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Research Note: Fuzzy Supplier Selection by Use of Weighted Indices

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Abstract

Since supplier selection is an important part in management fields, this research focuses on weighted non-hierarchical fuzzy model to increase supply chain management performance. Supplier selection researches have significantly increased but most of methods have been focused on hierarchical determination of indices. This article by use of a multiple objective function tried to present a method that can consider non-hierarchical determination of indices in specific conditions. This research by use of deliverable indices of supply chain management tries to select the best suppliers. In this paper it is assumed that all suppliers have the ability to supply needed items but client can only make a product they provide. Quality of supply chain deliverable, supply chain reliability and supply chain visibility names indices have been selected to increase efficiency in the supply chain. This approach presents local optimal solutions by use of a heuristic logic in supply chain management. These indices are used as fuzzy to select the appropriate suppliers. By this fuzzy method, appropriate supplier can be set for each of the items. The presented approach have been introduced a weighted indices to determine best supplier in specific conditions. In this research weighted non-hierarchical fuzzy sets have been used to select appropriate suppliers. This method is useful for supplier selection problems.

Keywords: Supply chain management, fuzzy, quality, reliability, information, supplier selection

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Introduction

This paper attempts to consider a mathematical model for supply chain management. Quality of supply chain deliverables, supply chain reliability and supply chain visibility has been used as indices. For Simplification of these concepts, we have used their abbreviations in this article.

SCQM as the quality level of deliverable items in destination has been considered. SCRL is the agility and ability of supplier for timely delivery of goods. The definition of SCV has been introduced in. SCV has been linked to the capability of sharing timely and accurate information on exogenous demand, quantity and location of inventory, transport related cost, and other logistics activities throughout an entire supply chain. So far, most research has been done in the compass of supply chain management. These researches have been used to models optimization in different conditions. Fuzzy models with use of SCQM, SCRL and SCV have been presented with indices. This fuzzy model can be used to determine the requirements of various industries. Tseng et al. (2011) discuss about increasing marketing performance and customer satisfaction by focusing on information technology in supply chain management focuses. Woolliscroft et al. (2013), by use of the identification and integration of key suppliers, are trying to create a powerful knowledge management. Chen et al. (2012), by using simulation optimization introduce a model for drug design that has reduced supply chain costs. Song et al. (2014) believes that a supply chain management system with various uncertain parameters has to offer. Yu, et al. (2014), by using fuzzy approach, first selects the lowest risk in a supply chain and then visibility of supply chain has increased. Brandenburg et al. (2014) introduce environmental and social factors governing of supply chain. Shaw et al. (2014), by use of fuzzy approach, try setting the weighting of the various factors that affect the supply chain. In (Ishizaka, et al, 2013) a method is described for membership function in fuzzy functions. (Bas, 2013) The model aims to provide a combination of SWOT and fuzzy. Pettersson et al. (2013) has focused on supply chain cost reduction and its impact on the increase in net national income. Wang et al. (2005) stated that selecting suitable suppliers in the supply chain, AHP is used. Peidro et al. (2009) explain previous research in the area of uncertainty in the supply chain and analyze what will be discussed in the future on. In (Long et al. 2011) simulation is used to analyze complex supply chain management. In (Singh et al, 2012) types of risks in global supply chains are investigated. He also determines the probability of each risk to reduce supply chain costs. Uthayakumar et al. (2013) designed an integrated inventory model to determine the factors such as optimal order quantity, order quality and etc. in a supply chain model. Methodology to solve a supply chain network based on randomness and uncertainty in network parameters has to offer in Mohammadi Bidhandi, et al. (2011). Aliev et al. (2007) has developed a model based on fuzzy numbers using a genetic algorithm searches for the answer to the problems aggregate production distribution planning. (Siyaprani et al. (2014) developed a model for food exports that have a relationship with supply chain management.

Fuzzy Supply Chain Management

In this research a fuzzy model is provided to enhance supply chain purchasing based on SCRL, SCQM, SCV indices. This model is responsible if whole of suppliers be able to supply needed items but every supplier only provide one item between many items. According to this approach we can find suppliers that have better supply chain management parameters. The abbreviations which are used in this article are as follow:

I	number of states
$SCRL_j$	minimum amount of needed supply chain reliability for state i
$SCQM_j$	minimum amount of needed supply chain quality management for state i
SCV_j	minimum amount of needed supply chain visibility for state i
$SCRL_i$	supply chain reliability in i state
$SCQM_i$	supply chain quality management in i state
SCV_i	supply chain visibility in i state
C_{SCRL}	cost of supply chain reliability for whole states
C_{SCQM}	cost of supply chain quality management for whole states
C_{SCV}	cost of supply chain visibility for whole states
B_{SCRL}	budget available to improve SCRL
B_{SCQM}	budget available to improve SCQM
B_{SCV}	budget available to improve SCV

$$y_i = \begin{cases} 1 & if\ the\ condition\ i\ occurs \\ 0 & otherwise \end{cases}$$

This research included of multi-objective models to provide a fuzzy supply chain management. In this section of model definition, we developed a model to improve SCRL, SCQM and SCV. Multi-objective model is described as follow:

$$\max SCRL = SCRL_i \times y_i \quad (1)$$

$$\max SCQM = SCQM_i \times y_j \quad (2)$$

$$\max SCV = SCV_i \times y_k \quad (3)$$

Subject to:

$$SCRL_i \geq SCRL_j \quad (4)$$

$$SCRL_i \times C_{SCRL} \leq B_{SCRL} \quad (5)$$

$$SCQM_i \geq SCQM_j \quad (6)$$

$$SCQM_i \times C_{SCQM} \leq B_{SCQM} \quad (7)$$

$$SCV_i \geq SCV_j \quad (8)$$

$$SCV_i \times C_{SCV} \leq B_{SCV} \quad (9)$$

$$\sum y_i = 1, \ y_i = 0,1 \quad (10)$$

$$\sum y_j = 1, \ y_j = 0,1 \quad (11)$$

$$\sum y_k = 1, \ y_k = 0,1 \quad (12)$$

Constraint (4) implements the minimum amount of supply chain reliability. Constraints (5), (7) and (9) restrict the spending of SCRL, SCQM and SCV ordinary under a planned budget for whole suppliers. Constraint set (6) enforces the minimum amount of supply chain quality management. Constraint (8) specifies the minimum amount of supply chain visibility. Constraints (10), (11) and (12) have been used to assign the favorable solution from possible solutions. These constraints considered as binary variables.

To avoid triviality a multi-objective fuzzy model has been used. (5), (7) and (9) constraints can consider after determining primary solution of fuzzy model.

$$\max SCRL \cong \widetilde{SCRL}_i \quad (13)$$

$$\max SCQM \cong \widetilde{SCQM}_i \quad (14)$$

$$\max SCV \cong \widetilde{SCV}_i \quad (15)$$

After determination of fuzzy solutions, it is possible to use (16) formula to recognize appropriate suppliers. In (16) formula a, b and c have been considered as weighting factor of fuzzy solutions.

$$g = a \times \widetilde{SCRL} + b \times \widetilde{SCQM} + c \times \widetilde{SCV} \qquad (16)$$

According to (16) formula if g increased, it means that supply chain management have better suppliers in network.

Numerical Example

A consumer is going to supply 3 items from 3 different suppliers. Whole of suppliers are able to provide requirements. In this example for simplicity, the triangular fuzzy numbers have been used. $\mu_m(x)$ is considered as membership function.

$$\mu_m(x) = \begin{cases} \dfrac{(x-l)}{(m-l)} & l \le x \le m \\ \dfrac{(r-x)}{(r-m)} & m \le x \le r \end{cases} \qquad (17)$$

This numbers have been showed in three different probability level (low, medium, high). This probability is used as different scales of abilities of suppliers in written indices.

SCV is considered as fuzzy to provide needed items from different suppliers. In this example the fuzzy numbers of indices are in [0, 10] interval. The fuzzy numbers of requirements for SCV is considered in table 1.

Table 1- SCV fuzzy numbers for all of conditions

Suppliers	Item 1	Item 2	Item 3
Supplier 1	(0,4,6)	(2,4,5)	(4,6,8)
Supplier 2	(3,6,9)	(2,4,5)	(3,5,7)
Supplier 3	(0,3,6)	(5,7,9)	(4,6,8)

SCRL fuzzy numbers is according to table 2.

Table2- SCRL fuzzy numbers for all conditions

Suppliers	Item 1	Item 2	Item 3
Supplier 1	(3,5,7)	(2,4,6)	(4,6,8)
Supplier 2	(1,4,6)	(4,6,8)	(2,4,7)
Supplier 3	(4,6,8)	(2,5,6)	(3,5,7)

Also, the fuzzy numbers of SCQM is written in table 3.

Table3- SCQM fuzzy numbers for all conditions

Suppliers	Item 1	Item 2	Item 3
Supplier 1	(0,2,4)	(4,6,8)	(3,5,7)
Supplier 2	(2,4,8)	(0,3,5)	(3,5,8)

Supplier 3	(5,7,9)	(4,6,8)	(2,4,6)

In this example objective function has three different conditions about situations of any result from earned fuzzy numbers. This conditions is shown in (18) formula. The numbers of objective functions is in [0, 10] interval.

$$objective\ function = \begin{cases} 0-3 & bad \\ 4-6 & moderate \\ 7-10 & good \end{cases} \quad (18)$$

Every supplier only can supply one item but Client is responsible for supplier selection. The situation is different for supply items required by suppliers. These situations have different SCRL, SCV and SCQM indices. These types of conditions are shown in Table 4. With regard to the supply of items needed by suppliers, the estimated of SCRL, SCV and SCQM for different situations are displayed in table 4.

Table4- Defuzzication of triangular fuzzy numbers

i	Item 1	Item 2	Item 3	SCRL	SCV	SCQM
1	Supplier 1	Supplier 2	Supplier 3	5.06	6.55	6.55
2	Supplier 1	Supplier 3	Supplier 2	5.92	5.17	2.55
3	Supplier 2	Supplier 3	Supplier 1	4.6	5.04	3.71
4	Supplier 2	Supplier 1	Supplier 3	2.8	6.42	6.63
5	Supplier 3	Supplier 1	Supplier 2	5.5	5.99	5.43
6	Supplier 3	Supplier 2	Supplier 1	4.2	6.17	3.02

According to Client weights of A, B, C respectively 0.3, 0.3 and 0.4 are considered. Due to table4 and (16) formula, Supply priorities are shown in Table5.

Table5- Prioritize suppliers

priority	1	2	3	4	5	6
situation	1	5	4	6	2	3
g	6.103	5.675	5.397	4.634	4.609	4.509

Conclusion

The purpose of this study is prioritized to select the appropriate suppliers. Although the selection is done using SCQM, SCV, SCRL indices but other fuzzy indices can also be used to increase efficiency in supply chain management. Also, by using appropriate weighting can be prioritized according to the criteria of client. Selection of appropriate suppliers to supply the required items can be very effective in increasing the efficiency of the supply chain management. The results of this approach can be used in many industries.

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