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A hybrid metaheuristic Algorithm for competitive supply chain network design considering marketing strategies

[1]Agostino Gustavo
[1]Department of management science, Technical University of Munich
[1]Corresponding author's e-mail: ag.gustavo@gmail.com

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ABSTRACT

Purpose: In this paper, a thorough model for creating a network for a supply chain that is multi-period, multi-echelon, and multi-product inventory controlled is proposed. Under the condition of static competition, different marketing plans and guerilla marketing techniques are taken into account. The proposed model's objective is to effectively meet customer demands in the face of existing competitors and demand price inelasticities. The suggested optimization model takes into account multiple goals that simultaneously take into account the market share and overall profit of the supply chain network under consideration.

Design/ Methodology/Approach: An effective hybrid meta-heuristic algorithm is developed that combines a Taguchi-based non-dominated sorting genetic algorithm-II and a particle swarm optimization to address the proposed multi-objective mixed-integer nonlinear programming model. The proposed hybrid solution algorithm applies a variable neighborhood decomposition search to improve a local search procedure.

Findings: Computing results show how effectively the suggested model and solution algorithm handle the pressure of competition by implementing the right marketing strategies.

Contribution to policy and practice: For further research, competition conditions, including foresight and dynamic competition, as well as considering the impact of the product price on the attractiveness of a service provider in the network design is proposed. Additionally, the uncertainty of the key parameters can be considered in the network design process. Finally, an efficient solution algorithm can be developed to tackle such a complex problem.

Originality/Value: The present research may assist scholars to move beyond a simple dyadic context and toward examining complete supply networks.

Background

Supply chain management is increasingly being prioritized by many corporations in order to increase their chances of success as rapid globalization continues to impact the business environment's level of competition (Hasani and Zegordi, 2015). As a result, there has been a significant change in what is expected of supply chain functions. As a result of dealing with more ferocious global competition, business leaders today demand more agility from their supply chains (Hasani and Khosrojerdi, 2016). The supply chain network design (SCND) problem deals with a variety of strategic and tactical decisions to address these problems (Fattahi et al., 2015). The major players in the business environment are encouraging corporations to increase their competitive advantages and take the competitive environment into consideration when making business decisions, despite the fact that concerns about business competition have grown significantly on a global scale (Costantino et al., 2012, Goh et al., 2007). With a solid marketing plan, business owners hope to consistently outperform the competition and gain a competitive advantage (Paksoy and Chang, 2010). Under competitive conditions, taking into account the planning of the marketing strategy in the network design could increase the supply chain's competitive advantage. As a result, in this paper, the design of the strategic supply chain network takes into account marketing strategies used in market conditions of competition to increase market share. An extensive mathematical model and an effective solution algorithm are suggested to properly address these issues.

The remainder of this paper is structured as follows. In section 2, the literature review of the SCND problem from various major aspects is presented. In section 3, the problem definition is introduced. In section 4, the proposed mathematical model for designing a competitive SCND is presented. In section 5, a proposed hybrid meta-heuristic method is introduced. In section 6, computational experiments and obtained results are presented. Finally, the paper is concluded in section 7 and some of the future research directions are highlighted.

Literature Review

Analyzing the development of earlier studies on the SCND reveals that the main trend of these studies is influenced by actual environmental factors. Therefore, the proposed SCND models take into account a variety of factors that are influenced by the decision-making environment. From the SCND problem, a dynamic or multi-period SCND formulation is created (Rezapour et al., 2011). The SCND problem's structure is expanded to include multiple echelons and various facilities within each echelon. A reverse flow of materials and closed-loop SCND problems are taken into consideration when designing the supply chain network to address more sustainable issues (Eskandarpour et al., 2014). Additionally, when designing a supply chain network, a variety of facilities are taken into account to manage the reverse flow of materials (Hasani et al., 2012). A complex material flow that takes into account numerous commodities and their bill of materials is thought to satisfy the needs of the customers (Eskandarpour et al., 2013). To gain a competitive advantage, supply chain managers must overcome a number of significant obstacles, including supplier capacity constraints (Thanh et al., 2008), manufacturer and distributor technology limitations, inventory storage requirements, and investment budgets (Hasani and Khosrojerdi, 2016). Additionally, there may be some unknowable factors that affect the supply chain network's design and planning (Goh et al., 2007). Numerous techniques, including fuzzy programming (Moghaddam, 2015), stochastic programming (Goh et al., 2007), and robust programming, have been used in some studies to address parameter uncertainty (Hasani et al., 2012).

Today's supply chain characteristics are complex, necessitating a greater integration of different strategic and tactical planning decisions. According to the relevant literature, the SCND problems involve strategic planning decisions regarding determining the quantity of necessary capacity, supplier selection, and technology selection. Additionally, some choices in the SCND issues relate to tactical planning choices, including choices related to material shipment, production planning, and inventory control (Eskandarpour et al., 2014). Numerous objective functions have been put forth in the literature in response to the demands of the business environment, including cost minimization (Wilhelm et al., 2013), profit maximization, and customer demand responsiveness maximization (Hasani and Hosseini, 2015). Several studies looked at the multiple objectives problem to take multiple objectives into account simultaneously (Hasani and Hosseini, 2015). Jay Conrad Levinson first popularized guerrilla marketing as a modern marketing tactic in 1984. In lieu of large marketing budgets, the unconventional marketing strategy known as "guerrilla marketing" has certain advantages (Paksoy and Chang, 2010). The guerilla marketing approach is appropriate for small and medium-sized businesses. Guerrilla marketing's primary focus is on increasing total profit margins rather than overall sales (Levinson, 1998). The goal of the guerrilla marketing strategy is to conduct more transactions with current clients of businesses in order to grow business geometrically. Instead of focusing on growing linearly by bringing on new customers and providing a variety of products, it offers related products and services (Navrátilová and Milichovsk, 2015). Establishing transient pop-up stores, a type of temporary shop, in key customer areas is one of the strategies used in guerrilla marketing to draw in more and more customers. Many businesses today, especially those in the fashion sector, use transient pop-up stores to capitalize on market opportunities (Bigat, 2012). (2010) Paksoy and Chang proposed a goal programming model for an inventory controlled supply chain model taking into account the opening of pop-up stores to meet consumer demands.

As the business environment is still being affected by a competitive environment, supply chain management is increasingly becoming the primary concern for many firms (Costantino et al., 2012, Goh et al., 2007). Business executives want their supply chains to be more agile in order to gain a competitive advantage (Farahani et al., 2014). Due to this phenomenon, supply chains rather than companies are now in competition with one another. Due to the high dynamics in a competitive business environment, the assessment of how the competition will affect supply chain design is sophisticated. In the context of competitive facility location, there are typically three types of competition: static (Aboolian et al., 2007, Rezapour et al., 2011), foresight, and dynamic (Farahani et al., 2014). A single objective deterministic mathematical model for SCND was proposed by Rezapour et al. (2011), taking into account an inelastic demand in the presence of preexisting competing chains. Rezapour et al. (2011) took into account a probabilistic customer behavior based on an attraction function depending on the retailer's location and level of service. For the medical device industry, Zegordi and Hasani (2015) proposed a solid mathematical model to design a global supply chain network under static competition conditions. Zegordi and Hasani (2015) consider the effects of capacity disruption on facility appeal before moving on to the condition of static competition.

In this study, a new comprehensive multi-objective mathematical model for designing a competitive supply chain network incorporating marketing strategy is presented. This study is different from the previous studies on SCND problem in considering the static competition condition as well as guerrilla marketing strategy concurrently in the design of the supply chain network. In addition, to tackle with the proposed complex multi-objective mixed-integer nonlinear programming model, an efficient hybrid meta-heuristic algorithm is developed.

Problem Definition

As a new entrant into the new competitive markets, the objective of this study is to design an effective network structure of a multi-echelon supply chain. In the face of rival businesses, this one wants to take more of the market. Guerrilla marketing is a successful strategy used to meet the needs of customers who want a variety of products. In this extremely competitive business environment, a pre-existing set of competitors with known competitive characteristics is taken into account. The characteristics of the markets and products under consideration have an impact on each service provider's appeal and usefulness. In this study, the customer demands are not price elastic. Additionally, the competition situation between the supply chain network under consideration, which is a new player on the market, and the other established rivals is known in advance and fixed during the planning horizon. As a result, this study takes into account the static competition condition. The company under consideration deals with a variety of strategic and tactical choices for designing the supply chain network, including choosing the locations of suppliers and distributors, opening pop-up stores, acquiring product components, holding inventory, producing semi-manufactured and final products, shipping materials, and determining the capacity of pop-up stores. The proposed model's ultimate goal is to simultaneously maximize the supply chain network's overall profit and its overall responsiveness to customer demands.

Mathematic Model

In this section, the proposed MINLP model for designing the competitive supply chain networks by considering the Guerrilla marketing strategy is explained.

Notation

Indices;

I, J, K, L,M, and C: Sets of suppliers, manufacturers, wholesalers, pop-up stores, customer zones, and pop-up stores controlled by competitors, respectively. P,N, T, and A: Sets of products, parts, periods, and attractiveness attributes, respectively.

Parameters;

C_{ijnt}: Transportation cost of part n from supplier i to manufacturer j in period t,
C_{jkpt}: Transportation cost of product p from manufacturer j to wholesaler k in period t,
C_{klpt}: Transportation cost of product p from wholesaler k to pop-up store l in period t,
C_{lmpt}: Distribution cost of product p from pop-up store l to customer zone m in period t,
C_{mpt}: Cost of not satisfying demand of product p at customer zone m in period t,
V_{pn}: Number of part n used in one unit of product p,
A_{it} and B_{jt}: Supplying capacity of supplier I and production capacity of manufacturer j, respectively,
E_{kt} and C_{lzt}: Storage capacity of wholesaler k and pop-up store l, respectively,
D_{mpt}: Amount of demand of product p at customer zone m in period t,
δ_{kt}, Fs_{it}, andFw_{kt}: Fixed cost of establishing pop-up store k, selecting supplier i, and selecting wholesaler k in period t, respectively.
α_p: Cost of holding a unit of product p in wholesaler k in period t,
β_p: Backordering cost of product p,
μ_{mpt}: Level of customer demand satisfaction at point m for product p in period t,
B_{jpt}: Total backordered amount of product p to manufacturer j in period t,
A_t: Maximum number of available potential pop-up stores in period t,

Pr_{mpt}: Selling price of product *p* at customer zone *m* in period *t*,

Vs_{in}, Vm_{jp}, and V_p: Occupied capacity of supplier *k* for supplying part *n*, occupied capacity of manufacturer j for producing product p, and amount of occupied space by product p, respectively, λp, β, Θz: Product p elasticity, capacity sensitivity, and utility function, respectively.

Variables;

yplt: 1 if pop-up store *l* is established in period t; 0 otherwise,
ysil: 1 if supplier *i* is selected in period t; 0 otherwise,
ywkl: 1 if wholesaler *k* is selected in period t; 0 otherwise,
qpkt: Inventory of product *p* in wholesaler *k* at the end of period *t*,
qspk and *sipk*: Safety stock and initial inventory level of product *p* in wholesaler *k*, respectively,
xijnt: Amount of part *n* transferred from supplier *i* to manufacturer *j* in period *t*,
wjkpt: Amount of product *p* transferred from manufacturer *j* to wholesaler *k* in period *t*,
yklpt: Amount of product *p* transferred from wholesaler *k* to pop-up store *l* in period *t*,
zlmpt: Amount of product *p* distributed from pop-up store *l* to customer *m* in period *t*,
ndmpt: Amount of demand of product *p* at customer zone *m* which is not satisfied in period t,
ulmpt and *mslmpt*: Utility of providing product *p* and captured market share of the demand of product *p* by pop-up store *l* for customer zone *m* in period *t*, respectively,
tmsmpt and *tumpt*: Total market share of product *p* and total utility of providing product *p*, respectively,
atlpt: Attractiveness of pop-up store *l* for delivering product *p* in period *t* (i.e.,*atlpt*>0),
fumpt (*S*) and *fumpt*(*C*): Total utility of the customer zone *m* to get supplied with product *p* via facilities which are controlled by the considered supply chain and competitors in period *t*, respectively,
ylzpt: Improvement level over the basic design of pop-up store *l* regarding the *z*th design attributes,

Mathematical model formulation

The aims of Obj. (1) and Obj. (2) are to maximize the total net present value of the profit and the total demand responsiveness of the supply chain network, respectively.

$$Max \quad \sum_{l,m,p,t} pr_{mpt} . z_{lmpt} - \left(\begin{array}{l} \sum_{i,j,n,t} C_{ijnt} . x_{ijnt} + \sum_{j,k,p,t} C_{jkpt} w_{jkpt} + \sum_{k,l,p,t} C_{klpt} . y_{klpt} + \sum_{l,m,p,t} C_{lmpt} . z_{lmpt} \\ + \sum_{k,t} \delta_{kt} . yp_{lt} + \sum_{i,t} Fs_{it} . ys_{it} + \sum_{i,t} Fw_{kt} . yw_{kt} + \sum_{t} \alpha_p q_{pkt} + \sum_{j,t} \beta_p b_{jpt} + \sum_{m,p,t} C_{mpt} . nd_{mpt} \end{array} \right) \tag{1}$$

$$Max \quad \sum_{m,p,t} tms_{mpt} \tag{2}$$

$$\sum_{n,j} Vs_{in} . x_{ijnt} \le A_{it} . ys_{it} \quad \forall i,t \tag{3}$$

$$\sum_{k,p} Vw_{jp} w_{jkpt} \le B_{jt} \quad \forall j,t \tag{4}$$

$$\sum_{l,p} V_p . y_{klpt} \le E_{kt} . yw_{kt} \quad \forall k,t \tag{5}$$

$$\sum_{k,p} V_p . y_{klpt} \le C_{lt} . yp_{lt} \quad \forall l,t \tag{6}$$

$$\sum_{j} w_{jkpt} + q_{pk,(t-1)} - \sum_{j} b_{jp,(t-1)} - \sum_{l} y_{klpt} - q_{pkt} \ge 0 \quad \forall k,p,t \tag{7}$$

$$\sum_{i,j} x_{ijnt} = \sum_{j,k} v_{pn} w_{jkpt} \quad \forall p,t \tag{8}$$

$$\sum_{k} y_{klpt} = \sum_{m} z_{lmpt} \quad \forall l,p,t \tag{9}$$

$$\sum_{l} z_{lmpt} + nd_{mpt} \ge \mu_{mpt} . D_{mpt} \quad \forall m,p,t \tag{10}$$

$$q_{pkt} \ge qs_{pk} \quad \forall p,k,t \tag{11}$$

$$\sum_{p} v_p q_{pkt} \le E_{kt} \quad \forall k,t \tag{12}$$

$$q_{pk0} = si_{pk} \quad \forall p,k \tag{13}$$

$$\sum_{k} \delta_{kt} . yp_{kt} \le A_t \quad \forall t \tag{14}$$

$$u_{lmpt} = \frac{at_{lpt}}{C_{lmpt}{}^{\beta}} \quad \forall m,p,t,l \in (S \cup C) \tag{15}$$

$$ms_{lmpt} = \frac{u_{lmpt}}{\sum_{l \in S \cup C} u_{lmpt}} \quad \forall m,p,t,l \in (S \cup C) \tag{16}$$

$$tms_{mpt} = \frac{\sum_{l \in S} u_{lmpt}}{\sum_{l \in S} u_{lmpt} + \sum_{l \in C} u_{lmpt}} = \frac{\sum_{l \in S} u_{lmpt}}{\sum_{l \in S \cup C} u_{lmpt}} \quad \forall m,p,t \tag{17}$$

$$g(tu_{mpt}) = 1 - e^{-\lambda_p \times \sum_{l \in S \cup C} u_{lmpt}} \quad \forall m,p,t \tag{18}$$

$$at_{lpt} = yp_{kt} \times \alpha_i \times \prod_{z=1}^{|ZA|} \left(1 + Y_{lzpt}\right)^{\theta_z} \quad \forall l,p,t \tag{19}$$

$$Y_{lzpt} = \begin{cases} \dfrac{(C_{lt})\big|_{l \in C}}{Min\left(C_{lt}\big|_{l \in C} , (C_{lt} + RC_{lt} \times yrc_{lt})\big|_{l \in S}\right)} \\ \dfrac{(C_{lt} + RC_{lt} \times yrc_{lt})\big|_{l \in S}}{Min\left(C_{lt}\big|_{l \in C} , (C_{lt} + RC_{lt} \times yrc_{lt})\big|_{l \in S}\right)} \end{cases} \quad \forall l,z,p,t \tag{20}$$

Eqs. (3)- (6) demonstrate the capacity of each supplier, manufacturer, wholesaler, and a pop-up store. Eq. (7) ensures that quantities of products shipped from a wholesaler to pop-up stores in each time period are less than or equal to the total quantity of incoming products from other manufacturers within the same time period and the remaining products from the previous time period. Eq. (8) ensures the parts usage according to the each product BOM.A balance between the total incoming and outgoing products, to and from the pop-up store is set up in Eq. (9).Eq. (10) states that the demand of each customer zone should be fulfilled through the incoming products. Eq. (11) and (12) ensure that the total inventory level in the wholesaler in each period should be between "greater than or equal to safety stock", and "less than or equal to wholesaler capacity". The initial inventory of the wholesaler is regarded in Eq. (13). The number of pop-up stores to be opened is restricted in Eq. (14). The utility of each customer zone for each pop-up store is calculated in Eq. (15).The market share, which is captured by a specific pop-up store, is calculated in Eq. (16). The total captured market share is calculated in Eq. (17). The exponential form of the demand function is shown in Eq. (18).The attractiveness of each pop-up store is calculated in Eq. (19).Eq. (20) indicates that the y_{lzpt} is a function of the total available capacity of each pop-up store.

Proposed hybrid solution algorithm

Due to the NP-hard nature of the SCND problem, solving large-size instances efficiently within a reasonable time is a challenging task (Fahimnia et al., 2013). To tackle this challenge in this study, an efficient hybrid meta-heuristic is proposed (Figure 1).Solution chromosome of the proposed hybrid solution algorithm is represented using a two-dimensional binary array. The size of the proposed binary array is $(|I|+|K|+|L|).|T|$. Using values of solution chromosome's genes, the binary decision variables are generated and the mixed integer non-linear problem transforms into a single weighted objective non-linear programming one which is solved by LINDOGLOBAL in GAMS 24.1.2 optimization software. The initial population of the proposed hybrid solution algorithm is generated randomly. The next populations are generated in three ways. In the first method, a predefined number of solutions are generated using the Taguchi-based crossover(Hasani and Zegordi, 2015). In the second method, a multi-point mutation operator is used to generate a specific number of solutions. Finally, a customized operator of the PSO is utilized to improve the two sets of the Pareto optimal solution, including the Pareto optimal solutions of each generation and the overall generations. This operator is a kind of a multi-point crossover, which is applied on decision variables as follows: if both genes of selected parents are equal to one or zero, then a related gene of a child has an equal value to its related genes of the parents; otherwise, the binary value of the child's gene is determined randomly. A roulette wheel selection scheme is adopted to select the fittest individual prior to the others into the next generation. Steps of the proposed VNDS are demonstrated in Figure 2. Various neighborhood structures of the proposed VNDS are listed in the following.

- ✓ Single random Pairwise interchange in which two departments are selected randomly and their positions are swapped.
- ✓ Multi Pairwise interchanges in which for a specific number of iterations departments are selected randomly and their positions are exchanged.
- ✓ Subsequence moving operator in which a group of departments are moved to another position altogether.
- ✓ Insertion mechanism in which a randomly selected department is omitted from its position and inserted between two other positions selected randomly.
- ✓ Subsequence shuffling operator in which a group of departments are selected and jumbled up.
- ✓ Inversion structure in which a group of departments are selected and positioned inversely.

- ✓ Subsequence moving and inversion operator in which a group of departments are positioned inversely and moved to another position altogether.
- ✓ Shifting neighborhood structure in which two random positions are selected depending on the first position, the department located in the position of the first random number is shifted backward or forward, respectively.
- ✓ Adjacent swap operator in which a department is selected randomly and replaces its position probabilistically with its left or right position.

Computational experiments and results

In this section, a number of thorough computational experiments are used to examine the efficacy of the proposed hybrid meta-heuristic solution algorithm, known as HNSG-PSO. Based on the expert opinions of the medical device company under consideration and the test problems proposed by Paksoy and Change (2010), 16 test problems are defined (Tables 1 and 2). An offline parameter tuning based on the Taguchi experimental design method is used to set the parameters of the proposed hybrid meta-heuristic solution algorithm (Table 3). First, GAMS optimization software and the quality of the best result obtained using a single-objective version of the proposed hybrid solution algorithm are compared. Only the first objective function is taken into account in this test. GAMS was only permitted to use the CPU for a total of 200 hours. Results show that for medium- and large-sized test problems, the proposed hybrid solution algorithm using variable neighbourhood decomposition search performs better than GAMS. Even after the permitted runtime limit, GAMS was unable to demonstrate the optimality of the optimum solutions for all test problems due to the limitations and capabilities of the solution algorithm. The average difference between the solutions of the algorithms mentioned above is 10.09 percent (Table 4). The effectiveness of using the suggested solution algorithm in comparison to the NSGA-VNS and NSGA-II is also looked into. Two widely used performance metrics-an average number and a ratio of Pareto-optimal solutions-are used to assess the quality of the Pareto solutions. Table 5's findings show that the proposed HNSG-PSO discovered superior Pareto solutions for every test problem. The conflict between the two considered objective functions is investigated using a successive procedure (Figure 4). The results of applying this procedure to the test problem 16, as a large-sized problem, is presented in Figure 5. The obtained results show that by increasing demand responsiveness, total profit decreases due to increasing cost of satisfying more demand. The impact of changes in competition condition is presented in Figure 6. The obtained results indicate that the total profit and demand responsiveness of the supply chain will decrease as a consequence of enhancing the competition condition. Limitation in the number and capacity of pop-up stores due to access constraint to appropriate locations could be some of the most important reasons for this phenomenon.

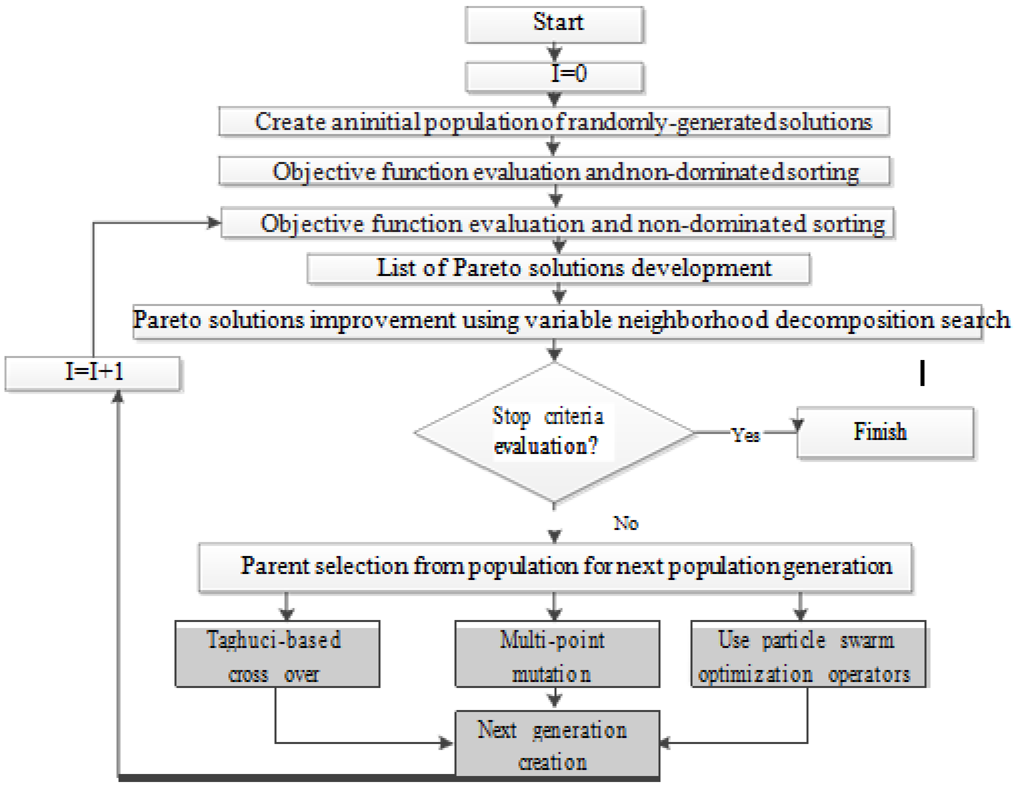
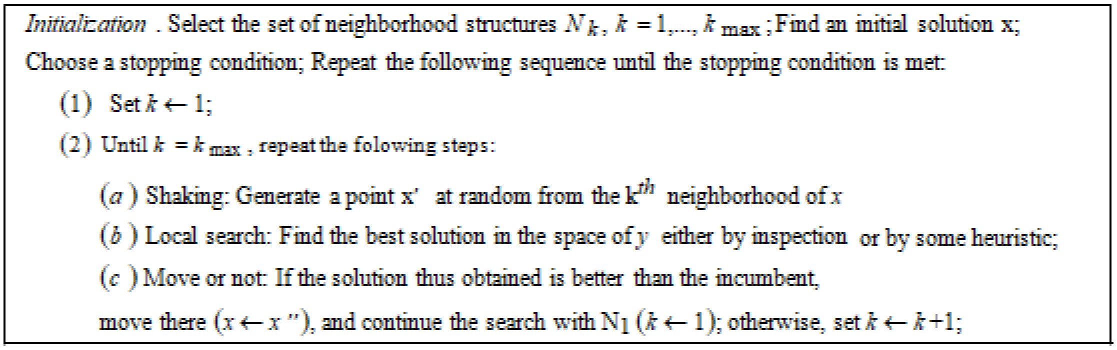


Figure 1. The schematic overview of the proposed hybrid solution algorithm structure



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Initialization . Select the set of neighborhood structures $N_k$, $k = 1,\ldots, k_{max}$; Find an initial solution x;
Choose a stopping condition; Repeat the following sequence until the stopping condition is met:
    (1) Set $k \leftarrow 1$;
    (2) Until $k = k_{max}$, repeat the folowing steps:
        (a) Shaking: Generate a point x' at random from the $k^{th}$ neighborhood of $x$
        (b) Local search: Find the best solution in the space of $y$ either by inspection or by some heuristic;
        (c) Move or not: If the solution thus obtained is better than the incumbent,
        move there ($x \leftarrow x''$), and continue the search with $N_1$ ($k \leftarrow 1$); otherwise, set $k \leftarrow k+1$;
```

Figure 2. The Pseudo-code of the proposed VNDS heuristic

Table 1 Proposed test problems

Parameters											Parameters										
Testproblems	I	K	L	M	P	N	T	β	λ	μ	Testproblems	I	K	L	M	P	N	T	B	λ	M
1	10	20	40	50	3	4	5	1	1	0.45	9	20	30	50	70	9	8	10	1	1	0.45
2	10	20	40	50	3	4	5	1	1	0.5	10	20	30	50	70	9	8	10	1	1	0.5
3	10	20	40	50	3	4	5	2	2	0.45	11	20	30	50	70	9	8	10	2	2	0.45
4	10	20	40	50	3	4	5	2	2	0.5	12	20	30	50	70	9	8	10	2	2	0.5
5	15	25	45	60	6	6	5	1	1	0.45	13	25	35	55	80	12	10	10	1	1	0.45
6	15	25	45	60	6	6	5	1	1	0.5	14	25	35	55	80	12	10	10	1	1	0.5
7	15	25	45	60	6	6	5	2	2	0.45	15	25	35	55	80	12	10	10	2	2	0.45
8	15	25	45	60	6	6	5	2	2	0.5	16	25	35	55	80	12	10	10	2	2	0.5

Table 2 Generation scheme of parameters of the proposed model

Parameter	Generation scheme	Parameter	Generation scheme	Parameter	Generation scheme
C_{ijnt}	[500,600]	E_{kt}	[1.6E+6,2.2E6]	Pr_{mpt}	[800,900]
C_{jkpt}	[300,500]	C_{lzt}	[1.6E+4,2.2E4]	Vs_{in}	1
C_{klpt}	[300,500]	D_{mpt}	[2.4E+6,3.3E6]	Vm_{lp}	1
C_{lmpt}	[300,500]	δ_{kt}	[1.0E+7,1.5E+7]	V_p	1
C_{mpt}	[900,1000]	Fs_{it}	[1.0E+10,1.5E+10]	α_p	[5E+5,7.5E+5]
θ_z	1	Fw_{kt}	[2.5E+11,3.0E+11]	β_p	[900,1000]
A_{it}	[3.2E+6,4.8E+6]	B_{jt}	[8E+5,1.2E6]		

Table 3 The design and noise factors for parameters turning using the Taguchi method

Design Factors	Algorithms	Levels		
	HNSG-PSO	Level1	Level2	Level3
NSGA-II iteration number	✓	300	400	500
NSGA-II population size	✓	50	75	100
Mutation rate	✓	30	20	10
Crossover rate	✓	50	60	70
VNDS iteration number		5	10	15
PSO1 operator rate	✓	50	70	30
PSO2 operator rate	✓	50	30	70
Fraction of full designed factorial experiments in Taguchi-based crossover		¼	1/2	1
Orthogonal array	$L_{27}(3^8)$			

Table 4 Results of investigating the solution quality of the proposed algorithm

Solution quality				Solution quality			
Test problem	HNSG-PSO	GAMS	Gap (%)	Test problem	HNSG-PSO	GAMS	Gap (%)
1	134653.01	131003.58	03.22	9	143233.10	394840.40	12.48
2	140035.47	126203.85	06.95	10	150071.10	385379.66	11.82
3	148816.33	129479.20	05.35	11	145446.16	373697.27	10.60
4	136256.04	134548.86	03.19	12	131029.09	388721.68	11.81
5	142576.76	255106.16	07.40	13	146327.95	494450.41	16.02
6	135262.57	264155.29	06.22	14	138280.27	462777.94	15.94
7	130982.17	257002.31	09.31	15	141763.69	468060.38	16.24
8	134034.75	250163.48	08.93	16	139149.57	441356.23	15.96

Table 5 Results of investigating the efficiency of the proposed HNSG-PSO

Test problem	HNSG-PSO		NSGA-VNS		NSGA-II		Test problem	HNSG-PSO		NSGA-VNS		NSGA-II	
	C1	C2	C1	C2	C1	C2		C1	C2	C1	C2	C1	C2
1	0.5421	32.12	0.2641	13.03	0.2047	9.81	9	0.9527	56.45	0.4642	22.90	0.3639	17.40
2	0.5834	34.57	0.2843	14.02	0.1882	10.19	10	0.8256	48.92	0.4023	19.85	0.2808	13.60
3	0.5811	34.43	0.2831	13.97	0.2251	11.08	11	0.7919	43.08	0.4718	24.09	0.3213	18.38
4	0.7279	32.97	0.3495	13.70	0.2377	10.06	12	0.9318	19.25	0.4519	8.89	0.3231	6.43
5	0.5484	18.26	0.3192	8.52	0.2477	5.74	13	0.8527	50.52	0.4155	20.50	0.3170	15.25
6	0.6507	38.56	0.3170	15.64	0.2349	11.89	14	0.8603	50.97	0.4192	20.68	0.3077	14.60
7	0.6812	40.36	0.3319	16.37	0.2363	13.03	15	0.8736	51.76	0.4257	21.00	0.3244	14.95
8	0.6531	41.72	0.3402	16.12	0.2324	11.32	16	0.7843	43.91	0.4708	24.18	0.3136	17.89

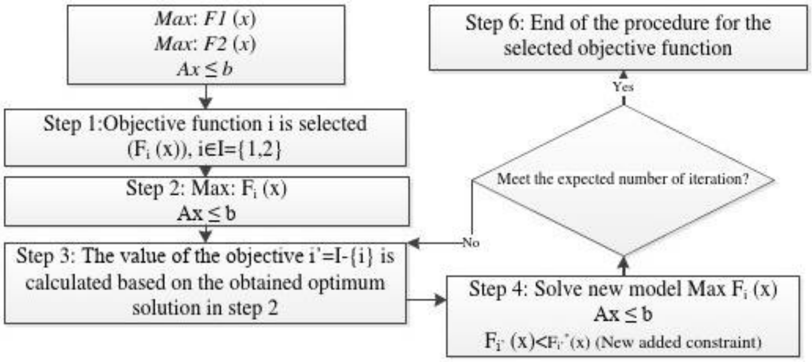

Figure 3. Procedure for investigating the behavior of optimizing one objective function against another one

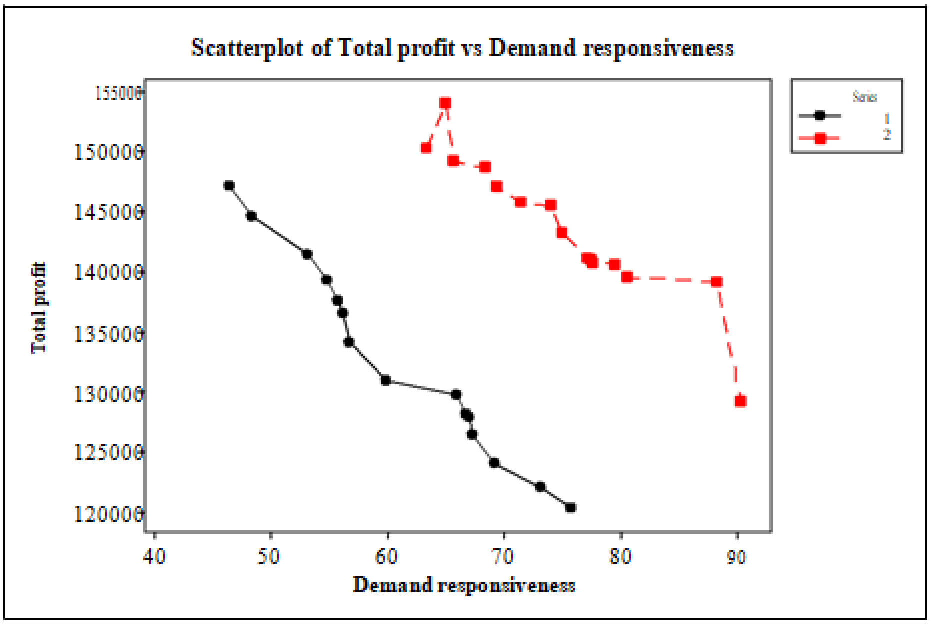

Figure 4. Conflict demonstration between two objective functions via optimizing the first and second objective function

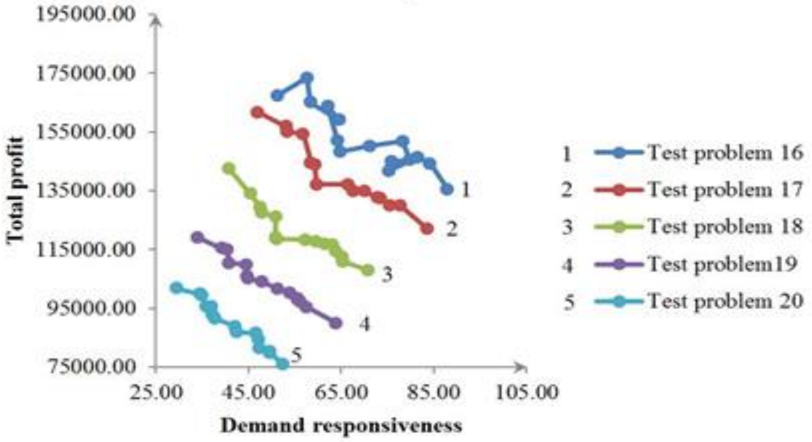

Figure 4. Pareto solution results of large-sized test problems 16-20

Conclusion

The SCND is a powerful modeling approach with potential of delivering a significant reduction in the supply chain costs and improvements in the service levels by better aligning strategies of supply chain management. In this study, to acquire the more and sustainable competitive advantages versus competitors, the guerrilla marketing strategy is considered in the strategic design of the supply chain network. Due to the characteristics of the marketplace such as the state of pre-existing competitors, a static competition is considered in the network design. The competition condition and attractiveness of facilities of the service providers are affected by the total demand, which is supplied by the pop-up stores. The aim of the proposed model is to maximize the total profit of the supply chain as well as the demand responsiveness concurrently. To tackle the proposed multi-objective model, a hybrid meta-heuristic algorithm incorporating the Taguchi-based NSGA-II and VNDS is proposed. The results of extensive experiments indicate the superior competitive advantages of considering the marketing strategies in the proposed SCND. In addition, the superiority of the proposed hybrid solution algorithm is investigated via comparing its performance with the other meta-heuristics. For further research, considering the other competition conditions, including foresight and dynamic competition, as well as considering the impact of the product price on the attractiveness of a service provider in the network design is proposed. Additionally, the uncertainty of the key parameters can be considered in the network design process. Finally, an efficient solution algorithm can be developed to tackle such a complex problem.

Declaration of Interests

The author declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Author Statement

The authors declare that all of us have seen and approved the final version of the manuscript being submitted. They warrant that the article is the authors' original work, hasn't received prior publication and isn't under consideration for publication elsewhere.

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