AN INTERACTIVE ALLOCATION FOR DEPOT-CUSTOMER-DEPOT IN A MULTI ASPECT SUPPLY CHAIN NETWORK

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Abstract Supply chain excellence has a real huge impact on business strategy. Building supply chains (SCs) as flexible system represents one of the most exciting opportunities to create value. This requires integrated decision making amongst autonomous chain partners with effective decision knowledge sharing among them. The key to success lies in knowing which decision has more impact on the supply chains performance. Here, we propose a supply chain which considers multiple depots, multiple vehicles, multiple products, multiple customers, and different time periods. This paper presents a mathematical model for selecting the appropriate depots among candidate depots, the allocation of orders to depots and vehicles, also the allocation of the returning vehicles to depots, to minimize the total costs.

Keywords Supply chain management; Allocation problem; Mathematical Model; Multi period.

چکیده زنجیره تامین تاثیر شگرفی بر استراتژی کسب و کار دارد. مطرح کردن زنجیره تامین به عنوان یک سیستم انعطاف پذیر نشان دهنده فرصتی برای خلق ارزش می‌باشد. این مفهوم به تصمیم گیری یکپارچه درمیان شرکا با علم تصمیم گیری کارا نیاز دارد. کلید موفقیت در دانستن این نکته است که کدام تصمیم بیشترین تاثیر را بر عملکرد زنجیره تامین دارد. در این مقاله، ما زنجیره تامینی را پیشنهاد می‌کنیم که چندین انبار، وسیله نقلیه، محصول، مشتری و فواصل زمانی را در نظر می‌گیرد. همچنین، ما در این مقاله یک مدل ریاضی برای انتخاب انبارهای مناسب از بین انبارهای موجود، تخصیص سفارش‌ها و وسایل نقلیه به انبارها و تخصیص وسایل نقلیه در مسیر برگشت به انبارها با هدف کمینه کردن تمامی هزینه ها ارایه می‌دهیم.

1. INTRODUCTION

Over the last decade or so, supply chain management has emerged as a key area of research among the practitioners of operations research. A lot of research is being carried out to make the supply chain more efficient and economic. The smooth and efficient functioning of business involves the smooth and efficient functioning of the principal areas of the supply chain.

A supply chain is a network comprised of a set of geographically dispersed facilities (suppliers, plants, and warehouses or distribution centers). It is often regarded as the art of bringing the right amount of the right product to the right place at the right time. If the facilities are to distribute product directly to customers, then single-stage model is appropriate. On the other hand, if several facilities are to be sited between the suppliers to the customers in order to produce product or act as regional warehouses or distribution centers, then multistage model is the appropriate one [1].

Mathematical programming models have proven their usefulness as analytical tools to optimize complex decision-making problems such as those encountered in supply chain planning. Geoffrion and Graves [2] described a multi-commodity distribution system design problem and solved it by Benders Decomposition.

This is probably the first paper that presents a comprehensive MIP model for the strategic design of supply chain networks. After that, a diversity of deterministic mathematical programming models dealing with the design of supply chain networks can be found in the literature [3-7]. A crucial component of the planning activities of a manufacturing firm is the efficient design and operation of its supply chain logistics network. A supply chain is a network of suppliers, manufacturing plants, warehouses, and distribution channels organized to acquire raw materials, convert these raw materials to finished products, and distribute these products to customers. These decisions can be classified into three categories according to their importance and the length of the planning horizon considered.

First, choices regarding the location, capacity and technology of plants and warehouses are generally seen as strategic with a planning horizon of several years. Second, supplier selection, product range assignment as well as distribution channel and transportation mode selection belong to the tactical level and can be revised every few months. Finally, raw material, semi-finished and finished product flows in the network are operational decisions that are easily modified in the short term [8].

One of the SC process models is often represented as a resource network. The nodes in the network represent facilities, which are connected by links that represent direct transportation connections permitted by the company in managing its supply chain [9]. Supply chain modeling has to configure this network and program the flows within the configuration according to a specific objective function based on algorithms [10]. Therefore, supply chain can be modeled as a configurable and flow-programmable resource network. The network employs a completely different and very selective view of what is going on in the supply chain [11].

Supply chain modeling offers short-, medium- or long-term optimization potentials. Elements within the optimization scope may be plants, distribution centers, suppliers, customers, orders, products, or inventories [12]. The standard problems for supply chain modeling are formulated in the following manner. A set of goals should be achieved by minimizing the costs of transfer and transformation. In partial solutions, particular goals are selected, such as securing a certain service level to minimize the lead time and maximize capacity utilization, or to secure the availability of resources [13]. Supply chain models can also be classified into various frameworks with respect to their problem scopes or application areas. Min and Zhou [14] viewed the problem scope as a criterion for measuring the realistic dimensions of the model.

Considering the inherent nature of supply chain problems that cut across functional boundaries, supply chain models involve making tradeoffs between more than one business processes (function) within the supply chain [15]. Therefore, only models that attempt to integrate different functions of the supply chain are regarded as supply chain models. Such models deal with the multi-functional problems of location/routing, production/distribution, supplier selection/inventory control, and scheduling/ transportation. Recently, Kerbache and Smith [16] classified optimization problems associated with queuing networks as follows: optimal topological problem (OTOP), optimal routing problem (OROP) and optimal resource allocation problem (ORAP).

Meixell and Gargeya [17] reviewed decision-support models for the design of global supply chains, and assess the fit between the research literature in this area and the practical issues of global supply chain design. Zhao et al. [18] proposed a fuzzy linear programming model for bi-level distribution network design in supply chain management, in which both customer demands for products and production capacity of branch plants are treated as fuzzy parameters. Javid and Parikh [19] discussed scanning location-specific barcodes as a possible way of localizing transactions to individual villages and customers. They presented the high-level design of this system and enumerate the possible technologies that can be used to determine a user's location via a mobile device. Li et al. [20] constructed the military product supplier selection index system based on military supply chain. Nagumey [21] considered the relationship between supply chain network equilibrium and transportation network equilibrium. This equivalence allows us to transfer the wealth of methodological tools developed for transportation network equilibrium modeling, analysis, and computation to the study of supply chain networks. Wang et al. [22] proposed methods for modeling service reliability in a supply chain. The logistics system in a supply chain typically consists of thousands of retail stores along with multiple distribution centers (DC). Products are transported between DCs and stores through multiple routes. Wu et al. [23] discussed a framework for supplier selection process and set up an evaluation model of supplier selection in terms of cost, quality, service, manufacture and technological capability, reputation and information system. Cárdenas-Barrón [24] proposed an *n*-stage-multi-customer supply chain inventory model, where there is a company that can supply products to several customers. It concluded that it is possible to use an algebraic approach to optimize the supply chain model without the use of differential calculus.

This paper concerns with a supply network which includes supplier, depots and customers. Here, we propose a supply chain which considers multiple depots, multiple vehicles, multiple products, multiple customers, and different time periods. The supplier receives the order and forwards it to depots of multiple products. A set of depots should be selected among candidate depots. The depots investigate the capacity level and accept/refuse supplying the order. Considering the location of the customers, the depots decide about sending the suitable vehicles. Each vehicle has its corresponded traveling time and cost. Also when the vehicles deliver the order to the customers, another allocation for the returning vehicles to depots is set. The aim is to identify the allocation of orders to depots, vehicles, and returning vehicles to depots to minimize the total cost. The main decision which is taken is the vehicle routing to optimize the cost and satisfy the time.

2. THE PROPOSED PROBLEM

The proposed problem of this paper considers different customers that should be serviced with

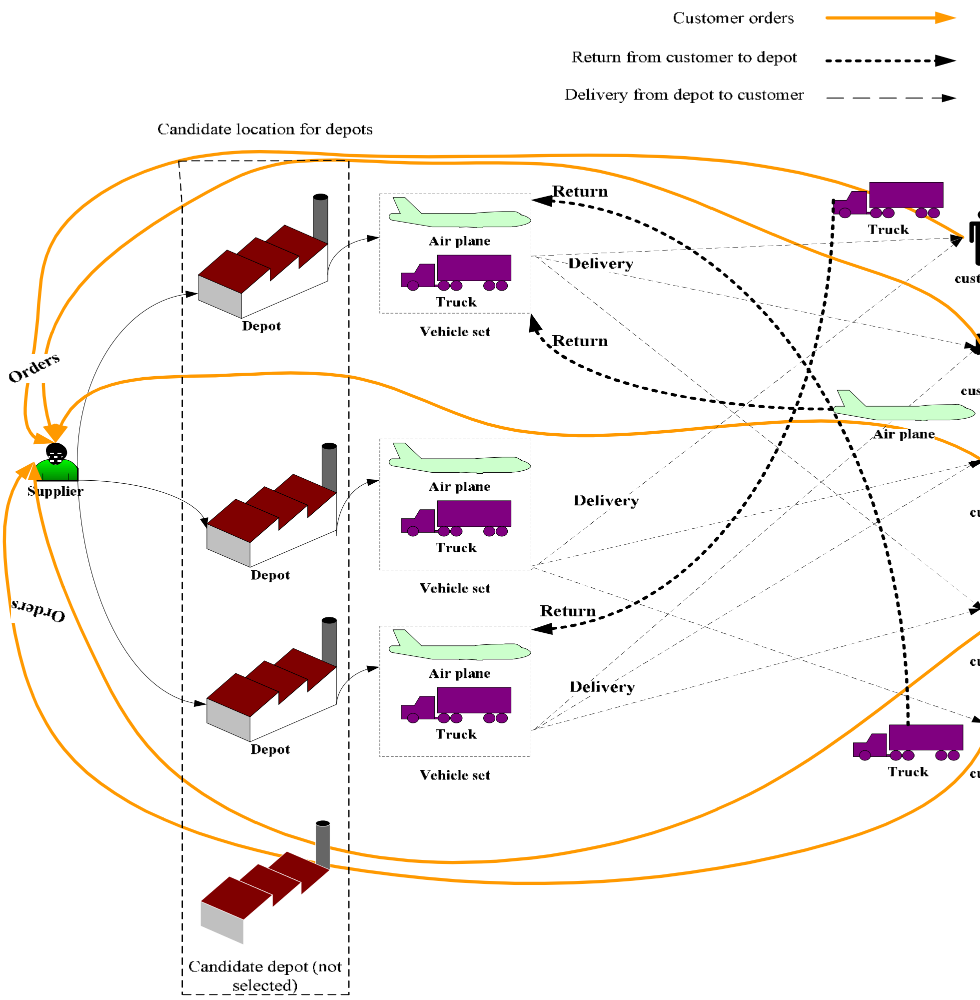

Figure 1. A Configuration of the Proposed Supply Chain Network

one supplier. The supplier provides various products and keeps them in different depots. The initial problem is choosing the appropriate depots among a set of candidate depots. Each depot use different types of vehicle to satisfy the orders. All of the depots already stationed at the related locations. Here, we consider a multi echelon supply chain network (one supplier, multi depot, and customers), multi commodity, deterministic demand. Set of vehicles are stationed at each depot. Each depot can store set of products. The received order list from customer can be responded by one or multi depots at each time. Each selected vehicle to deliver can transfer only one product. The returning vehicles are allocated to the depots when depots may not have specific vehicles in a period and should respond to an order. A configuration of the proposed supply chain network is shown in Figure 1.

The novel contribution of the work is related to the return of the vehicles to the depots which need the vehicle in that period due to satisfy the customer's demand. This kind of decision making certifying the flexibility of the proposed supply network is interesting.

3. MATHEMATICAL MODEL

The mathematical model for this problem is as follows:

Notations:

P : Set of all products

I : Set of all depots stationed

J : Set of all customers

T : Unit of time

V : Set of all vehicles

D_{jpt} : Demand of product p for customer j at time t

ND_{ivt} : The number of existence vehicles v in depot i at time t

NC_{jvt} : The number of existence vehicles v in customer j at the end of time t

VL_{vp} : Capacity of vehicle v for product p

CT_{ijv} : Traveling cost per mile from depot i to customer j using vehicle v

d_{ij} : Distance between depot i and customer j

M : A large number

Ch_{ip} The holding cost for product p in depot i

Cs_{ip} : The supplying cost for product p in depot i

CO_i : The opening cost of depot i

cap_p_{ip} : Maximum capacity of product p in depot i

cap_s_{ip} : Maximum capacity of storage of product p in depot i

Decision variables:

x_{ijpvt} : {1, If depot i deliver product p to customer j using vehicle v at time t; 0; o.w}

y_{jivt} :{1, if customer j deliver vehicle v to depot i at time t;0;o.w}

z_{ipt} :{1, if depot i receive product p at time t;0;o.w}

w_{it} :{1, if depot i is active at time t;0;o.w}

TH_{ipt} : Amount of received product p in depot i at time t

S_{ipt} : Amount of stored product p in depot i at the end of time t

f_{ijpvt} : Frequency of traveling between depot i and customer j by vehicle v at time t

QP_{ijpt} : Quantity of product p can be satisfied by depot i to customer j at time t

NR_{jivt} : Number of vehicle v delivered to depot i by customer j at time t

DV_{ivt} : Demand of vehicle v for depot i at time t

Objective function:

$$Minimize(F) = Min(f_1 + f_2 + f_3 + f_4 + f_5)$$

$$f_1 = \sum_{i \in I} \sum_{j \in J} \sum_{p \in P} \sum_{v \in V} \sum_{t \in T} x_{ijpvt} \cdot f_{ijpvt} \cdot d_{ij} \cdot CT_{ijv} \tag{1}$$

$$f_2 = \sum_{j \in J} \sum_{i \in I} \sum_{v \in V} \sum_{t \in T} y_{jivt} \cdot NR_{jivt} \cdot d_{ij} \cdot CT_{ijv} \tag{2}$$

$$f_3 = \sum_{p \in P} \sum_{t \in T} S_{ipt} \sum_{i \in I} \cdot Ch_{ip} \tag{3}$$

$$f_4 = \sum_{i \in I} \sum_{p \in P} \sum_{t \in T} TH_{ipt} \cdot Cs_{ip} \tag{4}$$

$$f_5 = \sum_{i\in I}\sum_{t\in T}(w_{it+1} - w_{it})\cdot CO_i \quad (5)$$

Constraints:

$$\sum_{p\in P} z_{ipt} \le M \cdot w_{it}, \quad \forall i \in I, \forall t \in T \quad (6)$$

$$\sum_{p\in P} z_{ipt} \ge w_{it}, \quad \forall i \in I, \forall t \in T \quad (7)$$

$$TH_{ipt} \le M \cdot z_{ipt}, \quad \forall i \in I, \forall p \in P, \forall t \in T \quad (8)$$

$$TH_{ipt} \ge z_{ipt}, \quad \forall i \in I, \forall p \in P, \forall t \in T \quad (9)$$

$$w_{it+1} \ge w_{it}, \quad \forall i \in I, \quad \forall t \in T \quad (10)$$

$$\sum_{i\in I} QP_{ijpt} = D_{jpt}, \quad \forall j \in J, \forall p \in P, \forall t \in T \quad (11)$$

$$\sum_{j\in J} QP_{ijpt} \le TH_{ipt} + S_{ipt-1}, \quad \forall i \in I, \forall p \in P, \forall t \in T \quad (12)$$

$$S_{ipt-1} + TH_{ipt} - \sum_{j\in J} QP_{ijpt} = S_{ipt}, \quad \forall i \in I, \forall p \in P, \forall t \in T \quad (13)$$

$$TH_{ipt} \le cap\_p_{ip}, \quad \forall i \in I, \forall p \in P, \forall t \in T \quad (14)$$

$$S_{ipt} \le cap\_s_{ip}, \quad \forall i \in I, \forall p \in P, \forall t \in T \quad (15)$$

$$QP_{ijpt} \cdot (1 - \sum_{v\in V} x_{ijpvt}) = 0, \quad \forall i \in I, \forall j \in J, \forall p \in P, \forall t \in T \quad (16)$$

$$QP_{ijpt} \ge \sum_{v\in V} x_{ijpvt}, \quad \forall i \in I, \forall j \in J, \forall p \in P, \forall t \in T \quad (17)$$

$$\left\lceil ((QP_{ijpt} \div VL_{vp}) \cdot x_{ijpvt}) + 0.999 \right\rceil = f_{ijpvt}, \quad \forall i \in I, \forall j \in J, \forall p \in P, \forall v \in V, \forall t \in T \quad (18)$$

$$ND_{ivt-1} - \sum_{j\in J}\sum_{p\in P} f_{ijpvt} + \sum_{j\in J} NR_{jivt} = ND_{ivt}, \quad \forall i \in I, \forall v \in V, \forall t \in T \quad (19)$$

$$\sum_{j\in J}\sum_{p\in P} f_{ijpvt} \le ND_{ivt-1}, \quad \forall i \in I, \forall v \in V, \forall t \in T \quad (20)$$

$$DV_{ivt} \le M \cdot w_{it}, \quad \forall i \in I, \quad \forall v \in V, \forall t \in T \quad (21)$$

$$\sum_{j\in J} NR_{jivt} = DV_{ivt}, \quad \forall i \in I, \quad \forall v \in V, \forall t \in T \quad (22)$$

$$NC_{jvt-1} = \sum_{i\in I} NR_{jivt}, \quad \forall j \in J, \forall v \in V, \forall t \in T \quad (23)$$

$$NR_{jivt} \le M \cdot y_{jivt}, \quad \forall j \in J, \forall i \in I, \forall v \in V, \forall t \in T \quad (24)$$

$$NR_{jivt} \ge y_{jivt}, \quad \forall j \in J, \forall i \in I, \forall v \in V, \forall t \in T \quad (25)$$

$$NC_{jvt-1} + \sum_{i\in I}\sum_{p\in P} f_{ijpvt} - \sum_{i\in I} NR_{jivt} = NC_{jvt}, \quad \forall j \in J, \forall v \in V, \forall t \in T \quad (26)$$

Integrity and non-negativity constraints:

$$x_{ijpvt} \in \{0,1\}, \quad \forall i \in I, \forall j \in J, \forall p \in P, \forall v \in V, \forall t \in T \quad (27)$$

$$y_{jivt} \in \{0,1\}, \quad \forall j \in J, \forall i \in I, \forall v \in V, \forall t \in T \quad (28)$$

$$z_{ipt} \in \{0,1\}, \quad \forall i \in I, \forall p \in P, \forall t \in T \quad (29)$$

$$w_{it} \in \{0,1\}, \quad \forall i \in I, \quad \forall t \in T \quad (30)$$

$$f_{ijpvt} \ge 0, \quad \forall i \in I, \forall j \in J, \forall p \in P, \forall v \in V, \forall t \in T \quad (31)$$

$$QP_{ijpt}, \ Integer, \quad \forall i \in I, \forall j \in J, \forall p \in P, \forall t \in T \quad (32)$$

$$NR_{jivt}, \ Integer, \quad \forall j \in J, \forall i \in I, \forall v \in V, \forall t \in T \quad (33)$$

$$TH_{ipt} \ge 0, \quad i \in I, \quad \forall p \in P, \forall t \in T \quad (34)$$

$$DV_{ivt} \ge 0, \quad \forall i \in I, \forall v \in V, \quad \forall t \in T. \quad (35)$$

Equations (1) and (2) are the objective functions which minimize total cost of both forward and backward distance, respectively. Equation (3) is the objective function which minimizes total cost of storage. Equation (4) is the objective function which minimizes total cost of supply. Equation (5) is the objective function which minimizes cost of opening depot. The constraints (6) and (7) show that each depot can be supplied when it is activated. The constraints (8) and (9) ensure that the amount of product each selected depot receives is nonnegative. The constraints (10) prevent the depots from changing their status more than once. The constraints (11) guarantee that all customer demands are met for all products required at all periods. The constraints (12) are the flow conservation at depots. The constraints (13) show amount of stored product at the end of period. The constraints (14) and (15) represent capacity restriction. The constraints (16) and (17) ensure that delivery is accomplished by only one vehicle. The frequency of traveling between depots and customers has been shown in constraints (18). The constraints (19) represent the number of remained vehicles at the end of period. The constraints (20) require that the frequency of traveled vehicles from depot is lower than or equal to its stationed vehicles. The constraint (21) requires that each activated depot can order vehicles. The constraints (22) guarantee that all depots' demands of vehicles are met, for all vehicles required and for any period. The constraints (23) are the flow balance of stationed vehicles at the end of period.

The constraints (24) and (25) guarantee that delivery of vehicles from customer to depot is accomplish while the corresponded path was selected. The constraints (26) represent the number of remained vehicles stationed at the corresponded customer at the end of period. The constraints (27) to (30) require that this variable is binary. The constraints (31) to (35) restrict all other variables from taking non-negative values.

3.1. Linearization To improve the performance of the proposed mathematical model we act out the following linearization for the nonlinear equations. As equation (1) is nonlinear, we turn it into the following equations,

$$\text{Equation (1)} \rightarrow \; f_1 = \sum_{i \in I} \sum_{j \in J} \sum_{p \in P} \sum_{v \in V} \sum_{t \in T} f_{ijpvt} \cdot d_{ij} \cdot CT_{ijv} \quad (36)$$

$$(QP_{ijpt} \div VL_{vp}) - M \cdot \left(1 - x_{ijpvt}\right) \le f_{ijpvt}, \quad (37)$$
$$\forall i \in I, \quad \forall j \in J, \quad \forall p \in P, \; \forall v \in V, \quad \forall t \in T$$

$$f_{ijpvt} \le M \cdot x_{ijpvt}, \quad (38)$$
$$\forall i \in I, \quad \forall j \in J, \quad \forall p \in P, \; \forall v \in V, \quad \forall t \in T$$

As equation (2) is nonlinear, we turn it into the following equations,

$$\text{Equation(2)} \rightarrow \; f_2 = \sum_{j \in J} \sum_{i \in I} \sum_{v \in V} \sum_{t \in T} NR_{jivt} \cdot d_{ij} \cdot CT_{ijv} \quad (39)$$

$$NR_{jivt} \le M \cdot y_{jivt}, \quad \forall j \in J, \; \forall i \in I, \; \forall v \in V, \; \forall t \in T \quad (40)$$

$$NR_{jivt} \ge y_{jivt}, \quad \forall j \in J, \quad \forall i \in I, \quad \forall v \in V, \quad \forall t \in T \quad (41)$$

For constraints (16-17) we use the following equations:

$$QP_{ijpt} \le M \cdot \sum_{v \in V} x_{ijpvt}, \quad (42)$$
$$\forall i \in I, \; \forall j \in J, \; \forall p \in P, \; \forall v \in V, \; \forall t \in T$$

$$QP_{ijpt} \ge \sum_{v \in V} x_{ijpvt}, \quad (43)$$
$$\forall i \in I, \; \forall j \in J, \; \forall p \in P, \; \forall v \in V, \; \forall t \in T$$

$$\sum_{v \in V} x_{ijpvt} \le 1, \quad \forall i \in I, \; \forall j \in J, \; \forall p \in P, \; \forall t \in T \quad (44)$$

For constraints (31),(32),(33) we use the following equations:

$$f_{ijpvt} \; , integer \quad \forall i \in I, \forall j \in J, \forall p \in P, \forall v \in V, \forall t \in T \quad (45)$$

$$QP_{ijpt} \ge 0, \quad \forall i \in I, \forall j \in J, \forall p \in P, \forall t \in T \quad (46)$$

$$NR_{jivt} \ge 0, \quad \forall j \in J, \forall i \in I, \forall v \in V, \forall t \in T \quad (47)$$

4. NUMERICAL ILLUSTRATIONS

Here, we propose a numerical example to indicate the effectiveness of the proposed mathematical model. The number of customers is three, number of products is three, number of candidate depots is seven, and number of vehicles is two. We consider a five period supply chain which there is no demand at period five. Other input data are given in Table 1.

To facilitate the computations, LINGO 8 package is applied to model the mixed integer code. The output of forward flow for the decision variables are presented in Table 2. The amount of received product from supplier in each depot is shown in table 3; meanwhile, the amount of storage of products in all depots for each period is zero. The backward flow for the decision variables is presented in table 4. The number of left vehicles at the end of period, and best objective are presented in Table 5.

Table 1. Input data

First period			
Order	Product 1	Product 2	Product 3
Customer 1	40	45	60
Customer 2	70	30	50
Customer 3	0	20	30

Second period			
Order	Product 1	Product 2	Product 3
Customer 1	19	0	18
Customer 2	0	0	13
Customer 3	13	15	17

Third period			
Order	Product 1	Product 2	Product 3
Customer 1	30	25	17
Customer 2	16	20	18
Customer 3	26	25	20

Fourth period			
Order	Product 1	Product 2	Product 3
Customer 1	10	15	0
Customer 2	8	16	12
Customer 3	15	0	14

Distance	Customer 1	Customer 2	Customer 3
Depot 1	20	25	10
Depot 2	10	15	17
Depot 3	14	12	13
Depot 4	10	15	12
Depot5	16	22	24
Depot 6	13	16	20
Depot 7	14	15	16

Capacity of vehicle	Product 1	Product 2	Product 3
Vehicle 1	30	50	20
Vehicle 2	10	15	8

Depot capacity	Product 1	Product 2	Product 3
Depot 1	100	85	90
Depot 2	90	80	70
Depot 3	80	75	70
Depot 4	90	100	70
Depot 5	85	65	75
Depot 6	80	70	60
Depot 7	100	70	80

Storage capacity	Product 1	Product 2	Product 3
Depot 1	50	50	50
Depot 2	50	50	50
Depot 3	50	50	50
Depot 4	50	50	50
Depot 5	50	50	50
Depot 6	50	50	50
Depot 7	50	50	50

Transferring cost per unit of distance	Vehicle 1	Vehicle 2
	50	30

Number of vehicles	Vehicle 1	Vehicle 2
Depot 1	14	12
Depot 2	14	12
Depot 3	14	12
Depot 4	14	12
Depot 5	14	12
Depot 6	14	12
Depot 7	14	12

Supplying cost	Product 1	Product 2	Product 3
Depot 1	10	8	11
Depot 2	12	6	10
Depot 3	11	7	15
Depot 4	13	10	9
Depot 5	14	7	14
Depot 6	13	12	14
Depot 7	8	13	9

Holding cost	Product 1	Product 2	Product 3
Depot 1	6	7	5
Depot 2	7	8	4
Depot 3	6	5	4
Depot 4	4	7	6
Depot 5	3	5	7
Depot 6	8	7	6
Depot 7	6	6	4

Opening cost	
Depot 1	2000
Depot 2	2000
Depot 3	2000
Depot 4	2000
Depot 5	2000
Depot 6	2000
Depot 7	2000

TABLE 2. The forward path output

X	Depot	Customer	Product	Vehicle	Period	F	QP
1	2	1	2	1	1	1	45
1	2	1	3	1	1	1	10
1	2	2	1	1	1	3	70
1	2	2	3	1	1	3	50
1	7	1	1	1	1	2	40
1	7	1	3	1	1	3	50
1	7	2	2	1	1	1	30
1	7	3	2	1	1	1	20
1	7	3	3	2	1	4	30
1	1	1	1	1	2	1	19
1	1	3	3	2	2	1	1
1	2	1	3	1	2	1	18
1	2	2	3	1	2	1	13
1	2	3	2	2	2	1	15
1	2	3	3	2	2	2	16

1	7	3	1	2	2	2	13
1	1	2	2	2	3	2	20
1	1	3	3	1	3	1	20
1	2	1	3	1	3	1	17
1	2	2	1	1	3	1	16
1	2	2	3	1	3	1	18
1	2	3	1	1	3	1	26
1	7	1	1	1	3	1	30
1	7	1	2	2	3	2	25
1	7	3	2	1	3	1	25
1	1	2	3	1	4	1	12
1	1	3	3	2	4	1	6
1	2	1	1	2	4	1	10
1	3	1	2	2	4	1	15
1	3	2	1	1	4	1	8
1	3	2	2	2	4	2	16
1	4	3	1	1	4	1	15
1	7	3	3	2	4	1	8

TABLE 3. The amount of received product in each depot

First period			
TH	Product 1	Product 2	Product 3
depot 2	70	45	60
depot 7	40	50	80
Second period			
TH	Product 1	Product 2	Product 3
depot 1	19	0	1
depot 2	0	15	47
depot 7	13	0	0
Third period			
TH	Product 1	Product 2	Product 3
depot 1	0	20	20
depot 2	42	0	35
depot 7	30	50	0
Fourth period			
TH	Product 1	Product 2	Product 3
depot 1	0	0	18
depot 2	10	0	0
depot 3	8	31	0
depot 4	15	0	0
depot 7	0	0	8

TABLE 4. The backward path output

Y	Customer	Depot	Vehicle	Period	NR
1	1	2	1	2	7
1	2	7	1	2	7
1	3	7	2	2	4
1	3	1	1	2	1
1	1	2	1	3	2
1	2	7	1	3	1
1	3	1	2	3	6
1	1	4	1	4	2
1	1	4	2	4	2
1	2	3	1	4	2
1	2	3	2	4	2
1	3	1	1	4	3
1	1	4	2	5	2
1	2	3	1	5	2
1	2	3	2	5	2
1	3	1	1	5	1
1	3	1	2	5	2

BEST OBJECTIVE: 70123

TABLE 5. The number of left vehicle at the end of periods

At the end of period 1		
Number of left vehicles	Vehicle 1	Vehicle 2
Depot 1	14	12
Depot 2	6	12
Depot 3	14	12
Depot 4	14	12
Depot 5	14	12
Depot 6	14	12
Depot 7	7	8
At the end of period 2		
Number of left vehicles	Vehicle 1	Vehicle 2
Depot 1	14	11
Depot 2	11	9
Depot 3	14	12
Depot 4	14	12
Depot 5	14	12
Depot 6	14	12
Depot 7	14	10
At the end of period 3		
Number of left vehicles	Vehicle 1	Vehicle 2
Depot 1	13	15
Depot 2	9	9
Depot 3	14	12
Depot 4	14	12
Depot 5	14	12
Depot 6	14	12
Depot 7	13	8

At the end of period 4		
Number of left vehicles	Vehicle 1	Vehicle 2
Depot 1	15	14
Depot 2	9	8
Depot 3	15	11
Depot 4	15	14
Depot 5	14	12
Depot 6	14	12
Depot 7	13	7
At the end of period 5		
Number of left vehicles	Vehicle 1	Vehicle 2
Depot 1	16	16
Depot 2	9	8
Depot 3	17	13
Depot 4	15	16
Depot 5	14	12
Depot 6	14	12
Depot 7	13	7

5. CONCLUSIONS

We proposed a supply network in which one supplier has provided various products for customers in different time periods. The contribution of the proposed model is the flexibility on vehicles and depots and also the location problem of candidate depots. The aim was to minimize not only the total cost and time of the order to delivery process but also the total cost and time of returning vehicles distances. The effectiveness and validity of the proposed mathematical model was presented using numerical illustrations. As our further research, we will consider to include qualitative parameters to our proposed problem.

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