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Modeling a Five-Echelon Supply Chain Network under Disruption with Considering Hub Centers by Scenario-Based Approach

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Abstract

The supply chain is a complex logistics system. In this chain, the raw material is converted to the final product and is provided to the end consumer. Intense competition in global markets and high customer attention to factors such as price, quality, delivery time and product diversity, have led investors to focus on supply chain management. As a result, choosing the supplier and order allocation of each supplier's order is very important. This paper aims at designing a five-echelon supply chain structure including multiple suppliers, multiple producers, multiple distributors and multiple customers for determining the optimal order of each product in a multi-objective and multi-period problem**.** Also, with regard to importance of distribution centers, these parts of the supply chain are considered hub centers. The considered multiple objective functions include minimizing total purchase, transportation costs, shortage cost and holding cost, also maximizing total score of each one.

Keywords: Production–distribution, Reliability, Quota allocation, Hub location, Supply chain.

1- Introduction and literature review

Managers over the past two decades have witnessed a period of changes and turning point in history in terms of technological developments, market globalization and stabilization of economic and political conditions. With increasing number of world-class competitors, organizations were forced to improve their internal processes quickly so that they could remain in the competition arena. So during the years, companies have been forced to focus on their market strategies, strong engineering, strong design and strong support for keeping their customers. Organizations have found that desirable presentation of the organization outcomes depend on the organization's ability to manage the flow of materials, information and money inside and outside the organization. This process is known as an arena or supply chain. In general, supplier selection is one of the most important and crucial decisions that not only is responsible for supplying parts, but also the responsibility of maintaining the organization in a competitive environment. Supplier selection becomes more important when an organization needs to choose a supplier for more than one period with different cost, delivery time and latency [10]. The following is a summary of the research carried out to date in supply chain management.

Mendoza and Ventura (2008) [5] introduced a two-step method for supplier selection and allocation of the order share to each one in the problems. In the first step, an Analytical Hierarchy Process (AHP) has been used to rank and reduce the number of suppliers using evaluation criteria. In the second step, a complex integer nonlinear programming model has been implemented to determine the optimal order value. Yue et al. (2010) [11] believed that order-based manufacturers face complex conditions in the process of choosing resources. Providers of the paper examined this issue to select resource partners for key sectors to obtain information about partners in providing their resources and allocating of shares to each one. A heuristic algorithm has been used in this model to improve the level of service and reduce the cost and delivery time. Mafakheri et al. [4] (2011) proposed a two-step method for multi-criteria dynamic programming for the supplier and allocation of orders to each one. In the first step, Analytical Hierarchy Process (AHP) is used to rank suppliers, and secondly, the allocation of orders to each one is made in such a way that the maximum utility function and supply chain costs are minimized. Songhori et al. (2011) [9] proposed a bi-objective integer-mixed programming model to minimize costs and maximize overall efficiency. Zhang (2011) [12] proposed a single-objective single-product model for supplier selection and an order value model under stochastic demand mode. The aim of these models is to minimize the number of suppliers, costs of purchase, shortages and maintenance. Chen (2012)[1] has used interval fuzzy sets to examine the imprecision and ambiguity of conventional fuzzy sets for supplier selection. Seif Barghi and Esfandiari (2014)[8] presented a multi-objective model for selecting suppliers that the stochastic demand and price dependent on order quantity are considered in their model. Feng and Ryu (2014) [2] consider a two-stage supply chain that the initial allocation of profits is selected in the first stage, and allocation is made by considering the reliability between the members in the second stage. Scheibe and Blachhurst (2017) [7] examined a case-study approach to qualitative theory to help understand the disruption in the supply chain. It was also shown that the risk correlations, combinational effects, cyclical relationships, competitors' risk, goals and incompatible motives should be considered in order to effectively deal with the disruption. Mackenz (2017) [3] presented a model by which a supply chain manager can examine and control various combinations of disruption management strategies. Pellegrino and Taura (2018)[6], adopting the supply chain perspective, addressed the supply chain financing challenge and analyzed it by the effectiveness of supply chain risk management (SCRM) in reducing the risk.

2- Research Method

We consider a general supply chain network of five different levels including customers, retail distributers, center hub distributers, producers, and suppliers. Customers are at the first level while at the second and third levels there are DCs which transport a number of products to the customers. At the fourth level, there are plants (producers) which provide the products for DCs and at the fifth level, Suppliers are located which give raw materials to the plants. Therefore, the Multi-objective problem has introduced all relevant cost about supply chain. Therefore, the Multi-objective problem has introduced all relevant cost about supply chain. The whole problem is comprised of all part of objection with sub-branch for each part of supply chain. Here some of the symbols and formulation of the model are discussed, and at last, proposals for future research in this area are presented.

- **Definition of parameters:**

i: Supplier index
j: producers index
k: center hub distributer index
n: retail hub distributer index
l : customers index
cr: raw product index
cp: complete product index
t: time period index
R_i: likelihood of reliability in supplier i
R_j: likelihood of reliability in producers j
R_k: likelihood of reliability in hub distributer k
R_n likelihood of reliability in retail distributer n
$PS_{ij\,cr\,t}$: Unit price of raw product cr from supplier i to producer j in period t
$PP_{jk\,cp\,t}$: Unit price of complete product cp from producer j to hub distributer k in period t
$PH_{kn\,cp\,t}$: Unit price of complete product cp from hub distributer k to retail distributer n in period t
$PD_{nl\,cp\,t}$: Unit price of complete product cp from retail distributer k to customer l in period t
$TS_{ij\,cr\,t}$: Unit transportation cost of raw product cr from supplier i to producer j in period t
$TP_{jk\,cp\,t}$: Unit transportation cost of complete product cp from producer j to distributer k in period t
$\mathrm{TH}_{\mathrm{kn\,cp\,t}}$: Unit transportation cost of complete product cp from hub distributer k to retail distributer n in period t
$TD_{nl\,cp\,t}$: Unit transportation cost of complete product cp from retail distributer n to customer l in period t
L_{ij} : distance from supplier i to producer j in period t
L'_{jk}:distance from producer j to hub distributer k in period t
$\mathrm{L''}_{\mathrm{kn}}$: distance from hub distributer k to retail distributer n in period t
L'''_{nl}:distance from retail distributer n to customer l in period t
$HS_{i\,cr\,t}$: holding percent of raw product cr in supplier i in period t
$HP_{j\,cp\,t}$: holding percent of complete product cp in producer j in period t
$\mathrm{HH}_{\mathrm{k\,cp\,t}}$: holding percent of complete product cp in hub distributer k in period t
$HD_{n\,cp\,t}$: holding percent of complete product cp in retail distributer n in period t
л$S_{i\,cr\,t}$: shortage percent of raw product cr in supplier i in period t
л$P_{j\,cp\,t}$: shortage percent of complete product cp in producer j in period t
л$\mathrm{H}_{\mathrm{k\,cp\,t}}$: shortage percent of complete product cp in hub distributer k in period t

$лD_{ncp\,t}$: shortage percent of complete product cp in retail distributer n in period t

$SS_{i\,cr\,t}$: Score of supplier i for suppling raw product cr in period t

$SP_{j\,cp\,t}$: Score of producer j for suppling complete product cp in period t

$SH_{k\,cp\,t}$: Score of hub distributer k for suppling complete product cp in period t

$SD_{n\,cp\,t}$: Score of retail distributer n for suppling complete product cp in period t

$D_{\,j\,cr\,t}$: Demand of producer j for raw product cr in period t

$D'_{l\,cp\,t}$: Demand of customer l for complete product cp in period t

- **Definition of Variables:**

$X_{ij\,cr\,t}$: The amount of demand for raw product cr for producer j that is satisfied during the period t through supplier i

$X'_{jkcp\,t}$:The amount of demand for complete product cp for distributer j that is satisfied during the period t through producer j

$X''_{kncp\,t}$: The amount of demand for complete product cp for retail distributer n that is satisfied during the period t through hub distributer k.

$X'''_{nlcp\,t}$: The amount of demand for complete product cp for customer l that is satisfied during the period t through retail distributer n.

$B_{ij\,cr\,t}$: Binary variable (if the raw product cr is supplied by the producer i in period t for supplier j, it is 1 otherwise it will be zero)

$B'_{jkcp\,t}$: Binary variable (if the complete product cp is supplied by the supplier j in period t for distributer k, it is 1 otherwise it will be zero)

$B''_{kncp\,t}$: Binary variable (if the complete product cp is supplied by the hub distributer k in period t for retail distributer n, it is 1 otherwise it will be zero)

$B'''_{nlcp\,t}$: Binary variable (if the complete product cp is supplied by the retail distributer k in period t for customer l, it is 1 otherwise it will be zero)

$$\begin{aligned}\text{Min } Z_1 :\ & \textstyle\sum_i \sum_j \sum_{cr} \sum_t PS_{ij\,cr\,t}\, X_{ij\,cr\,t}\, R_i + \sum_i \sum_j \sum_{cr} \sum_t TS_{ij\,cr\,t}\, L_{ij}\ X_{ij\,cr\,t}\ R_i\ + \\ & \textstyle\sum_j \sum_k \sum_{cp} \sum_t PP_{jk\,cp\,t}\, X'_{jk\,cp\,t}\, R'_j + \sum_j \sum_k \sum_{cp} \sum_t TP_{j\,k\,cp\,t}\, L'_{jk}\ X'_{jk\,cp\,t}\ R'_j + \\ & \textstyle\sum_k \sum_n \sum_{cp} \sum_t PH_{kn\,cp\,t}\, X''_{kl\,cp\,t}\, R''_k + \sum_k \sum_n \sum_{cp} \sum_t TH_{kn\,cp\,t}\, L''_{kl}\ X''_{kncp\,t}\ R''_k\ + \\ & \textstyle\sum_n \sum_l \sum_{cp} \sum_t PD_{nl\,cp\,t}\, X'''_{nl\,cp\,t}\, R'''_n + \sum_k \sum_n \sum_{cp} \sum_t TH_{kn\,cp\,t}\, L''_{kl}\ X'''_{nl\,cp\,t}\, R'''_n\end{aligned} \quad (1)$$

$$\begin{aligned}\text{Min } Z_2 :\ & \textstyle\sum_i \sum_j \sum_{cr} \sum_t HS_{i\,cr\,t}\, X_{ij\,cr\,t}\, R_i\ + \\ & \textstyle\sum_j \sum_k \sum_{cp} \sum_t HP_{j\,cp\,t}\, X'_{jk\,cp\,t}\ R'_j + \\ & \textstyle\sum_k \sum_n \sum_{cp} \sum_t HH_{k\,cp\,t}\, X''_{kn\,cp\,t}\, R''_k\ + \\ & \textstyle\sum_n \sum_l \sum_{cp} \sum_t HD_{k\,cp\,t}\, X'''_{nl\,cp\,t}\, R'''_n\end{aligned} \quad (2)$$

$$\begin{aligned}\text{Min } Z_3 :\ & \textstyle\sum_i \sum_j \sum_{cr} \sum_t лS_{i\,cr\,t}\, X_{ij\,cr\,t}\, R_i\ + \\ & \textstyle\sum_j \sum_k \sum_{cp} \sum_t лP_{j\,cp\,t}\, X'_{jk\,cp\,t}\, R'_j\ + \\ & \textstyle\sum_k \sum_n \sum_{cp} \sum_t лH_{k\,cp\,t}\, X''_{kn\,cp\,t}\, R''_k\ + \\ & \textstyle\sum_k \sum_n \sum_{cp} \sum_t лD_{n\,cp\,t}\, X'''_{nl\,cp\,t}\, R'''_n\end{aligned} \quad (3)$$

$$\begin{aligned}\text{Max } Z_4 :\ & \textstyle\sum_i \sum_j \sum_{cr} \sum_t SS_{i\,cr\,t}\, B_{ij\,cr\,t}\ + \\ & \textstyle\sum_j \sum_k \sum_{cp} \sum_t SP_{j\,cp\,t}\, B'_{jkcp\,t}\ +\end{aligned} \quad (4)$$

$\sum_k \sum_n \sum_{cp} \sum_t SH_{k\,cp\,t}\ \mathrm{B''}_{\mathrm{kn\,cp\,t}}$ +

$\sum_n \sum_l \sum_{cp} \sum_t SD_{n\,cp\,t}\ \mathrm{B'''}_{\mathrm{nl\,cp\,t}}$

Equation (1) is related to minimizing transportation and purchasing cost for all level of chain. Equation (2 introduces the functions to minimize the total percent of holding cost for all echelon. . Equation (3) is relevant to minimizing total percentage of shortage cost through the supply chain. Equation (4) shows the functions to maximizing total score for all level of supply chain.

s.t.

$$\sum_i \sum_j X_{\mathrm{ij\,cr\,t}}\,\mathrm{R_i} \geq D_{j\,cr\,t} \qquad \forall\, j, cr, t \tag{5}$$

$$\sum_j \sum_k \sum_{cp} \sum_t X'_{\mathrm{jk\,cp\,t}}\ \mathrm{R'_j} \geq \sum_k \sum_n \sum_{cp} \sum_t X''_{\mathrm{kn}\,cp\,t}\ \mathrm{R''_k} \tag{6}$$

$$\sum_k \sum_n \sum_{cp} \sum_t X''_{\mathrm{kncp\,t}}\ \mathrm{R''_k} \geq \sum_n \sum_l \sum_{cp} \sum_t X'''_{\mathrm{nl}\,cp\,t}\ \mathrm{R'''_n} \tag{7}$$

$$\sum_n \sum_l X'''_{\mathrm{nl}\,cp\,t}\ \mathrm{R''_k} \geq D'_{l\,cp\,t} \qquad \forall\, l, cp, t \tag{8}$$

$$X_{\mathrm{ij\,cr\,t}} \leq \mathrm{B_{ij\,cr\,t}} \quad D_{j\,cr\,t} \qquad \forall\, i, j, cr, t \tag{9}$$

$$X'_{\mathrm{jk\,cp\,t}} \leq \mathrm{B'_{jk\,cp\,t}} \quad D'_{l\,cp\,t} \qquad \forall\, j, k, cp, t \tag{10}$$

$$X''_{\mathrm{kn}\,cp\,t} \leq \mathrm{B''_{kn\,cp\,t}} \quad D'_{l\,cp\,t} \qquad \forall\, k, n, cp, t \tag{11}$$

$$X'''_{\mathrm{nl}\,cp\,t} \leq \mathrm{B'''_{nl\,cp\,t}} \quad D'_{l\,cp\,t} \qquad \forall\, n, l, cp, t \tag{12}$$

Constraint (5) is to supply the total demand for raw product cr from supplier i to producer j at time period t. Constraint (6) is to supply the total demand for complete product cp from producer j to hub distributer k at time period t. Constraint (7) is to supply the total demand for complete product cp from hub distributer k to retail distributer n at time period t Constraint (8) is to supply the total demand for complete product cp from retail distributer n to customer l at time period t. Constraint (9) to (12) check the possibility of the existence of the order.

3- Solution Methods

In this paper, an extensive SP approach is used to solve the problem. SP belongs to the more general category of uncertainty programming, which includes dynamic programming, decision trees, simulations, stochastic processes, and possible constraints. In the scenario-based programming method, stochastic quantities are considered to be stochastic variables. A scenario is an assumption about the future, which expresses the interaction between different factors under certain conditions. In fact, scenarios are a combination of stochastic parameters and a summary of different data modes in a few simple ways. Naturally, scenarios are created based on possible modes of the parameters. To model the problem, parameters with likelihood of uncertainties in the real world are considered to be uncertain. Obviously, in the real world, unstable domestic and foreign economic conditions, foreign exchange market volatility, security situation and etc., lead to volatile demand. Additionally, disasters like earthquakes, storms, fires, strikes by employees etc. cause variability in the amount of supplier disruptions. In this paper, we considers two parameters of demands under different scenarios. In this section, the definition of notations under scenario-based planning are illustrated. It should be noted that only some variables are affected by scenario-based planning.

- **Parameters:**

S : The index of the combination of scenarios of demand of raw product and demand of complete product.

e : index of scenario of demand of raw product

e' : index of scenario of demand of complete product

$D^s_{j\,cr\,t}$: Demand of producer j for raw product cr in period t under scenario s

$D^{s}_{l\,cp\,t}$: Demand of customer l for complete product cp in period t under scenario s

$X^{s}_{\mathrm{ij\,cr\,t}}$The amount of demand for raw product cr for producer j that is satisfied during the period t through supplier i under scenario s

- **Variables:**

$X'^{s}_{\mathrm{jk\,cp\,t}}$:The amount of demand for complete product cp for hub distributer k that is satisfied during the period t through producer j under scenario s

$X''^{s}_{\mathrm{kn\,cp\,t}}$: The amount of demand for complete product cp for retail distributer n that is satisfied during the period t through hub distributer k under scenario s

$X'''^{s}_{\mathrm{nl\,cp\,t}}$: The amount of demand for complete product cp for costumer l that is satisfied during the period t through retail distributer n under scenario s

$$\begin{aligned}\text{Min}\ \ Z_1^e:\ & \sum_i\sum_j\sum_{cr}\sum_t PS_{ij\,cr\,t}\,X^{s}_{\mathrm{ij\,cr\,t}}\,\mathrm{R_i} + \sum_i\sum_j\sum_{cr}\sum_t TS_{ij\,cr\,t}\,L_{ij}\ X^{s}_{\mathrm{ij\,cr\,t}}\,\mathrm{R_i} + \\ & \sum_j\sum_k\sum_{cp}\sum_t PP_{jk\,cp\,t}\,X'^{s}_{\mathrm{jk\,cp\,t}}\,\mathrm{R'_j} + \sum_j\sum_k\sum_{cp}\sum_t TP_{j\,k\,cp\,t}\,L'_{jk}\ X'^{s}_{\mathrm{jk\,cp\,t}}\,\mathrm{R'_j} + \\ & \sum_k\sum_n\sum_{cp}\sum_t PH_{kn\,cp\,t}\,X''^{s}_{\mathrm{kl}\,cp\,t}\,\mathrm{R''_k} + \sum_k\sum_n\sum_{cp}\sum_t TH_{kn\,cp\,t}\,L''_{kl}\ X''^{s}_{\mathrm{kn}cp\,t}\,\mathrm{R''_k} + \\ & \sum_n\sum_l\sum_{cp}\sum_t PD_{nl\,cp\,t}\,X'''^{s}_{\mathrm{nl}\,cp\,t}\,\mathrm{R'''_n} + \sum_k\sum_n\sum_{cp}\sum_t TH_{kn\,cp\,t}\,L''_{kl}\ X'''^{s}_{\mathrm{nl}\,cp\,t}\,\mathrm{R'''_n} \qquad \forall s\end{aligned} \tag{13}$$

$$\begin{aligned}\text{Min}\ \ Z_2^e:\ & \sum_i\sum_j\sum_{cr}\sum_t HS_{i\,cr\,t}\,X^{s}_{\mathrm{ij\,cr\,t}}\,\mathrm{R_i} + \\ & \sum_j\sum_k\sum_{cp}\sum_t HP_{j\,cp\,t}\,X'^{s}_{\mathrm{jk\,cp\,t}}\,\mathrm{R'_j} + \\ & \sum_k\sum_n\sum_{cp}\sum_t HH_{k\,cp\,t}\,X''^{s}_{\mathrm{kn}\,cp\,t}\,\mathrm{R''_k} + \\ & \sum_n\sum_l\sum_{cp}\sum_t HD_{k\,cp\,t}\,X'''^{s}_{\mathrm{nl}\,cp\,t}\,\mathrm{R'''_n} \qquad \forall s\end{aligned} \tag{14}$$

$$\begin{aligned}\text{Min}\ \ Z_3^e:\ & \sum_i\sum_j\sum_{cr}\sum_t \text{л}S_{i\,cr\,t}\,X^{s}_{\mathrm{ij\,cr\,t}}\,\mathrm{R_i} + \\ & \sum_j\sum_k\sum_{cp}\sum_t \text{л}P_{j\,cp\,t}\,X'^{s}_{\mathrm{jk\,cp\,t}}\,\mathrm{R'_j} + \\ & \sum_k\sum_n\sum_{cp}\sum_t \text{л}H_{k\,cp\,t}\,X''_{\mathrm{kn}\,cp\,t}\,\mathrm{R''_k} + \\ & \sum_k\sum_n\sum_{cp}\sum_t \text{л}D_{n\,cp\,t}\,X'''^{s}_{\mathrm{nl}\,cp\,t}\,\mathrm{R'''_n} \qquad \forall s\end{aligned} \tag{15}$$

$$\begin{aligned}\text{Max}\ \ Z_4:\ & \sum_i\sum_j\sum_{cr}\sum_t SS_{i\,cr\,t}\,\mathrm{B_{ij\,cr\,t}} + \\ & \sum_j\sum_k\sum_{cp}\sum_t SP_{j\,cp\,t}\,\mathrm{B'_{jkcp\,t}} + \\ & \sum_k\sum_n\sum_{cp}\sum_t SD_{k\,cp\,t}\,\mathrm{B''_{kn\,cp\,t}} + \\ & \sum_n\sum_l\sum_{cp}\sum_t SD_{n\,cp\,t}\,\mathrm{B'''_{nl\,cp\,t}}\end{aligned} \tag{16}$$

s.t.

$$\sum_i\sum_j X^{s}_{\mathrm{ij\,cr\,t}}\mathrm{R_i} \geq D^{s}_{j\,cr\,t} \qquad \forall j,cr,t,s$$

$$\sum_j\sum_k\sum_{cp}\sum_t X'^{s}_{\mathrm{jk\,cp\,t}}\,\mathrm{R'_j} \geq \sum_k\sum_n\sum_{cp}\sum_t X''^{s}_{\mathrm{kn}\,cp\,t}\,\mathrm{R''_k} \qquad \forall s \tag{17}$$

$$\sum_k\sum_n\sum_{cp}\sum_t X''^{s}_{\mathrm{kncp\,t}}\,\mathrm{R''_k} \geq \sum_n\sum_l\sum_{cp}\sum_t X'''^{s}_{\mathrm{nl}\,cp\,t}\,\mathrm{R'''_n} \qquad \forall s \tag{18}$$

$$\sum_n\sum_l X'''^{s}_{\mathrm{nl}\,cp\,t}\,\mathrm{R''_k} \geq D'^{s}_{l\,cp\,t} \qquad \forall l,cp,t,,s \tag{19}$$

$$X^{s}_{\mathrm{ij\,cr\,t}} \leq \mathrm{B_{ij\,cr\,t}}\quad D^{s}_{j\,cr\,t} \qquad \forall i,j,cr,t\ ,s \tag{20}$$

$$X'^{s}_{\mathrm{jk\,cp\,t}} \leq \mathrm{B'_{jk\,cp\,t}}\quad D'^{s}_{l\,cp\,t} \qquad \forall j,k,cp,t\ ,s \tag{21}$$

$$X''^{s}_{\mathrm{kn}\,cp\,t} \leq \mathrm{B''_{kn\,cp\,t}}\quad D'^{s}_{l\,cp\,t} \qquad \forall k,n,cp,t\ ,s \tag{22}$$

$$X'''^{s}_{\mathrm{nl}\,cp\,t} \leq \mathrm{B'''_{nl\,cp\,t}}\quad D'^{s}_{l\,cp\,t} \qquad \forall n,l,cp,t,s \tag{23}$$

Explanation of all equations is similar to their corresponding equations from (1) to (12) with the difference being that the given model is based on the combination of scenarios of the two types of demands. Also, it is worth noting that all Constraints are same for all functions.

4- Numerical Results and Sensitivity Analysis

In this section, five numerical examples are presented based on solving individual scenario combinations using a definite model and an extensive SP using a baseline scenario model. Furthermore, the numerical results are compared and analyzed. In fact, in each example, two scenarios are considered for each parameter of raw product demand and complete product demand. Two low and high raw product demand scenarios for the demand parameter, as well as the probability of low and high for the parameter of complete demand. Then, to solve the example, scenario combinations are discussed. The first combination mode refers to the condition in which the raw product demand parameter and the complete product demand are in the first scenario. The second combination mode refers to the combination of the first scenario of the raw product demand parameter and the second scenario of the complete product demand parameter. The third combination mode refers to the combination of the second scenario of the raw product demand parameter and the first scenario of the complete product demand parameter. The fourth combination mode refers to the condition in which the raw product demand parameter and the complete product demand are in the second scenario.

For each numerical example, the model is solved with four individual methods for four combination scenarios with an extensive SP approach; and results are compared. In the first method, the example is solved by using the expressed definite model based on the first combination mode values (low raw product demand, low complete product demand). Then, obtained independent variables from this solution are entered to problem as the constant values; and the definitive model is solved based on second combination mode values (low raw product demand, high complete product demand), third combination mode values (high raw product demand, low complete product demand), and fourth combination mode values (high raw product demand, high complete product demand),, separately. Finally, the numerical average of these four results is obtained. The solving of the second, third, and fourth methods is similar to that of the first method with the difference being that in these methods, the initial solution of the definite model is based on the values of the second, third, and fourth combination modes. Finally, the fifth method refers to the simultaneous solution of each of the four combination modes in a model using baseline scenario modeling; in fact, this method refers to extensive programming.

It is noteworthy that the CPLEX Optimization solver is used to solve these examples. Also, the parameters are considered with introduced data in the table 1.

Table 1- Parameters

All type of purchase costs = round(uniform(100, 700)) ;
All type of transportation costs = round(uniform(50, 100)) ;
All type of distance: = round(uniform(300,1000));
All type of percent of holding product= round(uniform(0.2,0.7)) ;
All type of percent of shortage product= round(uniform(0.2, 0.7)) ;
All type of score = round(uniform(1,9));
$D^{1}_{j\,cr\,t}$= round(uniform(1000,2000));
$D^{2}_{j\,cr\,t}$= round(uniform(5000,8000));
$D'^{\,1}_{l\,cp\,t}$= round(uniform(100,1000));

$D_{l\,cp\,t}^{\prime 2}$ = round(uniform(200,5000));

In this section, there are four individual runs to solve each combination mode using a definite model and a solution with extensive SP (simultaneous solving under any four combination modes) using the scenario-based model. In the concurrent mode, the probability of a combination of scenarios is equal to 0.25 ($\rho^1 = \rho^2 = \rho^3 = \rho^4 = 0.25$).
Table (2) shows the results of objective functions for each of example.

Table 2- Objective function values of numerical examples 1-5

NO	First method (based on the values of the first combination mode**)**	The second method (based on the values of the second combination mode**)**	The third method (based on the values of the third combination mode**)**	The fourth method (based on the values of the fourth combination mode**)**	The fifth method (based on the extensive stochastic programming model)
1	0.67	0.67	0.73	0.72	0.82
2	0.52	0.63	0.56	0.43	0.89
3	0.56	0.56	0.58	0.62	0.76
4	0.51	0.43	0.48	0.41	0.71
5	0.68	0.66	0.64	0.66	0.92
Mean	0.58	0.59	0.60	0.57	0.82

With regard to the values of objective functions in all the above examples and the numerical average of the results of all examples, it is clear that the value of the obtained general objective function through an extensive SP method is significantly different from the average value of the individual solution of the definitive scenarios. In all examples, it is obvious that if the model is solved with the values of each scenario individually using a definitive model, the value of the objective function is lesser than the solution of the model using an extensive SP method. This difference signifies the importance and positive impact of the extensive SP method.

5- Conclusions and Further Research Ideas

This paper investigated a five-echelon supply chain network design problem as a multi-objective multi-product multi-period problem. The considered multiple objective functions include minimizing total purchase, transportation costs, shortage cost and holding cost, also maximizing total score of each one. Due to the valid of each level, the model has investigated synchronic for all of them. Although there are many deterministic models with thousands of variables and constraints, results of these models are not accepted by managers due to not considering real world uncertainties. Scenario-based stochastic programming (SP) method is able to consider different scenarios for uncertain parameters, which have significant effects in supply chain operation. In this paper, the parameters of raw product's demand and complete product's demand were considered to be uncertain. Combination of different scenarios were considered in this regard.

As further researches in this area, it is possible to use multi-objective meta-heuristic algorithms and multi-criteria decision-making methods for selecting suppliers. Other extensions can be considering various types of supply risks in the model.

6- References

1. T. Y. Chen. (2012). Multiple criteria group decision-making with generalized interval-valued fuzzy numbers based on signed distances and incomplete weights. Applied Mathematical Modelling, 36(7), 3029-3052.

2. X. Feng, I. Moon and K. Ryu (2014). Revenue-sharing contracts in an N-stage supply chain with reliability considerations.International Journal of Production Economics, 147, 20-29.2014.

3. C. A. C. MacKenzie, A. Apte. (2017). Modeling disruption in a fresh produce supply chain. The International Journal of Logistics Management, 28(2), 656-679.

4. F. Mafakheri, M. Breton and A. Ghoniem. Supplier selection-order allocation: A two-stage multiple criteria dynamic programming approach.(2011). International Journal of Production Economics, 132(1), 52-57.

5. A. Mendoza and J.A. Ventura. (2008). An effective method to supplier selection and order quantity allocation. International Journal of Business and Systems Research, 2(1), 1-15.

6. R. Pellegrino, N. Costantino and D. Tauro. (2018). Supply Chain Finance: A supply chain-oriented perspective to mitigate commodity risk and pricing volatility.Journal of Purchasing and Supply Management.

7. K.P. Scheibe and J. Blackhurst. (2017). Supply chain disruption propagation: a systemic risk and normal accident theory perspective. International Journal of Production Research, 1-17.

8. M. Seifbarghy, and N. Esfandiari. (2014). Modeling and solving a multi-objective supplier quota allocation problem considering transaction costs. Journal of Intelligent Manufacturing, 24(1), 201-209.

9. M.J. Songhori, M. Tavana A. (2011). Azadeh and M.H. Khakbaz, M. H. A supplier selection and order allocation model with multiple transportation alternatives. The International Journal of Advanced Manufacturing Technology, 52(1-4), 365-376.

10. N. R. Ware, S. P. Singh and D. K. Banwet. (2014). A mixed-integer non-linear program to model dynamic supplier selection problem. Expert Systems with Applications, 41(2), 671-678.

11. J. Yue, Y. Xia and T. Tran. (2010). Selecting sourcing partners for a make-to-order supply chain. Omega, 38(3), 136-144.

12. J. L. Zhang and M. Y. Zhang. (2011). Supplier selection and purchase problem with fixed cost and constrained order quantities under stochastic demand. International Journal of Production Economics, 129(1), 1-7.