Analysis and modeling of supply chain management of fresh products based on genetic algorithm

Yaoting Chen^{1,2} · Huanting Chen³

Received: 2 August 2021 / Revised: 14 September 2021 / Accepted: 26 September 2021 / Published online: 9 November 2021
© The Society for Reliability Engineering, Quality and Operations Management (SREQOM), India and The Division of Operation and Maintenance, Lulea University of Technology, Sweden 2021

Abstract The important factor for the supply chain management of fresh products is partner selection. Environment protection is also an important factor, however the factor is not taken into account by the traditional supplier selection. Therefore, the supplier selection standard includes the green standard in this paper. Our work is to investigate an optimal mathematical modeling for green partner selection. The four targets of the proposed model are cost, product quality, green appraisal score and time. The proposed genetic algorithm with multi-targets are to search the set of optimum solutions using by weighted sum method. The proposed model introduces a supply chain network structure to analysis average number Pareto-optimal solutions with genetic algorithm for the four problems. It is pointed out that the variation of f_2 and f_3 with f_1 and f_4 is kept within obvious ranges. This practical result highlights the fact that the effects of the fact that effects of f_2 and f_3 are important factors affecting the performance supply chain network of fresh product.

Keywords Supply chain management(SCM) · Fresh product · Genetic algorithm (GA) · Multi-targets · Weighted sum method

1 Introduction

A supply chain of fresh products is related to climate in farmland; the quantity of fresh products is as function of increasing process which is scarcely manageable; the wastage procedure of any fresh products begins just after harvested and is related to the handling process; and all fresh products should be directly expended by customers or used for the purpose of materials. It is regretful that the wastage is about 30–50% of produce (Widodo et al. 2006; Chan et al. 2015). A lot of wastage is caused by non-match between reap and supply chain in capacity and timing. Therefore, practitioners and academicians pay more attention to SCM of fresh products (Jones and Riely 1985; Clark and Scarf 1960), issues on fresh products are not managed sufficiently and keep unsolved because of the above intrinsic characteristics.

Improvement chain ability is limited by the indefinite factors to do with making decision. The indefinite factors are included machine breakdowns, late deliveries, leads to increased inventories, unnecessary slack time, additional capacities or order cancellations (Zhou et al. 2015; Murray et al. 2009; Inkaya and Akansel 2017). The indefinite factors that pest complex relationship is a practical issue. It is uncertainty to discover corrective action to decrease. Supply chain provides the chance to enhance chain performances by decrease these uncertainties. It is a demand for certain extent of integrate of exercise and procedure within and between organization in the SCM to decrease non-determinacy and increase more cost for customers. The key properties in the process are related to the synchronization, elimination or the availability of information and decrease of time consumption.

✉ Yaoting Chen
chenyaoting23@163.com

¹ School of Business, Minnan Normal University, Zhangzhou 363000, China

² Analysis and Application for Business Big Data of Fujian Provincial Key Laboratory, Zhangzhou 363000, China

³ College of Physics and Information Engineering, Minnan Normal University, Zhangzhou 363000, China

Supply chain of fresh product should conform to service demand of final customer. It includes location stock along the supply chain and stock. It expands proper policies and sequences for SCM of fresh product as a single entity (Yeh and Chuang 2011; Ghasimi et al. 2014; Houtum et al. 1996). It is opposite to administer one part; a condition in which every part is mainly only related to its immediate suppliers and clients. Research worker have put attention on building the model for multi-level system. Simulation technique is a powerful methodology for complex problems because every stage of system can be modelling and networks with multi-effects is included (Chen et al. 2015). Supply chain management of fresh product includes a large field of modeling that is from simplified type of product to complex multi-system. It is also from linear-programming method to nonlinear-programming system. Several different optimization algorithms have been proposed, such as genetic algorithm, in supply chain management of fresh product. It can resolve the problems by integer programming, nonlinear programming, mixed-integer programming, fractional programming, multi-objective nonlinear programming, multi-objective integer linear programming etc. (Rasheed et al. 2021; Wilson 1995; Abdinnour 1999; Kazemi et al. 2009). The focus of supply chain management for fresh product are the production programme, the apportion and material flow. The production programme includes the control and administration of total production procedure. The apportion and material flow process confirm how products are recovered and moved from the factory or warehouse to customer. The procedure covers the controlled of stock search, transportation system, and final stock sender (Beamon 1998).

Multi-level stock/spread systems are investigated (Tatavarthy and Sampangi 2015). Integrate programming among several levels of the supply chain and location special stress on method for the chain modelling. It is not easy to build models and algorithms for stock principle of multi-level systems with random require and cyclic order. It is investigated that two-level spread system on Poisson demand and same retail location. It expands a similar modeling of system performance or costs with inventory levels. It is better understanding of underlying behaviors based on analytical model. A single firm is investigated using by a developed multi-period model, and minimization total cost subordinate to a discharge restrain of the time range is the objective (Atabaki et al. 2017). The proposed model is related with the advantage of having discharge mobility from duration to duration. Since practical lost are achieved over time, it is opportunity for the firm to change duration discharge goal. The mobility is revealed to decrease costs through the time range (Coello et al. 2001; Abdulah 2020).

Knowledge management requests/incidents/problems and existing monitoring tools can all be integrated to provide the support staff with possible solutions. It will explain how dashboards can assist Information and Communications Technology (ICT), with the focus on production support areas, to help resolve ICT incidents, problems, and requests (Amit et al. 2021). Kubernetes Container Scheduling Strategy (KCSS) based on Artificial Intelligence (AI) that can assist in decision making to control the scheduling and shifting of load to nodes. The aim to improve the container's schedule requested digitally from users to enhance the efficiency in scheduling and reduce cost (Diaz et al. 2021). A machine learning-based health-care model for accurate and early detection of diabetics is proposed (Kishor and Chakraborty 2021). Fast correlation-based filter feature selection is used to remove the irrelevant features. The synthetic minority over-sampling technique is used to balance the imbalanced dataset.

The weak points of current method are the issues that a great deal of constraints should be content prior to outcome should be used to practices. Most modeling only include few parameters, such as cost of exhaust of inventory, and neglect other parameters such as transportation, form handing. These methods ignore volume limitations and non-correlated hand systems. It did not include the convoluted data networks that happen when advanced position has not been able to give serve to downstream non-advanced position (Nakamba et al. 2017; Mani and Gunasekaran 2018), and this is the nature of SCM of fresh product. SCM of fresh product definitely concentrates on the correlated double-level paths of products (services and materials) and data with linking operational and Administrative actions to acquire a high level of mobility. Our work proposes a multi-level model with genetic algorithm for investigation supplier choose and manufacture roll traffic issue. Supply chains prove to be contended and the path to viability is to analysis the path benefit and sever the benefit for the factors included in the proposed model. Therefore, our work put to use the weighted sum method to achieve the optimal settle providing the maker policy to estimate different methods.

2 Analysis flow path of supply chain network

Producing fresh product of company in at Zhangzhou is studied. Supplier choose and storehouse of the company is to be select. It should content market requirement and volume limitations. Figure 1 is the flow path of supply chain network problem.

A multi-target optimal method can concurrently resolve different targets with customer satisfaction maximization and cost minimization. It can be put into use for the

Fig. 1 Flow path of supply chain network problem

purpose of choose suppliers of the supply chain. The multi-target optimal model includes a lot of optimum process which are Parato-optimal solutions (Imane 2020). It can be expressed as in the following. Interventionary studies involving animals or humans, and other studies that require ethical approval, must list the authority that provided approval and the corresponding ethical approval code.

If a minimized factor and two parameters $\mu = \{\mu_1, \mu_2, \dots, \mu_m\}$ and $v = \{v_1, v_2, \dots, v_m\}$ are considered. If μ is assumed as dominate v , and if

$$\forall i \in \{1, \dots, m\}, \mu_i \leq v_i \wedge \exists i \in \{1, \dots, m\} : \mu_i < v_i \quad (1)$$

where m is target enclosure.

All parameters are not guided by another decision vector of a given installation. It is call Pareto-optimal installation or non-dominated installation. Target-programming, target attainment, direction method and distance- method can be used as resolving multi-level issue (Mark et al. 2020; Lee et al. 2016). In this paper, genetic algorithm was used to acquire Pareto-optimal resolving for multi-level target. A multi-level method is proposed that included four targets and nine parameters in the model. Four targets are maximization of green appraisal scores, minimized time, minimization of the total cost and maximized average product quality respectively. There are some assumptions used in the model in the following. It assumes that required amount of all demand sides is available. Minimum boot-strap procreative volume and maximized procreative volume exist in attachment storing. The suppliers should recognize regulation fore if storing number is between minimum boot-strap producing capacity and maximum procreative volume. Transportation amount is not related to transportation cost. Unbalanced property between necessity sum from customers in each stage of supply chain and accessory amount provided by suppliers is caused by producing losses. The proposed model included transportation loss rate and product yield rate for the losses. The objectives and used parameters of proposed model can be expressed as in the following. Optimal precise modeling for deficient supply chain network.

$$\begin{aligned} \text{Min}f_1 = & \sum_{i=1}^{I-1} \sum_{j=1}^J \left\{ \sum_{r=1}^R \left[PC_{ij}^r \left\| \frac{\sum_{Z=1}^Z Q_{(i,j)}^{(i+1,k)n}}{J_{ij}} \right\| \right] \right. \\ & \left. + \sum_{k=1}^K \sum_{r=1}^R \left(TC_{(i,j)(i+1,k)} Q_{(i,j)(i+1,k)}^r \right) \right\} \end{aligned} \quad (2)$$

$$\begin{aligned} \text{Min}f_2 = & \sum_{i=1}^{I-1} \sum_{j=1}^J \left\{ \sum_{r=1}^R \left[PT_{ij}^r \left\| \frac{\sum_{k=1}^K Q_{(i,j)}^{(i+1,k)n}}{J_{ij}} \right\| \right] \right. \\ & \left. + BT_{ij} \sum_{k=1}^K \sum_{r=1}^R \left(Q_{(i,j)(i+1,k)}^r \right) \right\} \end{aligned} \quad (3)$$

$$\text{Min}f_3 = \sum_{i=1}^{I-1} \sum_{j=1}^J \left\{ \sum_{r=1}^R AQ_{(i,j)} \right\} N_{ij} \quad (4)$$

$$\text{Min}f_4 = \sum_{i=1}^I \sum_{j=1}^J \sum_{q=1}^{24} w_q H_{ij}^q N_{ij} \quad (5)$$

Equations (2)–(5) gives the targets of the proposed model. For the purpose of calculated outcome is knowing clearly, the last two targets of four targets are transformed into minimized. If (2) is the all expense of the green supply chain, (3) is the all stated, (4) and (5) provide the targets about outcome mean product character and evaluation grades.

Where x can be defined as supply chain level ($i = 1, 2, \dots, I$). y can be defined as partner j of level i ($x = 1, 2, \dots, I$; $j = 1, 2, \dots, J$). k can be defined as partner k of level i ($i = 1, 2, \dots, I$; $k = 1, 2, \dots, K$). r can be defined as the outcome code of supply chain system ($r = 1, 2, \dots, R$).

Where N_{ij} can be defined as if supply chain comrade j of level i has work, N_{ij} is 1. Other, N_{ij} is 0. This parameter decides whether of comrade j of level i will be chosen or not. $Q_{(i,j)(i+1,k)}^k$ can be defined as the volume carried from of comrade j of level i to level k of level $i + 1$ among the n -th outcome.

Where $K_{(i,j)(i+1,k)}$ can be defined as transportation failure coefficient from of level j of level i to level k of stage $i + 1$. $L_{x,y}$ can be defined as least working outcome volume of comrade j of level i . $U_{x,y}$ can be defined as most least working outcome volume of comrade j of level i . IRI can be defined as intact value of R . J_{ij} can be defined as outcome crop coefficient of level j of level i . PC_{ij}^n can be defined as level j of level i among the n -th outcome parts fabricating cost. $TC_{(i,j)(i+1,k)}$ can be defined as part transportation expense of comrade j of level i to comrade j of level $i + 1$. BT_{ij} can be defined as passel transportation periodic of comrade j of level i . $D_{i,k}^n$ can be defined as market demand of the n -th outcome on comrade k of level i . AQ_{ij} can be defined as comrade j of level i among the n -th outcome average crop character. S_{ij} can be defined as green evaluation lots of comrade j of level i .

Where H^1_{ij} can be defined as customer's buy or not of comrade j of level i . If customers are going on with purchase, H^1_{ij} is 1. And H^1_{ij} is 0 with other situation. H^2_{ij} can be defined as green customer's outlet partake of comrade j of level i . If the value is above 80%, H^2_{ij} is 1; if the value is between 60 and 80%, H^2_{ij} is 2; if the value is between 40 and 60%, H^2_{ij} is 3; if the value is between 20 and 40%, H^2_{ij} is 4; if the value is less than 20%, H^2_{ij} is 5. H^3_{ij} can be defined as passing ISO14000 validation of comrade j of level i . If it is passing, H^3_{ij} is 1; if it is more than 50%, H^3_{ij} is 2; if it is less than 50%, H^3_{ij} is 3; if it is not passing yet, H^3_{ij} is 4. H^4_{ij} can be defined as having surrounding conservation policies of comrade j of level i . If it has done, H^4_{ij} is 1; if it is more than 50%, H^4_{ij} is 2; if it is less than 50%, H^4_{ij} is 3; if it is none, H^4_{ij} is 4. H^5_{ij} can be defined as having surrounding conservation policies of comrade j of level i . If it has done, H^5_{ij} is 1; if it is more than 50%, H^5_{ij} is 2; if it is less than 50%, H^5_{ij} is 3; if it is none, H^5_{ij} is 4. H^6_{ij} can be defined as having withdrawing manufacturing design of comrade j of level i . If it has done, H^6_{ij} is 1; if it is more than 50%, H^6_{ij} is 2; if it is less than 50%, H^6_{ij} is 3; if it is none, H^6_{ij} is 4. H^7_{ij} can be defined as having renewable manufacturing design of comrade j of level i . If it has done, H^7_{ij} is 1; if it is more than 50%, H^7_{ij} is 2; if it is less than 50%, H^7_{ij} is 3; if it is none, H^7_{ij} is 4. H^8_{ij} can be defined as manufacturing withdrawing centage of comrade j of level i . If it is more than 80%, H^8_{ij} is 1; if it is between 70 and 80%, H^8_{ij} is 2; if it is between 60 and 70%, H^8_{ij} is 3; if it is between 50 and 60%, H^8_{ij} is 4; if it is less than 50%, H^8_{ij} is 5. H^9_{ij} can be defined as having contrary logistics system of comrade j of level i . If it has done, H^9_{ij} is 1; if it is more than 50%, H^9_{ij} is 2; if it is less than 50%, H^9_{ij} is 3; if it is none, H^9_{ij} is 4. H^{10}_{ij} can be defined as cube garbage of comrade j of level i . H^{11}_{ij} can be defined as vitality expense of comrade j of level i . H^{12}_{ij} can be defined as air contamination of comrade j of level i . H^{13}_{ij} can be defined as spare water of comrade j of level i . H^{14}_{ij} can be defined as led list of electric and electronic facility of comrade j of level i . H^{15}_{ij} can be defined as mercury bulk of electric and electronic facility of comrade j of level i . H^{16}_{ij} can be defined as hexavalent chromium bulk of electric and electronic facility of comrade j of level i . H^{17}_{ij} can be defined as polybrominated biphenyl bulk of electric and electronic facility of comrade j of level i . H^{18}_{ij} can be defined as polybrominated biphenyl ether bulk of electric and electronic facility of comrade j of level i . H^{19}_{ij} can be defined as cadmium bulk of electric and electronic facility of comrade j of level i . H^{20}_{ij} can be defined as solid garbage disposal expend of comrade j of level i . H^{21}_{ij} can be defined as chemical garbage disposal expend of comrade j of level i . H^{22}_{ij} can be defined as air contamination disposal expend of comrade j of level i . H^{23}_{ij} can be defined as water contamination disposal expend of comrade j of

level i . H^{24}_{ij} can be defined as energy disposal expend of comrade j of level i .

$$L_{ij}N_{ij} \leq \sum_{k=1}^K \sum_{n=1}^N Q^n_{(ij)(i+1,k)} \leq U_{ij}N_{ij} \quad (6)$$

$$L_{i,k}N_{i,k} \leq \sum_{j=1}^J \sum_{n=1}^N Q^n_{(ij)(x+1,z)} \leq U_{s,i,k}N_{i,k} \quad (7)$$

where Eqs. (6) and (7) indicate the restriction of comrade's outcome volume

$$\sum_{j=1}^J \| J_{i+1,k} (1 - K_{(ij)(i+1,k)}) Q^n_{(ij)(i+1,k)} \| = D^n_{i+1,k} \quad (8)$$

$$\sum_{j=1}^J \| J_{i,k} (1 - K_{(ij)(i+1,k)}) Q^n_{(ij)(i+1,k)} \| = \sum_l^{L+4} Q^n_{(i+1,k)(i+2,l)} \quad (9)$$

where Eqs. (8) and (9) provide the satisfaction of warehouses and customer requirements for the product.

$$H^8_{ij} < 4 \quad (10)$$

where Eqs. (10) indicate the outcome withdrawing coefficient of comrade j of level i is less than 4

$$H^{14}_{ij}, H^{15}_{ij}, H^{16}_{ij}, H^{17}_{ij}, H^{18}_{ij} \leq 1000 \quad (11)$$

where Eq. (11) shows the level i 's supplier j 's electrical and mercury, cadmium and hexavalent chromium, polybrominated biphenyl, electronic equipments's led, polybrominated diphenyl ether property is less than 1000 ppm.

$$H^{12}_{ij} \leq 100 \quad (12)$$

where Eq. (12) indicates level i 's supplier j 's electric and electronic facility' cadmium property is less than 100 ppm.

$$Q^n_{(ij)(i+1,k)} \geq 0 \quad (13)$$

where Eq. (13) indicates the non-negative limitation on decision parameter $Q^n_{(ij)(i+1,k)}$.

$$N_{ij} \in \{0, 1\} \quad (14)$$

where Eq. (14) indicates the integrality limitation on decision parameter N_{ij} . Because there is non-linear performance for the target, the non-linear model with compound formulation is proposed in our work.

3 Proposed modeling

The evaluation process for supply chain of fresh products based on genetic algorithm is developed. The flow chart of genetic algorithm used to search optimum mathematical planning model is shown in Fig. 2. It is highly important

Fig. 2 Flow chart of GA used to search optimum mathematical planning model

for the crossover and mutation factors in the genetic algorithm. The crossover and mutation modules can finish invention of new solutions. The possibility of the crossover is the key factors in the crossover actions. The certain chromosomes are chosen in the initial selection step would go through the crossover action and emerge offspring. The objective of mutation is to maintain variety and it prevents local optima trap. The effect of mutation should enhance this effectively. The mutation swaps the gene within the customers in the chromosome for uphold the practicability.

$$f'_i = \frac{f_i - f_i^{min}}{f_i^{max} - f_i^{min}} \quad (15)$$

where f_i^{min} and f_i^{max} are the minimum and the maximum value of i th target function. It should refresh a experimental unit of optimum solutions after first iteration.

The relevance $f(x)$ of every group are calculated using by Eqs. (16) and (17) in the following.

$$f(x) = w_1 f_1(x) + w_2 f_2(x) + \cdots + w_n f_n(x) \quad (16)$$

$$w_i = \frac{rnd_i}{\sum_{i=1}^n rnd_i} \quad (17)$$

where $f(x)$ is a welded fitness function, x is a chromosome, w_i is a permanent significance for $f_i(x)$, $f_i(x)$ is the i th target function, and n is the degree of the target function. rnd_i and rnd_j are non-passive arbitrary numbers.

A pack of chromosomes from the population can be selected based on the coming picking possibility. The picking possibility can be obtained using by Eqs. (18) and (19).

$$P(x) = \frac{f(x) - f_{\min}(\psi)}{\sum_{x \in \psi} \{f(x) - f_{\min}(\psi)\}} \quad (18)$$

$$f_{min}(\psi) = \min\{f(x)|x \in \psi\} \quad (19)$$

A creation with the crossover possibility is generated based on the crossover operation. The optimum parameter of every target is considered as a worthy solution for multi-target optimization problem. The proposed model can preserve these solutions to the following reproduction. Thereby, n chromosomes form present population can be

removed using by the elitist strategy. It can add the identical code of groups from an experimental unit of optimum solutions. Until the iteration times is reached, or repeated assessment, choice, crossover, mutation and elitist strategy. The unit of optimum solutions can be acquired using by the multi-target optimum algorithm. It can choose the best solutions. It should be pointed out that the fundamental discriminate property of a genetic algorithm is applied crossover. The position of single-point crossover is selected randomly. Two parents cross the crossover position are interchanged to product two offspring. The purport is to combine fresh products with different customer satisfaction maximization and cost minimization. To reduce product cost, two positions of crossover in genetic algorithm are selected randomly.

The portion between two positions of crossover is exchanged. Two-point crossover is unable to disrupt model with big definition size. The form of crossover can link to more pattern compared to single-point crossover. In addition, the interchange patterns do not necessarily include the extreme points of the strings. The success or failure of a particular crossover operator is related to complex methods on the specific fitness function, code, and other details of the genetic algorithm. It is clearly important for open problem to fully understand these interactions. Several researchers indicate different fields of various crossover operators (local bias, wreck potential, ability to create different schemas in one step) quantitatively using by genetic algorithm. It is unable to provide any critical conduct on when to use which type of crossover. Different types of crossovers are empirically compared. It depends on particular small suites of measurement functions, and different investigates produce different results (Gen and Syarif 2005; Barnes et al. 2006; Rizk et al. 2006).

4 Simulation results and discussion

The proposed model of this paper is to analysis and model of supply chain of fresh products partner and outcome bulk carriage. The problem is analyzed using by a multi-target optimization algorithm. It can get the unit of optimum solutions providing to the best decision to select according to the proposed model. The concept of the system is shown in a {4,4,4,4} supply chain network. There is part carriage expend, supreme volume, different yield and minimum for each supplier. And every channel should be carriage channel. The supply chain network includes four outcomes. Table 1 shows desire content of each outcome of each customer.

The fresh products supply chain network conundrum with three and four targets are to evaluated, thus the initial conundrum is divided into four conundrums. The original problem is diverse from the four conundrums. All constraints of the original conundrum with different objectives are the same. The four conundrums are shown in the following.

Conundrum 1 can be considered as minimum among f_1 , f_2 and f_3 . Conundrum 2 can be considered as minimum among f_1 , f_3 and f_4 . Conundrum 3 can be considered as minimum among f_2 , f_3 and f_4 . Conundrum 4 can be considered as minimum among f_1 , f_2 and f_4 . Conundrum 5 can be considered as minimum among f_1 , f_2 , f_3 , and f_4 .

Table 1 Desire content of each outcome of each customer

Customers	Desire content of each outcome			
	Type-A	Type-B	Type-C	Type-D
Customers-4.1	30	45	55	65
Customers-4.2	35	60	45	65
Customers-4.3	40	55	70	50
Customers-4.4	45	70	75	60

Table 2 Simulated results of the four conundrums

Customers	Simulated results				
	Average number of Pareto-optimal solutions	Generation size	Population size	Crossover probability	Mutation probability
Customers-4.1	7.5	200	400	0.6	0.04
Customers-4.2	9.2	200	400	0.6	0.04
Customers-4.3	7.9	200	400	0.6	0.04
Customers-4.4	5.3	200	400	0.6	0.04

The mutation probability, population size, generation size, and crossover probability of the parameters in genetic algorithm for the four conundrums is 0.04, 400, 200, and 0.6 respectively. Simulated results of the above four conundrums are given on Table 2. All coefficients are decided after preparation simulations. We utilized the mean number of optimum solutions to assess performances of proposed modeling. The mean number of optimum solutions for the four conundrums is 7.5, 9.2, 7.9 and 5.3 respectively.

The calculated results for conundrum 1 with the value of objective 1, 2 and 3 (f_1 , f_2 and f_3) are shown in Fig. 3. The value of objective 1 (f_1) performs approximately linearly with the decreasing the value of objective 2 (f_2) and decreasing the value of objective 3 (f_3). At the value of objective 1 of 3.2×10^5 , f_2 and f_3 is about 4.3×10^5 and 86. When the value of objective 1 is increased to 7.6×10^5 , the minimum f_2 is about 3.0×10^5 and the minimum f_3 is about 38.

Fig. 3 Calculated results for conundrum 1 with the value of objective 1, 2 and 3 (f_1 , f_2 and f_3)

The calculated results for conundrum 2 with the value of objective 1, 3 and 4 (f_1, f_3 and f_4) are shown in Fig. 4. The value of objective 1 (f_1) performs approximately linearly with the decreasing the value of objective 3 (f_3) and decreasing the value of objective 4 (f_4). At the value of objective 1 of 3.2×10^5 , f_3 and f_4 is about 86 and 5.6×10^4 . When the value of objective 1 is increased to 7.6×10^5 , the minimum f_3 is about 38 and the minimum f_4 is about 2.6×10^4 . It is noted that the value of objective 1 is increased from 6.4×10^5 to 7.6×10^5 , the variation of f_3 and f_4 is 17.3% and 3.3% respectively.

The calculated results for problem 3 with the value of objective 2, 3 and 4 (f_2, f_3 and f_4) are shown in Fig. 5. The value of objective 2 (f_2) performs approximately linearly with the increasing the value of objective 3 (f_3) and increasing the value of objective 4 (f_4). At the value of objective 2 of 4.3×10^5 , f_3 and f_4 is about 86 and 5.6×10^4 . When the value of objective 2 is decreased to 3.0×10^5 , the minimum f_3 is about 38 and the minimum f_4 is about 2.6×10^4 . It is noted that the value of objective 2 is decreased from 3.5×10^5 to 3.0×10^5 , the variation of f_3 and f_4 is 26.9% and 5.1% respectively.

The calculated results for problem 4 with the value of objective 1, 2 and 4 (f_1, f_2 and f_4) are shown in Fig. 6. The value of objective 1 (f_1) is inversely proportional to value of objective 2 (f_2). The value of objective 1 (f_1) with objective 4 (f_4) is closely related to and directly proportional relationship. The variation range of objective 1 (f_1) is 43.4%, the variation range of objective 2 (f_2) reach 78.9%. If variation range of objective 1 (f_1) is 6.3%, the variation range of objective 4 (f_4) reach 18.9%.

The calculated results for conundrum 5 with the value of objective 1, 2, 3 and 4 (f_1, f_2, f_3 and f_4) are shown in Fig. 7. The value of objective 1 (f_1) performs approximately nonlinearly with the increasing the value of objective 2,3

Fig. 5 Calculated results for conundrum 3 with the value of objective 2, 3 and 4 (f_2, f_3 and f_4)

Fig. 6 Calculated results for conundrum 4 with the value of objective 1, 2 and 4 (f_1, f_2 and f_4)

Fig. 4 Calculated results for conundrum 2 with the value of objective 1, 3 and 4 (f_1, f_3 and f_4)

Fig. 7 Calculated results for conundrum 5 with the value of objective 1, 2, 3 and 4 (f_1, f_2, f_3 and f_4)

and 4 (f_2, f_3 and f_4). At the value of objective 1 of 3.2×10^5 , f_2, f_3 and f_4 is about 4.3×10^5 , 86 and 5.6×10^4 . When the value of objective 1 is increased to 7.6×10^5 , the minimum f_2, f_3 and f_4 is about 3.0×10^5 , 38 and 2.56×10^4 . It is noted that the value of objective 1 is increased from 6.4×10^5 to 7.6×10^5 , the variation of f_2, f_3 and f_4 is 11.7, 17.4 and 3.4% respectively. It is pointed out that the variation of f_2 and f_3 with f_1 and f_4 is kept within obvious ranges. This practical result highlights the fact that the effects of the fact that effects of f_2 and f_3 are important factors affecting the performance supply chain network of fresh product.

Several important observations should be pointed out from calculated results from Fig. 7.

- (1) Fig. 7 relates the green appraisal score to transportation time, total time comprised of product time, mean outcome capability and transportation expend comprised of product cost together. It is results that integrates green appraisal score and supply chain factors of fresh product in E-commerce environment altogether.
- (2) Supply chain management manufactures for fresh product can use green appraisal score, product time, mean outcome capability and transportation expend to quantify the overall supply chain efficiency of fresh product in E-commerce environment. The proposed algorithm quantitatively optimal the relationship of green appraisal score, transportation time, total time comprised of product time, mean outcome capability and transportation expend comprised of product cost.
- (3) If transportation time and total time comprised of product time is facultative, a large mean outcome capability can be chosen for fresh product in E-commerce environment in order to effectively increase green appraisal score with reduction transportation expend comprised of product cost.
- (4) The Fig. 7 is based on multi-target genetic algorithm for evaluation supply chain of fresh products in E-commerce environment. The proposed modeling is obtained from a series of objectives evaluation as shown in Fig. 3–6. It should be pointed out that objectives coefficients of the proposed modeling are specific parameters for fresh product sample and not properties of the fresh product material. The different type or manufacturer on the fresh product in E-commerce environment should repeat calculated steps.

As seen in results, the fuzzy logic controlled genetic algorithm has obtained better solutions for all test problems. Some test problems have more computation time, since the general algorithm is not tuned and tuning time is not considered during the run process, however, the

computation time of proposed model includes the tuning time during the process. The pop size and max iteration and crossover rate is set as 400, 200 and 0.6 respectively. As the crossover rate changed, a gap about 0.2% is occurred for the general algorithm, while the solution obtained by the proposed model has not any gap. According to results is obtained in proposed model in less computation time. As another aspect, although the aim of the proposed model is maximizing green appraisal score and mean outcome capability, since the model considers minimization of transportation time and transportation expend, which is important issue. These periods are obtained for the test problem by general algorithm and proposed model. As results, the proposed model gives a better introduction time and overall performance.

The proposed model for supply chain management of fresh products aims to minimize logistics and production costs by integrating and managing capital and information flows. The fresh product system of smart city includes distributed manufacturing, logistics and spatial dispersed units, which cooperate and communicate over processes and networks in order to achieve the optimum manufacturing output to meet city demand. It is subject to principles and modes of complex structures which differ to scale-based production system. The city can be treated as a complex system, which are composed of many subsystems, and supply chain management of fresh products are one such important subsystem. The smart city manufacturing is an emerging trend that on the one hand, while it provides a minimum waste solution to that of the just-in-time system based on speed, its supply chain will operate on much lower scale volumes and be configured by actual city demand. The smart city requires a reconfiguration of supply chains because fresh product is more integrated in nature due to consolidation of production processes, hence eliminating supply chain nodes. It also brings changes to supply chain governance because collaboration with supplies is required. The characteristics of these technologies include: quick response to demand especially with the application of Industrial Internet of Things (IIOT) and Big Data; consolidation poof varied process; production of products with minimum modularity. The smart supply chain management of fresh products will involve the design of a model that improves the efficiency of relevant processes. An efficient model is presented that allows processes to more efficiently move fresh products closer to urban nucleus, prompting the evolution of a smart city into a smart territory. We believe that the greatest impact of the COVID-19 pandemic in the short term will be felt through the realignment of fresh produce supply chains due to the closure of nearly all foodservice outlets. As consumers move to buying fresh product almost completely through E-commerce environment, distribution infrastructure

specific to retail will remain strained throughout the spread of the disease and will test supply-chain relationships for some time after. Over the longer term, the potential impacts will be felt through input markets, most notably labor, and through structural changes in the industry, which may undergo fundamental and largely irreversible shocks, such as consolidation and a move toward online shopping. The proposed modeling of the paper provides a tool to evaluate supply chain management of fresh product in E-commerce environment under the impact of the COVID-19 pandemic.

5 Conclusions

The paper used a multi-target genetic algorithm for evaluation supply chain of fresh products in E-commerce environment. Four objectives for optimal process are included in the proposed model: (1) maximization of green appraisal score, (2) minimization of transportation time and total time comprised of product time, (3) maximization of mean outcome capability, (4) minimization of transportation expend and all expend comprised of product cost. For the purpose of evaluation optimal process, unit of optimum solutions for the policy maker is obtained based on the weighted sum method. The value of four objective with each problem is calculated using by genetic algorithm. In the future work, a modified weight sum method can be investigated for optimal process with uncertainty of costs and demands.

Funding Natural Science Foundation of Fujian Province (Grant Number: 2020J01820), National Natural Science Foundation of China (Grant Number: 61975072), Industry-University-Research Collaboration Foundation of the Fujian Province (Grant Number: 2020H6017), Social Science Foundation of the Fujian Province (Grant Number: FJ2019B143) and Science Foundation of the Zhangzhou (Grant Number: ZZ2019J15). Program for Innovative Research Team in Science and Technology in Fujian Province University (Optoelectronic Materials and Device Application), Natural Science Foundation of the Fujian Higher Education Institutions (Grant Number: JAT200316) National College Students' innovation and entrepreneurship training program (Grant Number: 202010402017, 202110402011).

Declarations

Conflict of interest The authors declare that they have no conflict of interest.

References

- Abdinnour HS (1999) Network design in supply chain management. *Int J Agile Manage Syst* 1:99–106
- Abdulah AA (2020) Minimizing the bullwhip effect in a supply chain: a simulation approach using the beer game. *Simul t Soc Mod Sim* 2:737–752
- Amit S, Lalit G, Chinmay C (2021) Improvement of system performance in an IT production support environment. *Int J Syst Assur Eng Manag* 12:461–479
- Atabaki MS, Mohammadi M, Naderi B (2017) Hybrid genetic algorithm and invasive weed optimization via priority based encoding for location-allocation decisions in a three-stage supply chain. *Asia Pac J Oper Res* 34:175008–175014
- Barnes SD, Bassok Y, Anupindi R (2006) Optimizing delivery lead time-inventory placement in a two-stage production/distribution system. *Eur J Oper Res* 173:1664–1684
- Beamon BM (1998) Supply chain design and analysis: models and methods. *Int J Prod Econ* 55:281–294
- Chan F, Han C, Montri D (2015) Stochastic modeling of a two-echelon multiple sourcing supply chain system with genetic algorithm. *J Manuf Technol Mana* 16:87–108
- Chen HT, Tan SC, Hui SYR (2015) Analysis and modeling of high-power phosphor-coated white light-emitting diodes with large surface area". *IEEE Trans Power Electron* 30:3334–3344
- Clark AJ, Scarf H (1960) Optimal policies for multi-echelon inventory problem. *Mana Sci* 40:475–490
- Coello CAC, Veldhuizen DAV, Lamount GB (2001) Evolutionary algorithms for solving multi-objective problems. Publishers, Kluwer. Academic
- Diaz JM, Shariq AB, Edeh MO, Chinmay C, Qaisar S, Emiro DLHF, Paola AC (2021) Artificial intelligence-based Kubernetes container for scheduling nodes of energy composition. *Int J Syst Assur Eng Manag* 7:56
- Gen M, Syarif A (2005) Hybrid genetic algorithm for multi-time period production-distribution planning. *Comput Ind Eng* 48:799–809
- Ghasimi SA, Ramli R, Saibani N (2014) A genetic algorithm for optimizing defective goods supply chain costs using JIT logistics and each-cycle lengths. *Appl Math Model* 38:1534–1547
- Houtum V, Inderfurth GJ, Zijm K (1996) Materials coordination in stochastic multi-echelon systems. *Eur J Oper Res* 95:1–23
- Imane IEF (2020) Imane, M; Youness, F; Jabir, A; Fouad, J; Proposing a supply chain collaboration framework for synchronous flow implementation in the automotive industry: a Moroccan case study. *Information* 11:431
- Inkaya T, Akansel M (2017) Coordinated scheduling of the transfer lots in an assembly-type supply chain: a genetic algorithm approach. *J Intell Manuf* 28:1005–1015
- Jones TC, Riely DW (1985) Using inventory for competitive advantage through supply chain management. *Int J Phys Distri Mat Mana* 15:16–26
- Kazemi A, Zarandi MHF, Hussein SMM (2009) A multi-agent system to solve the production-distribution planning problem for a supply chain: a genetic algorithm approach. *Int J Adv Manuf Technol* 44:190–193
- Kishor A, Chakraborty C (2021) Early and accurate prediction of diabetics based on FCBF feature selection and SMOTE. *Int J Syst Assur Eng Manag* 7:55
- Lee ATL, Chen HT, Tan SC, Hui SYR (2016) Precise dimming and color control of LED systems. *IEEE Trans Power Electron* 31:65–80
- Mani V, Gunasekaran A (2018) Four forces of supply chain social sustainability adoption in emerging economies. *Int J Prod Econ* 199:150–161
- Mark K, Christopher JV, Jeremy A, Preston B, Nenad GN (2020) Risk assessment framework for outbound supply-chain management. *Information* 11:417

- Murray BC, Newell RG, Pizer WA (2009) Balancing cost and emissions certainty: an allowance reserve for cap-and-trade. *Rev Environ Econ Policy* 3:84–103
- Nakamba CC, Chan PW, Sharmina M (2017) How does social sustainability feature in studies of supply chain management? A review and research agenda. *Supply Chain Manag Int J* 22:522–541
- Rasheed A, Aslam H, Rashid K (2021) Antecedents of pro-environmental behavior of supply chain managers: an empirical study. *Manag Environ Qual* 32:420–435
- Rizk N, Martel A, Damours S (2006) Multi-item dynamic production-distribution planning in process industries with divergent finishing stages. *Comput Oper Res* 33:3600–3623
- Tatavarthy SR, Sampangi G (2015) Solving a reverse supply chain TSP by genetic algorithm. *Appl Mech Mater* 813:1203–1207
- Vorst JGAJ, Beulens AJM, Beek P (2000) Modeling and simulating multi-echelon food systems. *Eur J Oper Res* 122:354–366
- Widodo KH, Nagsawa H, Morizawa K, Ota M (2006) A periodical flowering-harvesting model for delivering agricultural fresh products. *Eur J Oper Res* 170:24–43
- Wilson I (1995) Distribution control systems within the supply chain. *Logis Inf Manage* 8:40–42
- Yeh WC, Chuang MC (2011) Using multi-objective genetic algorithm for partner selection in green supply chain problems. *Exp Sys Applica* 38:4244–4253
- Zhou L, Xu X, Deng S, Liu X (2015) Redesigning a supply chain distribution network: formulation and genetic algorithm-based solution procedure. *Int J Inf Technol Dec Mak* 14:847–876

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.