company which the production have been done in some stages and considering the limitation of time for producing a part till requested time to transportation (Watanabe and et.al, 1994).

The main reasons for doing this research are:

1) Improving the transportation total expected costs of raw materials in supply chain management.
2) Improving the transportation total expected time of raw materials in supply chain management
3) Improving the transportation total expected supply quality status of raw materials in supply chain management.
4) Smoothing transportation operations throughout the supply chain and supply network.

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2. LITERATURE REVIEW

2.1. Supply Chain

Supplying chain consists of material stream, money and information between supplier's network, transportation, producer, distribution network and final customer (Javid, 2004).

2.2. Supply chain management

Supply chain management (SCM) is the management of a network of interconnected businesses involved in the provision of product and service packages required by the end customers in a supply chain. Supply chain management spans all movement and storage of raw materials, work-in-process inventory, and finished goods from point of origin to point of consumption (Isaei, 2012).

2.3. Supply Network

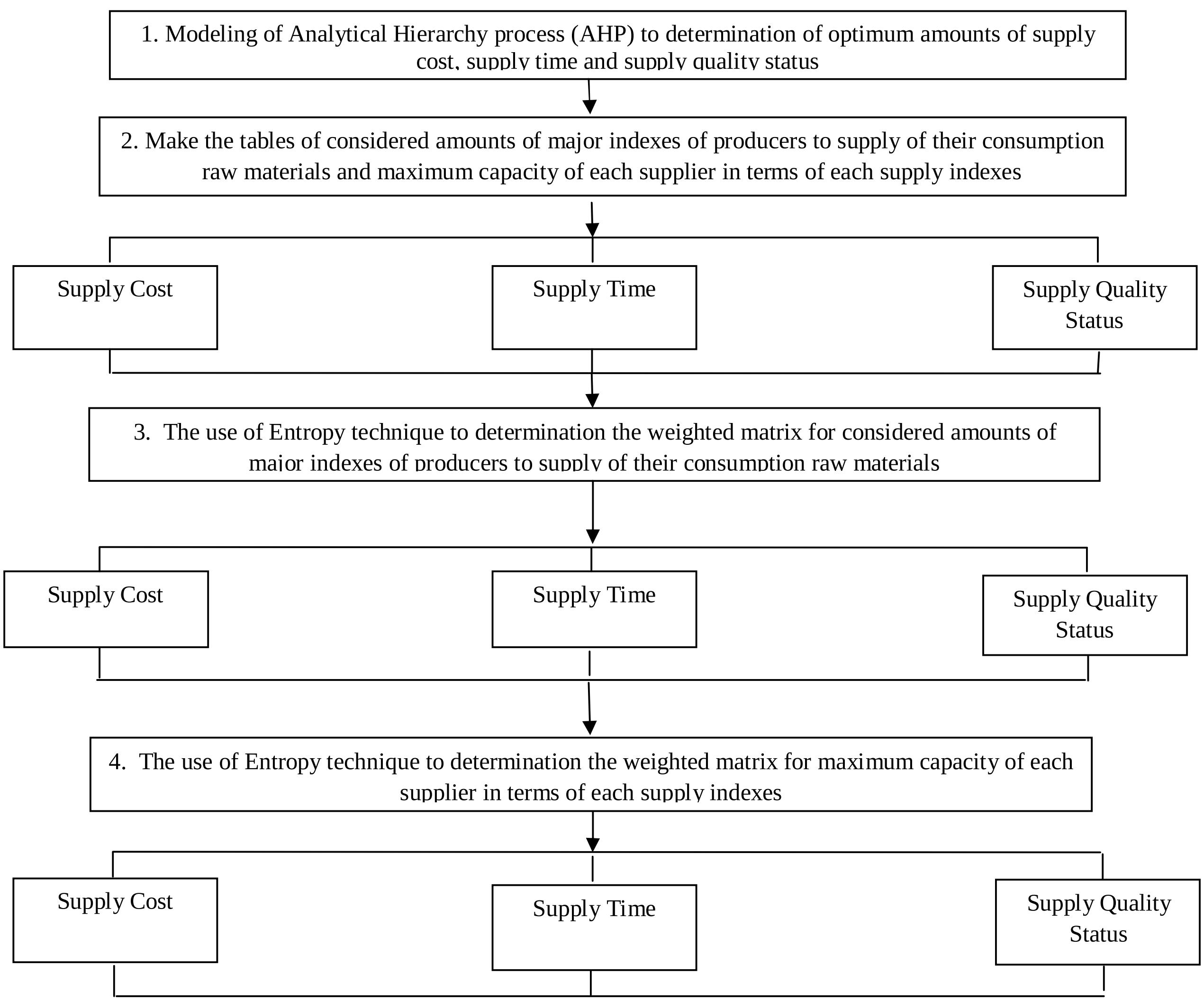
A supply network is a pattern of temporal and spatial processes carried out at facility nodes and over distribution links, which adds value for customers through the manufacturing and delivery of products. It comprises the general state of business affairs in which all kinds of material (work-in-process material as well as finished products) are transformed and moved between various value-added points to maximize the value added for customers (Asghar poor, 2002).

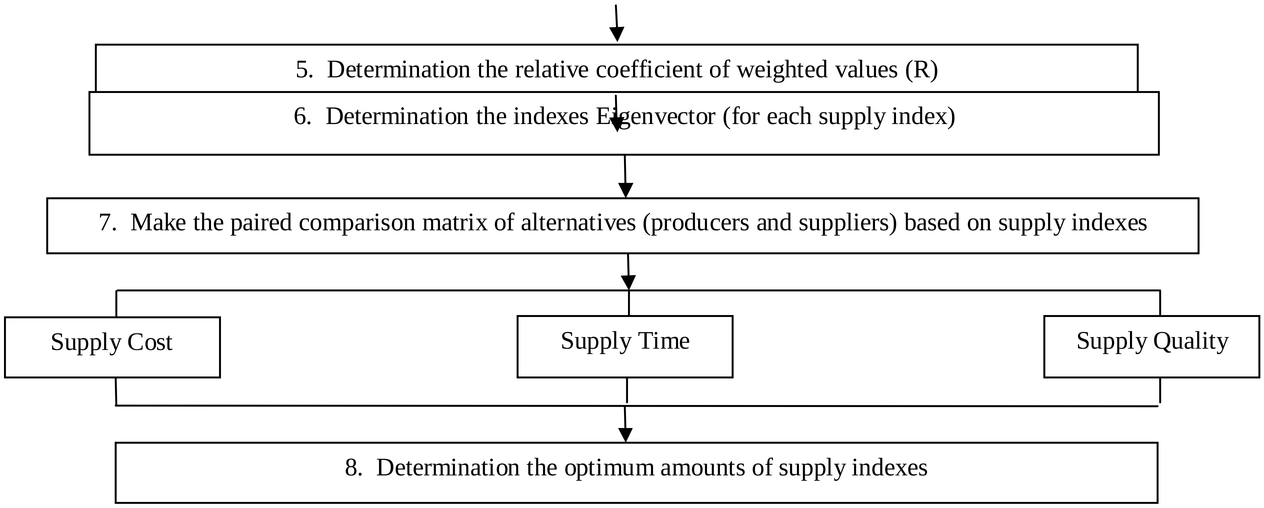
2.4. Logistics

The keyword "logistic" has been used in the U.S.A military forces for more than one century and gradually has been accepted by the other military forces of English language countries. In the recent decades this is also developed in trade market and civil industrial. Logistic has originally come from a Greek work "logistics" and it means science of computation and skill in computerizing. Antoine Henry Jomini had the first systematic try to definition this word with low accordance and connected to the other war elements. He was a French commentator and war writer. He defined the logistic in his book 'the brief art of war" in 1838 like this: logistic is the scientism art of militaries movement. Based on his definition, the logistic apparently consists of all supporting and moving activities of militaries such as, planning (Henry Jomini, 1838).

3. RESEARCH METHODOLOGY

Figure 1: Research Practical Model





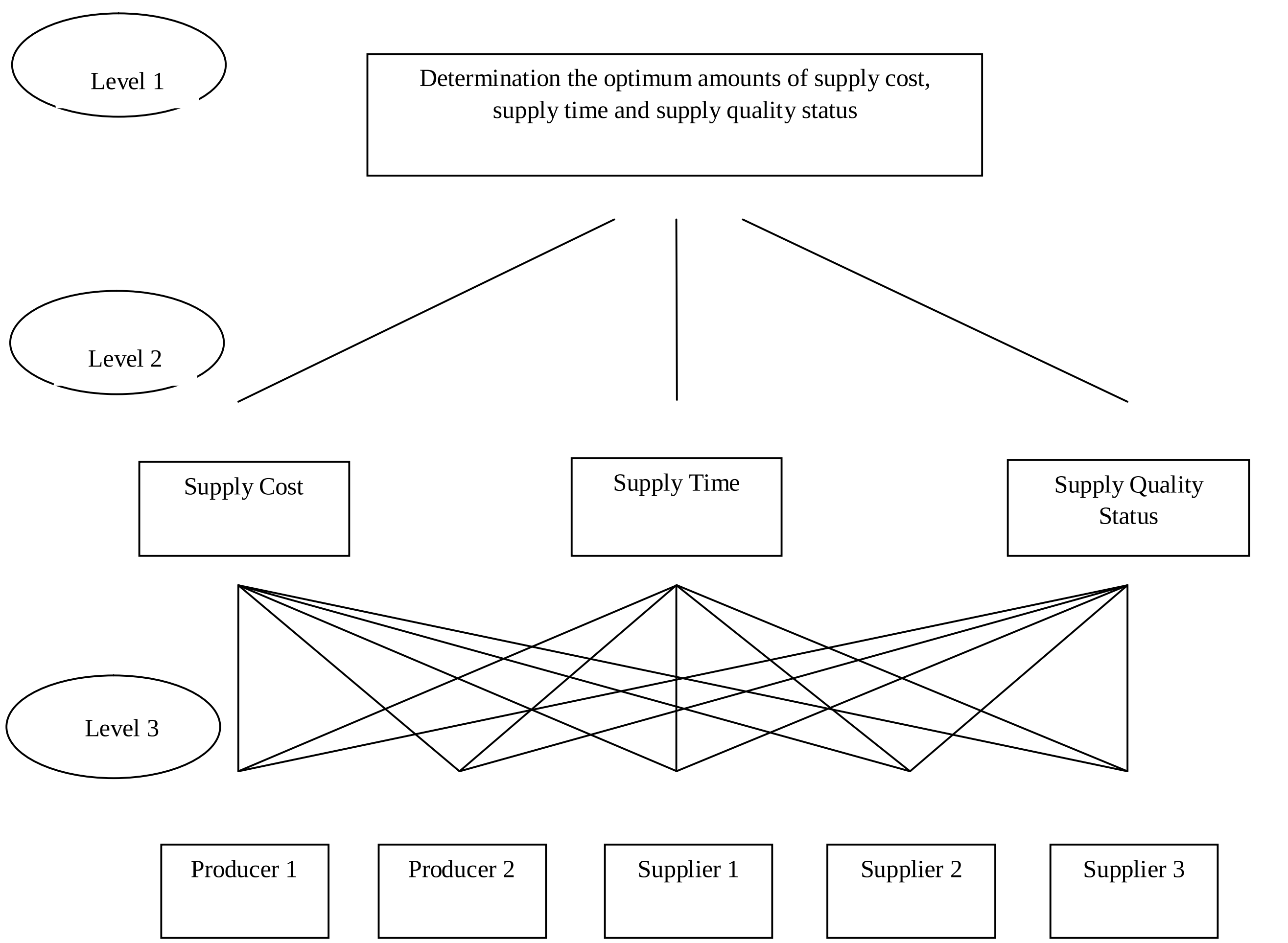
Case Study

Consider a supply chain that includes three main suppliers and two producers. These two producers are as customer demands suppliers. Capacity of each supplier is determined by industrial experts. Per unit cost of supplying (currency based) and supply time (time based) and supply quality status (bipolar index space) is determined.

3.1. Modeling of Analytical Hierarchy process (AHP) to determination of optimum amounts of supply cost, supply time and supply quality status

In this step of research, make the Analytical Hierarchy process model to determination of optimum amounts of supply cost, supply time and supply quality status. This model is composed of three levels. The First level shows that aim of study, the second level shows that indexes of study and the third level show that the alternatives of study:

Figure 2: levels of supply in management in this study



3.2. Make the tables of considered amounts of major indexes of producers to supply of their consumption raw materials and maximum capacity of each supplier in terms of each supply indexes

In this step of research, make the tables of considered amounts of major indexes of producers to supply of their consumption raw materials and maximum capacity of each supplier in terms of each supply indexes. These indexes are main indexes in determination the optimum relationship between producers and suppliers in supply chain:

Table1. Amounts of major indexes of producers to supply of their consumption raw materials

Index / Producers	Supply Cost	Supply Time	Supply Quality status (Based on bipolar scale space technique)	
Producer 1	3	3	Very Good	9
Producer 2	2	4	Good	7

Table2. Maximum capacity of each supplier in terms of each supply indexes

Index / Suppliers	Supply Cost	Supply Time	Supply Quality status (Based on bipolar scale space technique)	
Supplier 1	4	2	Good	7
Supplier 2	3	3	Fair	5
Supplier 3	1	4	Fair	5

3.3. The use of Entropy technique to determination the weighted matrix for considered amounts of major indexes of producers to supply of their consumption raw materials

In this step of study, the main aim is determination the weighted matrix for considered amounts of major indexes of producers to supply of their consumption raw materials. The weighted matrix in this step shows that importance of considered major indexes of producers to supply of their consumption raw materials:

Table3. Amounts of major indexes of producers to supply of their consumption raw materials

Index / Producers	Supply Cost	Supply Time	Supply Quality status (Based on bipolar scale space technique)	
Producer 1	3	3	Very Good	9
Producer 2	2	4	Good	7

The steps of this section are:

1. Make the decision making matrix

$$A = \begin{bmatrix} 3 & 3 & 9 \\ 2 & 4 & 7 \end{bmatrix}$$

2. Determination the weighted matrix by using of entropy technique

2.1. Determination the P matrix:

$$p = \begin{bmatrix} 0.6 & 0.428 & 0.562 \\ 0.4 & 0.571 & 0.437 \end{bmatrix}$$

2.2. Determination the Ej matrix:

$$Ej = [0.97 \quad 0.985 \quad 0.99]$$

2.3. Determination the Éj matrix:

$$\acute{E} = 1 - Ej = [0.015 \quad 0.03 \quad 0.01]$$

2.4. Determination the Éj matrix:

$$Wj = \acute{E}j \div \Sigma \acute{E}j$$

$$Wj = [0.545 \quad 0.272 \quad 0.182]$$

3.4. The use of Entropy technique to determination the weighted matrix for maximum capacity of each supplier in terms of each supply indexes

Table4. Maximum capacity of each supplier in terms of each supply indexes

Index / Suppliers	Supply Cost	Supply Time	Supply Quality status (Based on bipolar scale space technique)	
Supplier 1	4	2	Good	7
Supplier 2	3	3	Fair	5
Supplier 3	1	4	Fair	5

The steps of this section are:

1. Make the decision making matrix

$$A = \begin{bmatrix} 4 & 2 & 7 \\ 3 & 3 & 5 \\ 2 & 4 & 5 \end{bmatrix}$$

2. Determination the weighted matrix by using of entropy technique

2.1. Determination the P matrix:

$$p = \begin{bmatrix} 0.444 & 0.222 & 0.411 \\ 0.333 & 0.333 & 0.294 \\ 0.111 & 0.444 & 0.294 \end{bmatrix}$$

2.2. Determination the Ej matrix:

$$Ej = [0.883 \quad 0.966 \quad 0.988]$$

2.3. Determination the Éj matrix:

$$\acute{E}j = 1 - Ej = [0.117 \quad 0.034 \quad 0.012]$$

2.4. Determination the Éj matrix:

$$Wj = \acute{E}j \div \Sigma\ \acute{E}j$$

$$Wj = [0.717 \quad 0.208 \quad 0.073]$$

3.5. Determination the relative coefficient of weighted values (R)

In this step of study, according to the calculated values of weighted matrices for considered amounts of major indexes of producers to supply of their consumption raw materials and maximum capacity of each supplier in terms of each supply indexes, will be calculated the coefficient of relative weighted (R). The coefficient of relative weighted shows that the relative importance of supply indexes in terms of maximum capacity of each suppliers and considered amounts of major indexes of producers to supply of their consumption raw materials:

$$Ri = \frac{\text{Wi (suppliers)}}{\text{Wi (producers)}} \ , \qquad i = 1{,}2{,}3$$

$$R1 = \frac{\text{W1 (suppliers)}}{\text{W1 (producers)}} = \frac{0.717}{0.545} = 1.315$$

$$R2 = \frac{\text{W2 (suppliers)}}{\text{W2 (producers)}} = \frac{0.208}{0.272} = 0.764$$

$$R3 = \frac{\text{Wi (suppliers)}}{\text{W3 (producers)}} = \frac{0.073}{0.182} = 0.401$$

3.6. Determination the indexes Eigenvector (for each supply index)

In this step of study, the main aim is determination the indexes eigenvector with the use the relative coefficient of weighted values matrix (R). To calculate the values of indexes eigenvector, calculate the Geometric mean in each row of table5. Finally, divide the calculated values on summation of calculated values:

Table5. Eigenvector for indexes (E.I)

Supply index of producers / Supply index of suppliers	Supply Cost	Supply Time	Supply Quality Status	Geometric Mean	Eigenvector for indexes (E.I)
Supply Cost	1.315	2.636	3.939	2.39	0.718
Supply Time	0.381	0.764	1.142	0.692	0.208
Supply Quality Status	0.134	0.268	0.401	0.243	0.073

3.7. Make the paired comparison matrix of alternatives (producers and suppliers) based on supply indexes

In this step of study, the main aim is Paired comparison of alternatives (producers and suppliers) based on supply indexes. The use of relationship scores (in locating problem issue) to determination values the paired comparison matrix base on supply indexes:

Table6. Standard scores the relationships between departments

Relationship	Score	Closeness Degree
A	4	Absolutely necessary
E	3	Especially important
I	2	Important
O	1	Ordinary closeness
U	0	Unimportant
X	-1	X

The closeness relationships between producers and suppliers in terms of each supply index are:

Table7. The closeness relationships between producers and suppliers in terms of supply cost

Supplier / Producer	Producer 1		Producer 2		Supplier 1		Supplier 2		Supplier 3	
Producer 1	O	1	E	3	E	3	E	3	I	2
Producer 2	E	3	O	1	A	4	E	3	E	3
Supplier 1	E	3	A	4	O	1	I	2	A	4
Supplier 2	E	3	E	3	I	2	O	1	I	2
Supplier 3	I	2	E	3	A	4	I	2	O	1

Table8. The closeness relationships between producers and suppliers in terms of supply time

Supplier / Producer	Producer 1		Producer 2		Supplier 1		Supplier 2		Supplier 3	
Producer 1	O	1	I	2	E	3	A	4	A	4
Producer 2	I	2	O	1	A	4	E	3	E	3
Supplier 1	E	3	A	4	O	1	E	3	I	2
Supplier 2	A	4	E	3	E	3	O	1	I	2
Supplier 3	A	4	E	3	I	2	I	2	O	1

Table9. The closeness relationships between producers and suppliers in terms of supply quality status

Supplier / Producer	Producer 1		Producer 2		Supplier 1		Supplier 2		Supplier 3	
Producer 1	O	1	E	3	A	4	I	2	I	2
Producer 2	E	3	O	1	A	4	I	2	E	3
Supplier 1	A	4	A	4	O	1	I	2	I	2
Supplier 2	I	2	I	2	I	2	O	1	E	3
Supplier 3	I	2	E	3	I	2	E	3	O	1

Therefore, the paired comparison matrix of alternatives (producers and suppliers) based on supply indexes are:

3.7.1. The paired comparison matrix of alternatives (producers and suppliers) based on supply cost

In this step of study, will be calculated geometric mean and eigenvector for alternatives based on supply cost. To calculate the values of indexes eigenvector, calculate the Geometric mean in each row of table 10:

Table10. The geometric mean and eigenvectorfor alternatives based on supply cost

Based on Supply Cost	P 1(Producer 1)	P 2	S 1(Supplier 1)	S 2	S 3	Geometric Mean	Eigenvector for Alternatives (E.A)
P 1	1	3	3	3	2	2.71	0.191
P 2	3	1	4	3	3	3.223	0.228
S 1	3	4	1	2	4	3.13	0.221
S 2	3	3	2	1	2	2.449	0.173
S 3	2	3	4	2	1	2.632	0.186

3.7.2. The paired comparison matrix of alternatives (producers and suppliers) based on supply time

In this step of study, will be calculated geometric mean and eigenvector for alternatives based on supply time. To calculate the values of indexes eigenvector, calculate the Geometric mean in each row of table 11:

Table11. The geometric mean and eigenvectorfor alternatives based on supply time

Based on Supply Time	P 1(Producer 1)	P 2	S 1(Supplier 1)	S 2	S 3	Geometric Mean	Eigenvector for Alternatives (E.A)
P 1	1	2	3	4	4	3.13	0.215
P 2	2	1	4	3	3	2.913	0.2018
S 1	3	4	1	3	2	2.913	0.2018
S 2	4	3	3	1	2	2.913	0.2018
S 3	4	3	2	2	1	2.632	0.181

3.7.3. The paired comparison matrix of alternatives (producers and suppliers) based on supply quality status

In this step of study, will be calculated geometric mean and eigenvector for alternatives based on supply quality status. To calculate the values of indexes eigenvector, calculate the Geometric mean in each row of table 12:

Table12. The geometric mean and eigenvector for alternatives based on supply quality status

Based on Supply Quality Status	P 1(Producer 1)	P 2	S 1(Supplier 1)	S 2	S 3	Geometric Mean	Eigenvector for Alternatives (E.A)
P 1	1	3	4	2	2	2.632	0.202
P 2	3	1	4	2	3	2.913	0.223
S 1	4	4	1	2	2	2.828	0.217
S 2	2	2	2	1	3	2.213	0.169
S 3	2	3	2	3	1	2.449	0.188

3.7.4. Make the Eigenvector table for each alternative based on each supply index

Table13. Eigenvector for each alternative based on each supply index (E.A)

Supply index / Alternative	Supply Cost	Supply Time	Supply Quality Status
Producer 1	0.191	0.215	0.202
Producer 2	0.228	0.2018	0.223
Supplier 1	0.221	0.2018	0.217
Supplier 2	0.173	0.2018	0.169
Supplier 3	0.186	0.181	0.188

3.8. Determination the optimum amounts of each supply index

In this step of study, will be calculated the score of each alternative. Each alternative that has been higher score, is optimum alternative and its amounts of each supply index, is optimum amounts of each supply index:

$$\text{Score of Alternative i: } \Sigma\,((E.A)\ i \times (E.I)\ i)$$

Score of Producer1 = 0.191× 0.718+ 0.215× 0.208+ 0.202× 0.073= 0.1966
Score of Producer2 = 0.228× 0.718+ 0.2018× 0.208+ 0.223× 0.073= 0.2219 *
Score of Supplier1 = 0.221× 0.718+ 0.2018× 0.208+ 0.217× 0.073= 0.2165
Score of Supplier2 = 0.173× 0.718+ 0.2018× 0.208+ 0.169× 0.073= 0.1785
Score of Supplier3 = 0.186× 0.718+ 0.181× 0.208+ 0.188× 0.073= 0.1849

According to scores of producers and suppliers, producer2 has higher score than other alternatives. Therefore, it's considered amounts of supply indexes are as optimum amounts of supply indexes:

Optimum supply cost is: 2
Optimum supply time is: 4
Optimum supply quality status is: 7 (good)

5. Conclusion and suggestion

According to the results of doing this research, the role of optimization of supply indexes in supply chain management, is a vital affair for every production or service organization. In fact the determining an accurate program for implementation of transportation process and feeding of producers according to the changing in supply orders, is an important competitive advantage for every organization.

According to the obtained results from optimization of supply indexes in supply chain management the decreasing of cost and time and increasing quality status in transportation total expected in parts transportation in order to feeding of producers will be observed. According to the obtained results, producer1 proposed amounts of supply indexes as optimum amounts of supply indexes and optimum supply cost is 2 (cost based), optimum supply time is 4 (time based) and Optimum supply quality status is: 7 (good). Because of variety of variations, it is not possible to control the total variations that mean that some impressive variations on the result of research are out of control. So, it is suggested that the related researches in this filed should be done by all impressive variations.

As for the optimization of supply indexes in supply chain management and it's relating to the costs is a new issue in Iranian organizations, so in considering of its indexes and in organizations and filed study, this research has been faced with the previous researches limitations. Also it is suggested that research in this field should be done by impressive various indexes in supply chain management systems and different organizations.

As for various producers and suppliers in supply chain and supply network, in this study, just considered a few number of producers and suppliers in supply chain and supply network. So, we suggest that the related research in this field, with regards of the total producers and suppliers, should be done.

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