Chapter 2
Literature Review

2.1 Supply Chain Management and Uncertainty

2.1.1 Supply Chain Management

As the result of revolution of modern business management mode, the theory and method of supply chain management is also the most important basic theory in the field of management and the frontier of management science. Chopra et al. [1] in *Management Science* wrote: "Operation and supply chain are currently the most critical themes in management science and improving the theoretical and practical evolution of management science." This statement highly praises the theoretical and practical significance of supply chain management.

"Supply Chain" was first coined in Houlihan's article in 1987 [2]. Stevens [3] gave a complete definition of supply chain in his article that "supply chain is a system which is concerned with supplier management, purchasing, materials management, manufacturing management, facilities planning, customer service and information flow as with transport and physical transportation." From then on, numerous scholars have defined supply chain from different perspectives. For example, Saunders [4] pointed out: "Supply chain is an exchanging network, starting from the raw material suppliers, involving procurement, manufacture, assembly, distribution, retail and other processes, and ending with the delivery to end-customers." Ellram [5] considered supply chain as: "… an integrative approach to dealing with the planning and control of the material flow from suppliers to end-users. It is an approach aimed at co-operatively managing and controlling distribution channel relationships for the benefit of all parties involved, to maximize efficient use of resources in achieving the supply chain's customer service goals [6, 7]. Christopher [8] defined supply chain from the viewpoint of processes and activities as "the network of organizations that are involved through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services in the hands of the ultimate consumer."

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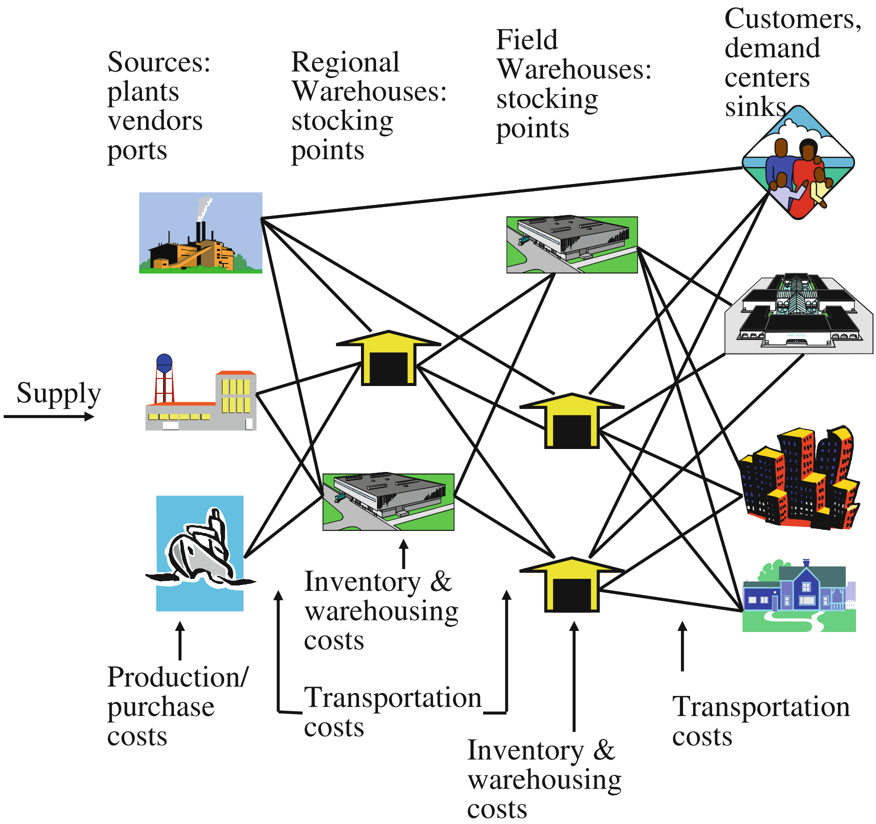


Fig. 2.1 A example of supply chain or logistics network

Simchi-Levi et al. [9] described supply chain as logistics network in which different facilities frequently have different, conflicting, objectives. Ma et al. [10] considered supply chain as a utilized structured network that is built around core products and controls information, material, and capital flow to maintain a smooth process of production from raw-material suppliers to end consumers (see Fig. 2.1).

Stadtler [11] presented a meaningful structure of supply chain management which illustrates many facets of supply chain management (see Fig. 2.2). The roof stands for the ultimate goal of supply chain management (increased competitiveness) and the principal means of realizing the goal (customer service). The roof rests on two pillars representing the two main components of supply chain management, which are the integration of a network of organizations and the coordination of information, material and financial flow. The two main components which require some degree of innovation management, are broken down into several parts. Firstly, forming a supply chain needs to select the appropriate partners. Secondly, in order to make the separate enterprises by law to form an efficient and successful network organization, collaboration between enterprises need to be promoted in

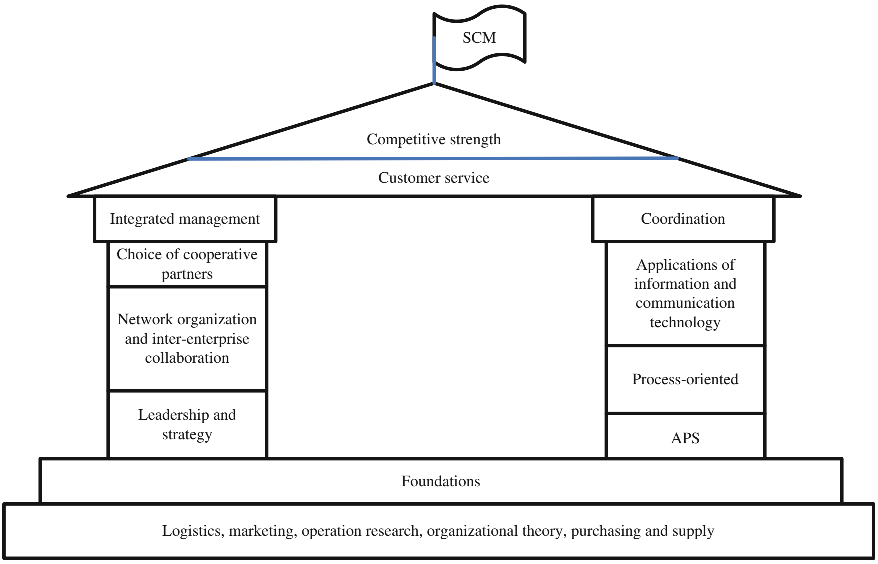


Fig. 2.2 Supply chain management building [11]

practice. Thirdly, for an inter-organizational supply chain, new concepts of leadership aligning strategies of the partners involved are important.

Stadtler et al. pointed out that the coordination management of supply chain can be executed efficiently by utilizing the latest information and communication technology. In this way the previous manually executed work can be done automatically, and activities at the interface of two entities can be scrutinized, while repeated activities can be reduced. Therefore, process orientation is often accompanied by process redesigning followed by a standardization of the new process. For executing customer orders, enterprises need to prepare materials, personnel, machinery and tools. Although production and distribution plan as well as purchasing plan have been used for years, these plans are isolated from each other and have limited in using scope. Coordinating plans over several sites and several legally separated organizations represents a big challenge that is taken up by Advanced Planning System (APS). The APS also shows many principles to build the base of supply chain management (for the details of APS see literature [11]). There are also other researchers from different perspectives defined boundaries of supply chain management, e.g. Kannan and Handfield [12], Berry et al. [13], Kopczak [14], and so on.

In summary, supply chain management is a set of approaches to effectively integrate suppliers, manufacturers, warehouses and retailers, so that the produced merchandise can be distributed at the right amount and at the right time to the right place, satisfying the requirement of service level as well as minimizing the cost of the system.

In recent years, there have been a large number of books about supply chain management at home and abroad, such as Christopher [8], Simchi-Levi [9], Ma et al. [10], Chopra and Meindl [15], Huang [16, 17], Zhang and Sun [18], and so on.

No matter on what level they discuss supply chain management, these works all reflect the essence of supply chain management from different perspectives: the global optimization of thought and new relations of cooperation.

In sum, the touchstone of supply chain management theory is whether it can make supply chain operate effectively. The significance of supply-chain planning to supply chain management is widely discussed in literature [9, 19, 20]. There are several examples as followed:

Actual case 2.1: Procter & Gamble estimates that it saved $65 Million for customers in a supply chain that has been operated for 18 months. "According to the situation of Procter & Gamble, the essence of its approach lies in manufacturers and suppliers working closely together …jointly creating business plans to eliminate the waste of source across the entire supply chain operation process [9]."

Actual case 2.2: In the autumn of 1996, consumer-goods manufacturers Warner-Lambert and Wal-Mart Stores initiated experimental study of Collaborative Plan, Forecast and Replenish System (CPFR). This information system will promote deeper cooperation on forecasting between dealers and manufacturers. CPFR system could feasibly exchange forecast sketches, details of future sales promotions and past sales trends, and other data. As a result, each side could more conveniently check co-related information and add new information [19].

Actual case 2.3: Facts proved that the cooperation of Wal-Mart and its suppliers is a successful example of SCM. Bendiener and his colleagues conducted a 2-year research on the application effects of supply chain management, including 90 discrete manufacturing corporations and 75 processed manufacturing companies. The results showed that the total cost of the entire supply chain dropped down by 10 % by using supply chain management; the rate of delivery on time increased by more than 15 % in supply chain system; the ordering-production cycle shortened by 25–35 %; productivity improved by more than 10 %; and asset growth rate of core business increased by 15–20 % [20].

The examples above indicate that organizations have benefited remarkably from supply chain management, which reflects the importance of supply chain management in practice. However, there are many uncertainties that affect the effectiveness of supply chain and will be analyzed as follows.

2.1.2 Uncertainty in Supply Chain

Man's understanding of natural phenomena shows that there are two basic categories of natural phenomena: one is the deterministic whose basic characteristic is that when their initial states are known, their future states will be ascertained; the other is the uncertain whose basic characteristic is that when their initial states are known, their future states can not be predicted [21]. These two categories reveal and reflect the relationship between inevitability and contingency, clarity and obscurity, and accuracy and inexactness in the process of development and change of objects. Certainty implies properties of regularity, necessarily, clarity and accuracy of objectives whereas uncertainty refers to disorder, contingency, ambiguity, and similarity in the connection and development process of objects. Uncertainty is the essential attribute of objects, and certainty is the product of man's knowledge and ideas which contain uncertainties. Certainty is often expressed by a large amount of uncertainties which are complements of certainty, and these two concepts are dialectically united. Mastering certainty is the basis of knowledge and practice of science, and only by knowing and using certainty can freedom be obtained. We should attach importance to uncertainty, be good at using advantageous uncertainty, avoid adverse uncertainty, and master certainty through uncertainty [21, 22].

Uncertainty embodies in all aspects of supply chain: supply, production, storage, transportation, and sales, i.e., supply chain is operated in an uncertain environment which mainly leads to a plenty of risks. Enterprises are subjected to suspension of supply chain due to uncertainty, and thus suffer huge losses. The following example demonstrates this argumentation:

Actual case 2.4: In 1999, a massive earthquake devastated Taiwan. Initially, 80 % of the islands' power failed. Companies such as Hewlett-Packard and Dell, most of whose spare parts were from Taiwan manufacturers, were impacted by supply interruptions. Similarly, the snow disaster occurred in 2008 in China also resulted in paralysis of supply chain, and therefore many enterprises suffered heavy losses [9].

It is obvious that various endogenous and exogenous uncertainties abound in supply chain, e.g. delivery status of suppliers, changing market demand, and so on. Chopra and Meindl [15] summarized uncertainty in supply chain as demand and supply uncertainty. Li and Luo [23] complemented that classification of Sunil Chopra and Peter Meindl: uncertainty in supply chain can be divided into demand, manufacturing and supply uncertainty. Furthermore, they analyzed the sources resulting in uncertainty of supply chain and illustrated the uncertainty as well as their relations between various supply chain decisions. Finally, they summarized some management measures to reduce uncertainty. Zhang and Sun [18] applied fuzzy set theory to constructing simulations to analyze and describe supply-chain uncertainty. Lee and Billington [24] found that the assessment of uncertainty on the operation performance was one of the four areas that business executives were required most for decision support when he was consulted by Hewlett-Packard about its supply chain management.

From this point of view, one of the most important tasks of supply chain management is to minimize, sometimes to avoid adverse effects caused by uncertainty in a supply chain to ensure the regularity of material flow, enhance flexibility as well as certainty, and reduce costs. To achieve those goals, optimizing the supply chain program plays a profound role in supply chain management.

In order to reduce the uncertainty in a supply chain by coordination between participants, all types of uncertainty should be firstly accurately recognized and described. One of the theories which focus on it is uncertainty theory that is introduced in the following part.

2.2 Uncertainty Theory

Uncertainty theory is also referred to as probability theory, credibility theory, or reliability theory and includes fuzzy random theory, random fuzzy theory, double stochastic theory, double fuzzy theory, the dual rough theory, fuzzy rough theory, random rough theory, and rough stochastic theory. This section focuses on the probability theory and fuzzy set theory, including probability spaces, random variables, probability spaces, credibility measurement, fuzzy variable and its expected value operator, and so on.

2.2.1 Stochastic Theory

Definition 2.1 Let Ω be a nonempty set. A is a class of sets which consists of subsets of Ω. If the following conditions are true,

(a) $\Omega \in \mathrm{A}$;
(b) if $\Omega \in \mathrm{A}$, then $A^c \in \mathrm{A}$;
(c) if $A_j \in \mathrm{A}$ $(i = 1, 2, \ldots, n)$, then $\bigcup_{i=1}^{n} A_j \in \mathrm{A}$

then A is an algebra. If change (c) as operation is closed about a countable union, A is called a σ-algebra [21].

Definition 2.2 [25]: Let Ω be a nonempty set, A is a σ-algebra over Ω (called an event), a set function $\Pr\{A\}$ is a probability measure on product σ-algebra and the triplet $(\Omega,\ \mathrm{A}, \Pr))$ a probability space, if

(a) $\Pr\{\Omega\} = 1$;
(b) for every event $A \in A$, $\Pr\{A\} \geq 0$;
(c) For every countable sequence of mutually disjoint events $\{A_i\}_{i=1}^{\infty} \geq 0$, we have

$$\Pr\left\{\bigcup_{i=1}^{\infty} A_i\right\} = \sum_{i=1}^{\infty} \Pr\{A_i\} \tag{2.1}$$

Definition 2.3 A random variable is a measurable function from a probability space $(\Omega, \mathrm{A}, \Pr)$ to the set of real numbers $\Re$, and n-dimensional random vector is a measurable function from a probability space $(\Omega, \mathrm{A}, \Pr)$ to the space of n-dimensional real vectors $\Re^n$ [26].

Example 2.1 Take $\Omega = (\omega_1,\ \omega_2)$ with $\Pr(\omega_1) = \Pr(\omega_2) = 0.5$. Then the function

$$\xi(\omega) = \begin{cases} 0, & \text{if } \ \omega = \omega_1 \\ 1, & \text{if } \ \omega = \omega_2 \end{cases}$$

is a random variable.

Theorem 2.1 *The vector* $(\xi_1, \xi_2, \ldots, \xi_n)$ *is a random vector if and only if* $\xi_1, \xi_2, \ldots, \xi_n$ *are random variables* (proof see Literature [26]).

Theorem 2.2 *Let* ξ *be an n-dimensional random vector defined on the space of probability* $(\Omega, \mathrm{A}, \Pr)$, *and* $f : \Re^n \to \Re$ *is a measurable function. Then* $f(\xi)$ *is a random variable* (proof see Literature [26]).

2.2.2 Fuzzy Set Theory

Fuzzy set theory was firstly proposed by Zadeh [27] via membership function in 1965. In 1970, Bellman and Zadeh [28] published a paper Decision-Making under Fuzzy Environment in Management Science which is a pioneer in the domain. From then on, many researchers have devoted to this study and consequently greatly promoted its evolution. Liu and Liu [29] presented the concept of credibility measure in 2002 and then Li X. and Liu B. refined the concept of credibility measure later [30]. Based on his research, Liu B. further proposed uncertain theory [22].

Definition 2.4 Let Θ be a nonempty set, $P(\Theta)$ is over the set which is composed of all subsets of Θ. If *Pos* satisfies following conditions:

(a) $Pos(\Theta) = 1$
(b) $Pos(\phi) = 1$
(c) For every subset $\{A_i\}$ of $P(\Theta), Pos\{\bigcup_i A_i\} \sup_i Pos\{A_i\}$ is true

Then *Pos* is called probability measure, and $(\Theta,\ P(\Theta), Pos)$ is called a probability space [22].

Definition 2.5 Let ξ be the function from probability space $(\Theta,\ P(\Theta), Pos)$ to the set of real numbers $\Re$, then ξ is called a fuzzy variable. The n-dimensional random vector ξ is a measurable function from a probability space $(\Theta, P(\Theta), Pos)$ to the set of n-dimensional real vectors $\Re^n$ [22].

Definition 2.6 Let ξ be a fuzzy variable. Then the expected value of ξ is defined by

$$E(\xi) = \int_{0}^{+\infty} Cr\{\xi \geq r\}dr - \int_{-\infty}^{0} Cr\{\xi \geq r\}dr \tag{2.2}$$

provided that at least one of the two integrals is finite [22].

In stochastic programming, the uncertain parameters are described by discrete or continuous probability density function, and when uncertain parameters in fuzzy planning is regarded as fuzzy numbers, the constraints are treated as fuzzy set to deal with. Some of the constraints allow being against, and defining satisfaction of constraint as subordinate function of constraint.

Definition 2.7 Let ξ be a fuzzy variable defined on the probability space $(\Theta, P(\Theta), Pos)$. Then the following function which is derived from the probability measure

$$u(x) = Pos\{\theta \in \Theta | \xi(\theta) = x\}, \quad x \in \Re \tag{2.3}$$

is defined the membership function of ξ.

According to fuzzy set theory of Zadeh [27, 31] there are two kinds of measure: one is probability measure-*Pos*, the other is necessity measure-*Nec*. The probability of fuzzy event is the biggest probability in all values which can make the event true while the necessity is defined as impossible which is the opposite of the event. Let ξ be a fuzzy variable with membership function $u(x)$. Let r be a real number. Then $Pos\{\xi \geq r\}$ and $Nec\{\xi \geq r\}$ show respectively the possibility and necessity of every fuzzy event $\{\xi \geq r\}$. Then credibility measure [29] is

$$Cr\{\xi \geq r\} = \frac{1}{2}(Pos\{\xi \geq r\} + Nec\{\xi \geq r\}) \tag{2.4}$$

It is necessary to point out that although probability of a fuzzy event is 1, it does not mean the event is true. For the same reason, when the probability of the event is 0, it may happen, but if the credibility of a fuzzy event is 1, then the event is true; in contrast, if the credibility of a fuzzy event is 0, then the event will definitely not happen.

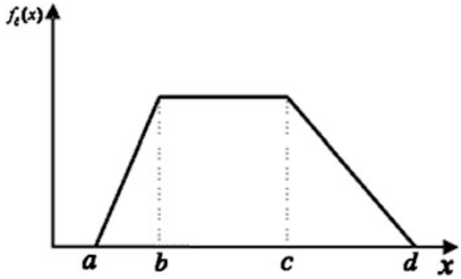
Example 2.2 Let ξ be a fuzzy variable with membership function (see Fig. 2.3) $f_\xi(x)$: $R \rightarrow [0, 1]$ satisfying

$$f_\xi(x) = \begin{cases} \dfrac{x-a}{b-a}, & a \leq x \leq b \\ 1, & b \leq x \leq c \\ \dfrac{x-d}{c-d}, & c \leq x \leq d \\ 0, & \text{others} \end{cases} \tag{2.5}$$

with $x, a, b, c, d, \in R$, $a \leq b \leq c \leq d$, ξ is a standard trapezoidal fuzzy variable, $\xi = (a, b, c, d)$.

In function (2.5), a and d are upper and lower bound of ξ respectively. $d - a$ and $c - b$ mean the fuzzy degree of the trapezoidal fuzzy number and the larger $d - a$ and $c - b$ are, the stronger the fuzzy degree is. Especially when $b = c$, ξ is called as a triangular fuzzy number. when $a = b = c = d$, ξ is a real number.

Fig. 2.3 Subordinate function of trapezoidal fuzzy variable



According to the definition of expected value of fuzzy variable, the trapezoidal fuzzy variable $\xi = (a, b, c, d)$ has an expected value $E(\xi) = (a + b + c + d)/4$. The triangular fuzzy variable ξ = (a, b, c) has an expected value $E(\xi) = (a + 2b + c)/4$. The fuzzy variable in Chap. 6 is the trapezoidal fuzzy variable $\xi = (a, b, c, d)$.

Liu [32] divided fuzzy programming into fuzzy expected value programming, fuzzy chance-constrained programming and fuzzy relevant-chance programming and so on. Specific approach is also connected with calculating method of fuzzy number, e.g. the comparative method, the calculation of the mean etc. [33].

2.2.3 Fuzzy Random Theory

Fuzzy random variables describe the fuzzy random phenomena via mathematical tools which were originally proposed by Kwakernaak [34, 35] and developed by Puri and Ralescu [36, 37], Kruse and Meyer [38], Liu and Liu [39].

Definition 2.8 Let ξ be a measurable function from a probability space $(\Omega, \mathrm{A}, \Pr)$ to a collection of fuzzy numbers. For any Borel subset B of $\Re$, $Pos\{\xi(\omega) \in B\}$ is a measurable function of ω, ξ is a fuzzy random variable [39].

Example 2.3 Let $(\Omega, \mathrm{A}, \Pr)$ be a probability space. If $\Omega = (\omega_1, \omega_2, \ldots, \omega_m)$, and u_1, u_1, …, u_m are fuzzy variables, then function

$$\xi(\omega) = \begin{cases} u_1, & \text{if } \omega = \omega_1 \\ u_2, & \text{if } \omega = \omega_2 \\ \ldots, & \ldots \\ u_m, & \text{if } \omega = \omega_m \end{cases} \tag{2.6}$$

is a fuzzy random variable.

Therefore, the essence of a fuzzy random variable is a random variable valued by a fuzzy variable. In Chap. 6, when customer's demand is a fuzzy random variable, conditions of the demand for a manufacturer's products may be good, not bad, or not good. Each of these three cases would appear with a certain probability, which means it is random. Furthermore, the customer's demand in these cases is vague. When the market is in good condition, the customer's demand is about 5000 units; when the market is medium, the customer's demand is about 2600 units; and when the market is in bad condition, the customer's demand is about 900 units. All these statements are fuzzy, and thus the customer's demand is a fuzzy random variable.

Definition 2.9 Let ξ be a measurable function from a probability space $(\Omega, \mathrm{A}, \mathrm{Pr})$ to a collection of fuzzy numbers. For any Borel subset B of $\Re^n$, $Pos\{\xi(\omega) \in B\}$ is a measurable function of ω, ξ is a fuzzy random vector [39].

Theorem 2.3 *Let ξ be an n-dimensional fuzzy random vector. If $f : \Re^n \to \Re$ is a measurable function, then $f(\xi)$ is a fuzzy random variable* [39].

Proof According to the credibility of f, for every Borel subset B of $\Re$, $f^{-1}(B)$ is a Borel subset of $\Re^n$. Then for every $\omega \in \Omega$,

$$Pos\{f(\xi(\omega)) \in B\} = Pos\left\{\xi(\omega) \in f^{-1}(B)\right\} \tag{2.7}$$

□

Therefore, $Pos\{f(\xi(\omega)) \in B\}$ is a measure function of ω, i.e., $f(\xi)$ is a fuzzy random variable. The theorem is proved.

Definition 2.10 Let $f : \Re^n \to \Re$ be a measurable function space $(\Omega_i, \mathrm{A}_i, \mathrm{Pr}_i)$, and ξ_i fuzzy random variable on the probability space $(\Omega_i, \mathrm{A}_i, \mathrm{Pr}_i), i = 1, 2, \ldots, n$, then $\xi = f(\xi_1, \xi_2, \ldots \xi_n)$ is a fuzzy random variable on the product probability space $(\Omega_1 \times \Omega_2 \times \cdots \times \Omega_n, \mathrm{A}_1 \times \mathrm{A}_2 \times \cdots \times \mathrm{A}_n, \mathrm{Pr}_1 \times \mathrm{Pr}_1 \times \cdots \times \mathrm{Pr}_n)$, and defined as

$$\xi(\omega_1, \omega_2, \cdots \omega_n) = f(\xi_1(\omega_1), \xi_2(\omega_2), \ldots, \xi_n(\omega_n)) \tag{2.8}$$

for any $(\omega_1, \omega_2, \ldots \omega_n) \in \Omega_1 \times \Omega_2 \times \cdots \times \Omega_n$ [39].

2.3 The Status Quo and Characteristics of Supply Chain Planning Research

2.3.1 Research Review

Supply chain planning, the core of supply chain management, is crucial to the success of supply chain operation so that a large number of researchers and enterprises pay great attention to it. Supply chain planning can be divided into production, material, sales and transportation planning according to its functions and strategic planning, tactical planning and operational planning according to its time span [40]. Supply chain planning studied in this book is the optimization of supply chain under uncertain environment, i.e., in consideration of all uncertain parameters, how to apply models and algorithms to rationally arrange the quantity purchases, production, inventory and transportation in a supply chain. As far as the functions of supply chain planning are concerned, the research object in this book belongs to supply-chain integration planning; while as far as time dimension is concerned, it belongs to tactical planning.

With the evolution of theories and approaches of supply chain management in the last three decades, supply chain planning has been greatly developed and widely used. The fruitful research results obtained in many aspects are to be reviewed chronologically below.

Zak and Frank [41] are pioneers who used discrete Markov Chain in finite state to describe a stochastic nature of supply and demand under centralized distribution of resources. The outcome shows that the size of system loss has close relations with functions of the system, the initial inventory level and allocation of resources. To avoid material shortage and resources inactiveness, they designed mathematical models in different situations and algorithms applying brand and bound method to optimize the initial inventory and resource allocation. The goal of those measures was to minimize total system costs of losses.

Cohen and Moon [42] researched factory load allocation problem. On the basis of some assumptions, he established multiple periodic mixed integer programming model to determine the distribution of the raw materials procurement, production lines, production and finished product delivery number, and designed a modified Benders decomposition algorithm to solve this problem, finally giving a numerical example to illustrate the effectiveness of the algorithm and the applicability of the model. Blumenfeld et al. [43] studied the production–transportation scheduling coordination problem of the monophyletic point to multipoint in the production network and the raw materials of original point were directly delivered to the destination. The relevant costs include set up cost, inventory cost and transportation cost. The article compares the differences of total costs between synchronized scheduling system and independent scheduling system. The results show that synchronous scheduling can effectively save system cost.

Bhatagar et al. [44] raised a question about coordination of multi-plants production in a vertically integrated firm, and had a thorough review of conventional coordination problems and multi-plants coordination problems. Chien [45] studied a similar problem in [43] considering stochastic demand conditions. Based on the stable and independent weekly demand and the known probability distribution, they derived the average profit function of the unit product production and transportation and then got the optimal production–transport strategy by means of the analytic method. The numerical example verified the validity of the model based on Monte Carlo (Monte Carlo) simulation and sensitivity analysis.

Chandra and Fisher [46] investigated the coordination between the production scheduling and the vehicle routing problem. The research assumes that each stage of product demand is a known parameter, the factory manufactures products and keeps the finished goods inventory, and vehicles deliver the products to retail outlets. The paper proposes a heuristic algorithm based on decomposition strategy, followed by tests of "coordinated" and "uncoordinated" situations with randomly generated data. The computing results indicate that the coordination between production and distribution is less restrained in production capacity and the set up cost and inventory cost are reduced.

Arntzen et al. [47] designed a multi-cycle mixed integer model to reconstruct the supply chain of Digital Equipment Corporation to evaluate global supply chain alternatives and determine worldwide manufacturing and distribution strategies in Digital Equipment Corporation. The factors considered in his model included the fixed cost, variable production cost, inventory cost, all kinds of transport mode fees, taxes, tariffs, duty drawbacks, etc. in order to minimize the total cost of the supply chain. The plan for purchasing–production–distribution through the model saved more than $100 million for DEC company.

Thomas and Griffin [48] reviewed the coordination of supply chain management research in terms of operation and strategy. There were three categories of operational coordination: Buyer-Vendor coordination, Production-Distribution coordination and Inventory-Distribution coordination. As to the strategic areas his research mainly discussed facility location problem based on mixed integer programming, and finally put forward the existing shortcomings in the course of study and feasible research direction. Cheung and Powell [49] considered the distribution network of multi-factory and multi-warehouse, studying distribution planning problem under the condition of demand uncertainty, establishing a two-stage stochastic programming model, proposing the approximation algorithm to solve the model, and using a practical example to validate its validity. Furthermore, through the comparison of the calculation results and the corresponding deterministic model they illustrated the superiority of random distribution planning model. Finally, with the conclusion of single cycle two-stage stochastic they established a dynamic multi-stage stochastic programming model and gave the idea of solving the model.

Hill [50] studied a production–inventory–transportation problem under the condition of a single vendor-a single buyer. The study assumed that the buyer purchased goods by batch, and for each batch the seller would ship the goods to the buyer for several times. The elements considered included the set up cost of each batch, fixed cost of each consignment, and the inventory holding costs of the buyer and the seller. The decision goal was to optimize the whole system based on minimizing the average total cost per unit time, and then to determine production plan and shipment schedule. However, the research did not take uncertain parameters and multi-node supply chain network into consideration.

Beamon [51] reviewed the relevant research on supply chain design and analysis, and proposed some future research directions. Supply chain model is divided into deterministic models, stochastic analytical models, economic models, and simulation models. The future directions of the research include supply chain performance measurement methods, the establishment of the decision-making model and developing standards and technology of supply chain design and analysis.

Fumero and Vercellis [52] studied the coordination of production management, inventory allocation and vehicle routing decision problems by establishing the production and distribution planning synchronous optimization model, and using the Lagrangian relaxation method for solution of lower limit and heuristic feasible solution. Their study verified the effectiveness of the proposed algorithm through test results of different scales of problems, compared the system cost under the condition of the coordinated decision and independent decision, and showed that coordinated decision can effectively save the cost. Escudero et al. [53] studied production-supply-sell planning problem of the manufacturing–assembly–supply system under the condition of uncertainty, establishing a two-stage stochastic programming model with compensation problem, and proposing the method of separating the model variable, but they did not design the further algorithm.

Von Lanzenauer and Pilz-Glombik [54] established a multi-cycle mixed integer programming model, and studied the problems of supply chain tactical decision, aiming to determine the order, the production and transportation decisions under the condition of the different information. The model is applied to a modified version of MIT's Beer Distribution Game. The research showed the performance of optimization decision model through contrasting the result of the human decision-making under the same conditions and finally pointed out the method of the computer solution to the model. Bredstrom and Ronnqvist [55] took the interaction between production and distribution into account based on the supply chain of a large pulp producer in Sweden, establishing the integration of production–route scheduling mixed integer programming model, putting forward the decomposition strategy and solving ways of the model. In this case study, nevertheless, neither algorithms nor empirical analyses were presented.

Gupta and Maranas [56] considered the uncertainty of the customer demands and established a two-stage stochastic programming of production-sale planning. The variables in the model were divided into manufacturing decisions and logistics decisions with an effective tool (optimized software GAMS) computing the model directly. Furthermore, the performances under different environments with certainty and uncertainty were compared. Luh et al. [57] only presented a framework for production scheduling of supply chain without any investigation on planning issues.

Pibernik and Sucky [58] analyzed the meaning and limitations of dispersed and concentrated supply chain planning. He emphasized that supply chain planning decisions were usually dispersed and introduced a general decentralized control design method for supply chain planning.

Peidro et al. [59] analyzed 103 articles, reviewing the methods of supply chain planning under uncertain environment. His main purpose is to provide the reader with quantitative approaches of supply chain under uncertain environment, in order to propose a starting point of the supply chain planning model for further research. At the same time he discussed the future main line of supply chain research.

Chen et al. [60] analyzed the difference between the model of traditional production planning and control and that of supply chain. They pointed out the main problems that SCM face are flexible constraints, production scheduling and production capacity.

Zhou et al. [61] described production planning of multi-location plant and distributors on condition that unit production cost, production capacity and demand are fuzzy parameters. They built up a fuzzy expected value model and fuzzy related chance-constrained programming model in consideration of different decision criteria and discussed a clear equivalent form of the fuzzy programming model when the fuzzy variables were triangular fuzzy numbers. Moreover, specific steps were presented to solve the model by using genetic algorithm. Zhou and Wang [62] also studied the distributed factories and distributors of production planning problem for a supply chain, and established the model to minimize the total costs, including earliness and tardiness penalties, production costs, and transportation costs. The production planning and scheduling scheme were obtained via solving model transformation.

Hou and Hu [63] investigated the logic and method of supply chain planning and explained an overall plan as well as a step-by-step approach with examples. Sun and Gao [64] proposed a programming model for production planning of two-echelon distribution network in the case of sharing information between manufacturers and distributors. They also designed a heuristic algorithm.

Yao and Zhou [65] pointed out that supply chain production planning and scheduling in mass-customization was a typical multi-objective dynamic optimization with random demands and stochastic constrained resources. A stochastic multi-objective dynamic programming model was proposed and an example was briefly analyzed to show the maturity of the optimization and the feasibility of the model. Furthermore, the realization of the important dynamic optimized scheduling was presented, and the process of practical application were verified and explained. Yang and Wu [66] investigated capacitated lot sizing problems in multi-plants supply chain and established a programming model with the goal of minimizing the total cost of production, inventory, and transportation in the case of a limited production capacity. A two-level genetic-algorithm based approach was proposed.

Zhu et al. [67] built up a collaboration planning model (CPM) on the basis of negotiation between upstream and downstream, studied the application of the dynamic game theory and Nash equilibrium bargaining game theory in the model and conducted a simulation test of the validity of the model and algorithm. Li et al. [68, 69] discussed the supply chain in steel industry: (1) problems of collaborative production planning in a two-level supply chain were studied to establish the corresponding linear programming model which integrated transport plans; (2) collaborative production planning was analyzed in the three-level supply chain which was composed of a mine, a concentrator, and a steel industry. A mixed integer nonlinear programming model was correspondingly established which integrated freight into production plan. Chen et al. [70] studied the optimization of supply chain collaborative planning of multi-suppliers, multi-manufacturers and multi-distribution centers. The model was aimed at balancing optimization of supply chain cost and running time. Three-dimension-array coding of genetic algorithm was adopted, together with gene segment cross and gene shift mutation to optimize supply chain costs and time synthetically. Ma and Song [71] analyzed the problem of planning management in garment enterprises and focused on integrated planning management in SCM based on make-to-order production. They also discussed the design and implementation of integrated planning management system. Cheng et al. [72] established a model of strategic and operational supply chain planning under uncertainty and used examples to compare it with the model of supply chain planning under certainty. Furthermore, sensitivity analysis of flexibility was applied in that paper. Yang et al. [73] built up a coordinated planning model based on response time of supply chain on the basis of the integration of local and global plan. Moreover, an algorithm was proposed which verified the model. Lin et al. [74] proposed a three-level production planning and control model, focusing on core business in a supply chain. Specific algorithm and instances were presented for production planning in node enterprises.

Ge et al. [75] proposed a global supply chain planning model under uncertainty, including fuzzy demand and random production capacity. Zhou and Jin [76] proposed a coordination method for a distributed multi-plant supply chain planning and presented an optimal internal price-coordination with augmented Lagrangian relaxation. Jiang [77] analyzed characteristics of production planning in a supply chain and constructed three-level model of production system in the network. They presented a production planning resolution model of the supply chain with a manufacturing network. Chen [78] pointed out that information uncertainty was a major source of uncertainty in supply chain and analyzed its impact on production planning from the perspective of demand and supply. They presented an improving method for dynamic response of production through information sharing and weakening information uncertainty. Li et al. [79] discussed the uncertainties in a global supply chain and proposed a relevant tactical production-distribution planning model based on fuzzy random expected value programming. They put forward an intelligent algorithm model based on computer fuzzy stochastic simulation combined with genetic algorithm. Finally, a data simulation was analyzed. Wang et al. [80] analyzed the design of Bill of Material (BOM), order processing model, and hierarchical production planning for mass customization. Focusing on supply chain, they researched prototype system of production planning for mass customization and its functional subsystems such as demand management, production planning and control, and logistics management. Finally, the characteristics of the production planning in the system were summarized. Yu and Wang [81] proposed a new artificial life algorithm of food chain and applied it to the selection and allocation of production capacity among the enterprises within a supply chain.

Nie et al. [82] studied coordinated production planning between multi-level supply chain partners. They imposed demand and correlation constraints on the multi-level capacitated lot-sizing production planning model and decomposed it down to sub-problems of independence of partners by using additive separability of the model structure and Lagrangian relaxation. Therefore, a multi-level supply chain coordination and optimization of production planning were achieved without interference the decision-making and private information of partners. The coordination, the superiority and robustness of that approach was also tested by numerical simulations based on Lagrangian relaxation and genetic algorithms programming. Kong and Luo [83] studied the dynamic supply chain planning and proposed a distributed-agent-based coordination mechanisms and algorithms. Du and Liang [84] proposed an approach based on the common bill of materials to construct supply chain networks and built up a capacity-constraint of integrated production planning model to maximize the overall benefits of partners in the supply chain.

Su et al. [85] described an extended-task network with its production, storage, and different modes of transport from the viewpoint of its complex production processes. In order to solve manufacturing supply chain planning model based on the extended-task network, he presented updated strategies with diversified reference set and algorithm strategy of path reconnection algorithm with dispersed variation. Ma and Shen [86] analyzed a one-time transportation with one-product in a supply chain and established a system of dynamic programming model for logistics. He also explored the optimal logistics capabilities and the circulation quantity that should be allocated on each stage of the system to minimize costs of the whole system. Shen and Ma [87] set up a model to investigate the operational capability of a time-based multi-stage supply chain. Fang et al. [88] analyzed a guidance model of the joint plan forecasts and replenishment (CPFR) and three major components. Moreover, they summarized four key factors for successful implementation of the model, reviewed the application of CPFR and its cost-effectiveness in practice, and outlined the problems of its implementation in China. Ji et al. [89] studied the integrated plan to develop three-stage supply chain and designed an integrated supply chain planning model with limited production capacity which included more multi-vendors, multi-manufacturers, multi-distributors, multi-periods, and multi-products. The goal of the model was to minimize the total costs of manufacturing, inventory, outsourcing, transportation, and stock-out. An algorithm of the integrated supply chain planning model was presented on the basis of genetic algorithm. Xiao [90] studied supply chain logistics planning knowledge management model in the integrated situation. Li and Liu [91] investigated the decomposition mechanism of master production planning, material requirement planning, and production planning in the cluster mass-customized supply chain. Zhao et al. [92] studied the production planning in a distributed multi-plant supply chain with fuzzy unit production cost, fuzzy production capacity and fuzzy demand, and set up a fuzzy expected value models and fuzzy associated programming model according to different decision criteria. They discussed a clear equivalent of the fuzzy programming model when fuzzy variables are triangular fuzzy numbers, and presented specific steps to solve the model with genetic algorithm.

Cai et al. [93] established production planning model and state equation in a cycle of supply chain and integrated the forward and backward production plans through the fuzzy quantified factor. They analyzed the uncertainty of closed loop supply chain. In the paper, a fuzzy adaptive production planning model was presented and the application of the model was discussed and simulated. Fu and Pan [94] analyzed the difficulties caused by supply-chain uncertainty in the coordination between inventory and production planning with demand for raw materials in the node configuration in many enterprises. Taking fuzzy lead time into account, they discussed the collaborative process of assembly components (parts) of the re-order points and production quantities in assembly-type manufacturing enterprises and proposed a production and inventory model with multi-fuzzy parameters and obtained optimization with interactive fuzzy interval number and fuzzy multi-objective decision-making. Shao and Ji [95] analyzed pricing and planning coordination and the related strategies of manufacturers and suppliers in a supply chain under the condition that the demand was uncertain and influenced by price. A compensation contract was proposed for the effective decision-making coordination of manufacturers and suppliers, and the numerical analysis was applied to demonstrating the effectiveness of that contract.

2.3.2 Characteristics of Current Studies

From the above introduction we can see that although scholars have made outstanding contributions to the study of supply chain planning and achieved fruitful results, the optimized and integrated supply chain planning has not yet aroused the concern of researchers in more complex supply chain network environment with many uncertain parameters and multi-period. The detailed analyses are as follows:

1. In the research scope of supply chain planning, researchers seem to pay too much attention to supply chain production planning while few scholars are involved in integrated logistics planning of procurement-production-inventory-transportation of node enterprises in a multi-level multi-node supply chain.
   It is well known that the local optimum system does not mean the global optimum whereas a global optimal system may be damaged due to local interest. The essence of SCM is a global optimization and new partnership. As a result, optimization of any subsystem in a supply chain can not guarantee the operation of the entire supply chain optimization. Based on previous research results, the research in this book tries to establish a global multi-level, multi-node integrated supply chain planning model and provides technical guidance from the perspective of the supply chain global optimization.
2. From the perspective of research in supply chain planning, the researchers focused more on the environment of single-stage production planning in a supply chain and neglected more complex supply chain network environment with many uncertain parameters and multi-level.
   As it is mentioned above, uncertainty is the essential attribute of objectives [38, 39]. There are so many endogenous and exogenous uncertainties in a supply chain, such as demand, price, cost, etc. In these settings, it is difficult but important to have effective supply chain strategies that minimize system costs (or revenue maximization) and meet customer demand. Therefore, supply chain programming should take uncertain parameters as more as possible into account. In addition, the supply chain is physically not just a single-stage supply chain. In reality, most companies' supply chain is very complex, in which there are various types of supply and material demand between enterprises, that is to say, supply chain is a multi-level, multi-product, and multi-entity structure in the real economic environment. Considering the uncertainty of demand and price, we attempt to establish a three-(or multi-)level multi-product and multi-node supply chain with the uncertainty model of procurement-production-inventory-transportation logistics planning according to the controlling types, and to design hybrid intelligent algorithm to solve these model.

2.4 Intelligent Algorithm

Production planning model and its solution have been more considered in the research of supply chain planning. Among them, multi-level multi-product capacitated lot-sizing problem (MLCLSP) is the most common one. Gitran and Yanasse [96] has proved the lot size under capacity constraints, even single item, is NP-hard. Chen and Thizy [97] proved MLCLSP was a strong NP-hard. Thus, MLCLSP is a very complex combined optimization problem which is the objective that is studied in the book. Karimi et al. [98] and Drexl and Kimms [99] presented an excellent overview of the solutions to this kind of problems. These solutions mainly fall into the deterministic method [100] and the heuristic method [101]. With the deterministic method, an optimal solution can be obtained. However, once the scale of the problem is large, this method is less efficient. In contrast, although the heuristic method such as simulated annealing, genetic algorithms, and Lagrangian relaxation algorithm cannot obtain the exact optimal solution, it is able to efficiently solve problems which the deterministic method cannot do and problems in which large scale solution is involved. For the uncertainty model in the book, we use stochastic simulation, fuzzy simulation, random fuzzy simulation and nested genetic algorithm neural network to solve them. Neural networks and genetic algorithms are introduced below.

2.4.1 Neural Network Algorithm

The artificial neural network [26] is a kind of adaptive system, which is composed of many neurons and used to abstractly simplify and simulate human brain activity. The artificial neuron as shown in Fig. 2.4 can be used as a simple processor that can deal with the arrival signals by weighted sum as:

$$y = (\omega_0 + \omega_1 x_1 + \omega_2 x_2 + \cdots + \omega_n x_n) \tag{2.9}$$

where $x_1, x_2, \ldots, x_n$ mean the input value, $\omega_0, \omega_1, \omega_2, \ldots, \omega_n$ mean weight, and y means the output of neuron.

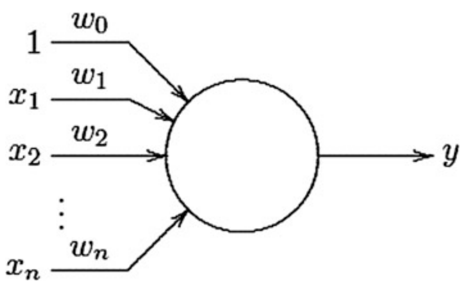


Fig. 2.4 An artificial neuron [48]

In practice, a nonlinear function with no memory is usually defined as an activation function to change the output of neurons.

$$y = \sigma(\omega_0 + \omega_1 x_1 + \omega_2 x_2 + \cdots + \omega_n x_n) \tag{2.10}$$

The choice of activation function depends on its application object in the mixed intelligent algorithm. In Chap. 6 of the book, we use Sigmoid function:

$$\sigma(x) = \frac{1}{1 + \mathrm{e}^{-x}} \tag{2.11}$$

as activation function, its derivative is:

$$\sigma'(x) = \frac{\mathrm{e}^{-x}}{(1 + \mathrm{e}^{-x})^2} \tag{2.12}$$

Their shape is shown in Fig. 2.5.

Neural network has been widely used in fields of function approximation, pattern recognition, image dealing, artificial intelligence, optimization and so on [26, 102]. Multilayer feed forward artificial neural network is a major type of the neural network which is connected by input layer, one or more output layers and hidden layers in a forward way. Each layer is composed of many artificial neurons. The output of previous layer neurons is the input of the next layer as shown in Fig. 2.6.

The multi-layer forward artificial neural network was firstly proposed by Minsky and Papert [103]. Cybenko [104] and Hornik et al. [105] have proved that multi-layer forward networks with any number of neurons of the ixia hidden layer can be close to any Borel continuous function. Moreover, if there are infinite neurons in the hidden layer, only one network of forward neurons is needed to approximate to any continuous function with arbitrary precision. So the multi-layer forward neural network has been widely applied in function approximation [106].

Assume that we are going to train a three layer forward neural network to approximate the uncertain function U. After the architecture of network and the amount of neurons are fixed, the function approximation will be implemented by adjusting the weight vector ω constantly. The calculation process of adjusting is

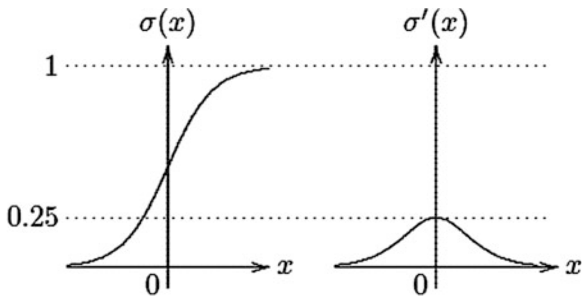


Fig. 2.5 Sigmoid function and its derivative [48]

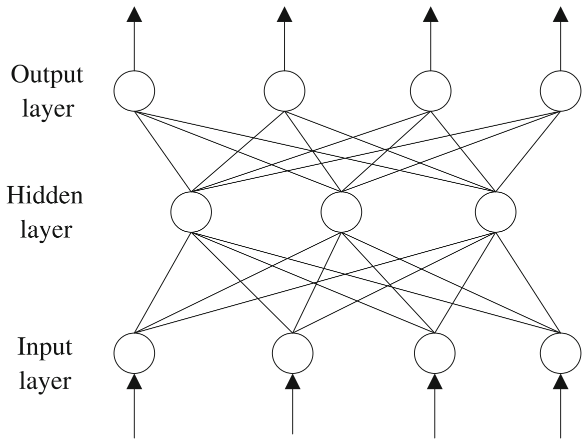


Fig. 2.6 A multi-layer forward artificial neural network [48]

called as the training process of network. The training process of neural network is essentially a training of a sample set as below:

$$\left\{x^{(k)}, y_1^k, y_2^k, \ldots, y_m^k, z^{(k)}, \quad k = 1, 2, \ldots, N\right\}$$

The process of weight's adjustment under watching and studying aims to minimize the error of the following function [26, 102]:

$$Err(\omega) = \frac{1}{2}\sum_{i=1}^{N}\left\|z^{(k)} - U^{(k)}\right\|^2 \tag{2.13}$$

Sometimes it also finds minimization of average errors:

$$Err(\omega) = \frac{1}{N}\sum_{i=1}^{N}\left\|z^{(k)} - U^{(k)}\right\| \tag{2.14}$$

To make the output of the network and expected output close to each other as much as possible. In (2.14), $z^{(k)}$ is the value of the uncertain function corresponds to $\left(x^{(k)}, y_1^k, y_2^k, \ldots, y_m^k\right)$, $U^{(k)}$ is to the output of the network corresponds to $\left(x^{(k)}, y_1^k, y_2^k, \ldots, y_m^k,\right)$.

2.4.2 Genetic Algorithm

Genetic Algorithm (GA) was first proposed in 1975 by Holland [107]. As a strong and widely application method for random search and optimization, GA is one of the most influential methods of Evolutionary Computation [108]. During the past decades, there have been many literatures about Genetic Algorithm including evolution strategies, evolutionary programming and genetic algorithm program design [109]. Generally speaking, there are five components of GA [108, 110–114] which are respectively Genetic representation of a solution to a problem, the method for building initial population of solution, the evaluation function for judging the population depending on individual adaptability, and a genetic operator which is used to change the genetic composition of chromosome coming from the process of replication and the parameter value of GA.

GA maintains the population P(t) by a group of chromosomes (t presents hereditary algebra). Each chromosome presents a potential solution and is evaluated to get its value of proportional after its judgment. Some chromosomes will experience random transformation of genetic operations (crossover and mutation) to produce new generational chromosomes c(t). The new chromosomes c(t) will continue to be judged. Good individuals from parent generation and offspring generation will form one new population. After several generations, the algorithm converges to an optimal chromosome which may present the optimal or suboptimal solution to the problem. The general structure of the genetic algorithm can be described as follows [108].

```
begin
        t ← 0;
        Initiate P(t)
        Evaluate P(t)
        While (not satisfy terminal condition) do
        Begin
            Recombinant P(t) to bear C(t)
            Evaluate C(t)
            Select P(t+1) from P(t) to C(t)
            t ← t+1
        end
end
```

GA is a new parallel optimization search method which is different from the traditional optimization methods in the field of application. Goldberg [114] summarized the differences between GA and traditional optimization method as follows: GA operates the code of the solution set not the solution set itself; GA searches from one population, not a single solution; GA uses the compensation information (fitness function), not derivatives or other complementation knowledge; GA uses methods of probability, not the deterministic rule of state transition.

As a global optimization method, GA solved a plenty optimization problems in the field of logistics [115] and supply chain management. Applications shows that GA can converge to the global optimal solution with the greatest probability with the help of population searching strategy and the technology of information exchange between chromosomes, rather than gradient information. The greatest advantage of GA is keeping information that has been searched through the interaction between populations. GA is especially suitable to solve combinatorial optimization problems which is far better than the optimization method based on a single search process.

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One of the disadvantages of GA is the slow speed of calculation. For example, too large population may increase the amount of calculation whereas too small population is likely to provide insufficient samples that may lead to poor optimization performance; too big crossover probability will destroy chromosomes with high fitness whereas too small crossover probability rate will stop the search; too big mutation probability will lead to random search whereas too small mutation probability will make it difficult to produce new chromosomes. Another disadvantage of GA is "prematurity", which means premature convergence. It is caused by two factors: on the one hand, the most important crossover operator makes chromosomes locally similar in the population and causes the search to stop; on the other hand, mutation probability is too small to make the search turn to the other solution spaces. In addition, another disadvantage of GA is its weakness of hill-climbing. To improve GA performance and calculating speed, we can improve it through the following fields [115–117]:

In terms of coding method, it is necessary to depend on the situation of practice to set up the appropriate encoding and decoding scheme in order to overcome the shortcomings of the binary code. When variables are real vectors, we can directly use code by real number to inject heuristic information relevant to the field of problem in order to increase the search ability of GA.

In the area of replication, the protection strategy of optimal chromosomes is adopted, i.e. the best chromosomes in the parent generation are put directly into the offspring generation to avoid destroying the best chromosomes because of the contingency of genetic operators. What's more, the global optimal solution can be found with 100 % probability.

In the area of crossover, we can add artificial ingredients into algorithm based on the basic crossover operations. For example, we can constrain the high fitness chromosome to crossover from each other according to a certain rule to obtain a much higher fitness chromosome quickly; Otherwise, only chromosomes with low fitness in a population are to experience crossover and mutation in order to generate better offspring to replace them. By doing so, we can reduce the possibility of losing good chromosomes and deconstruction of population to make GA converge stably. Because only the chromosomes with low fitness are calculated, the computation times are reduced and the searching speed is accelerated. In addition, the variable crossover can avoid local optimum and enhance local searching ability to some extent.

Two improving strategies can be applied to the mutation operation. The first one is to change the ordinary stable mutation rate, e.g. adaptive mutation. In the beginning a smaller mutation is adopted and in the later iterations, when the population is difficult to produce chromosomes with higher fitness, mutation rate should be increased in order to produce new and better chromosomes and to avoid local optimum. The second one is to change the scope of mutation operators. In order to change the divergence of mutation operator in the whole process of search, time-varying factors of controlling the process are introduced which make mutation operators feasible in the whole region at the beginning time space, and then the scope decreases with the increase of searching times.

References

1. Chopra S, Lovejoy W, Yano C (2004) Five decades of operations management and the prospects ahead. Manage Sci 50(1):8–14
2. Houlihan JB (1985) International supply chain management. Int J Phy Distrib Mater Manag 15(1):22–38
3. Stevens J (1989) Integrating the supply chain. Int J Phys Distrib Mater Manag 19(8):3–8
4. Saunders MJ (1995) Chains, pipelines, networks and value stream: the role, nature and value of such metaphors in forming perceptions of the task of purchasing and supply management. In: First worldwide research symposium on purchasing and supply chain management. Tempe, Arizona, USA, pp 476–485, Mar 1995
5. Ellram LM (1991) Supply chain management: the industrial organization perspective. Int J Phys Distrib Logistics Manag 21(1):13–22
6. Lee HL, Ng SM (1997) Introduction to the special issue on global supply chain management. Prod Oper Manag 6(3):191–192
7. Lee HL, Billington C (1992) Managing supply chain inventory: pitfalls and opportunities. Sloan Manag Rev 33(3):65–73
8. Christopher M (2012) Logistics and supply chain management. Pearson, UK
9. Simchi-Levi D, Kaminsky P, Simchi-Levi E (2003) Designing and managing the supply chain. Irwin/McGraw-Hill, San Francisco
10. Ma SH, Lin Y, Chen ZX (2005) Supply chain management. Machinery Industry Press, Beijing
11. Stadtler H (2005) Supply chain management and advanced planning-basics, overview and challenges. Eur J Oper Res 163(3):575–588
12. Kannan VR, Handfield RB (1998) Supply chain management: supplier performance and firm performance. Int J Purchasing Mater Manag 34(3):2–9
13. Berry D, Towill DR, Wadsley N (1994) Supply chain management in the electronics product industry. Int J Phys Distrib Mater Manag 24(10):20–32
14. Kopczak LR (1997) Logistics partnership and supply chain restructuring: survey results from the US computer industry. Prod Oper Manag 6(3):191–192
15. Chopra S, Meindl P (2001) Supply chain management: strategy, planning, and operation. Tsinghua University Press, Beijing
16. Huang XY (2007) Supply chain operations—coordination, optimization and control. Science Press, Beijing
17. Huang XY (2004) Supply chain model and optimization. Science Press, Beijing

18. Zhang T, Sun LY (2005) Supply chain uncertainty management: technologies and strategies. Tsinghua University Press, Beijing
19. Verity JW (1996) Clearing the cobwebs from the stockroom. Bus Week 21:140
20. Bendiner J (1998) Understanding supply chain optimization: from "what if" to what's best. APICS Perform Advantage 8:34–39
21. Liu BD, Peng J (2005) Uncertainty theory tutorial. Tsinghua University Press, Beijing
22. Liu BD (2007) Uncertainty theory, 2nd edn. Springer, Berlin
23. Li CL, Luo YF (2003) Uncertainty of supply chain management research. Sci Technol Prog Policy 10:84–86
24. Lee HL, Billington C (1995) The evolution of supply chain management models and practice at Hewllet-Packard. Interfaces 25(5):42–63
25. Liu BD, Zhao RQ (1998) Stochastic programming and fuzzy programming. Tsinghua University Press, Beijing
26. Liu BD, Zhao RQ, Wang G (2003) Uncertain programming and applications. Tsinghua University Press, Beijing
27. Zadeh LA (1965) Fuzzy sets. Inf Control 8(3):338–353
28. Bellman RE, Zadeh LA (1970) Decision making in a fuzzy environment. Manage Sci 17 (4):141–164
29. Liu B, Liu YK (2002) Expected value of fuzzy variable and fuzzy expected value models. IEEE Transact Fuzzy Syst 10(4):445–450
30. Li X, Liu B (2006) A sufficient and necessary condition for credibility measures. Int J Uncertainty Fuzziness Knowl Based Syst 14(5):527–535
31. Zadeh LA (1999) Fuzzy sets as a basis for a theory of possibility. Fuzzy Sets Syst 100:9–34
32. Liu B (2009) Theory and practice of uncertain programming, 2nd edn. Springer, Berlin
33. Fortemps P, Roubens M (1996) Ranking and defuzzification methods based on area compensation. Fuzzy Sets Syst 82(3):319–330
34. Kwakernaak H (1978) Fuzzy random variables–I: definitions and theorems. Inf Sci 15(1): 1–29
35. Kwakernaak H (1979) Fuzzy random variables–II: algorithms and examples for the discrete case. Inf Sci 17(3):253–278
36. Puri ML, Ralescu DA (1983) Differentials of fuzzy functions. J Math Anal Appl 91(2): 552–558
37. Puri ML, Ralescu DA (1986) Fuzzy random variables. J Math Anal Appl 114(2):409–422
38. Kruse R, Meyer KD (1987) Statistics with vague data. Springer Science & Business Media, Berlin
39. Liu YK, Liu B (2003) Fuzzy random variables: a scalar expected value operator. Fuzzy Optim Decis Making 2(2):143–160
40. Cheung RKM, Powell WB (1996) Models and algorithms for distribution problems with uncertain demands. Transp Sci 30(1):43–59
41. Zak YA, Frank RY (1975) Optimal planning of level of initial reserves and funds for material resources. Avtomatika i Telemekhanika 36(9):99–107
42. Cohen MA, Moon S (1991) An integrated Plant loading model with economies of scale and scope. Eur J Oper Res 50(3):266–279
43. Blumenfeld DE, Burns LD, Daganzo CF (1991) Synchronizing production and transportation schedules. Transp Res Part B Methodol 25(1):23–37
44. Bhatnagar R, Chandra P, Goyal SK (1993) Models for multi-plant coordination. Eur J Oper Res 67(2):141–160
45. Chien TW (1993) Determining profit-maximizing product/shipping policies in a one-to-one direct shipping, stochastic demand environment. Eur J Oper Res 64(1):83–102
46. Chandra P, Fisher ML (1994) Coordination of production and distribution planning. Eur J Oper Res 72(3):503–517
47. Arntzen BC, Brown GG, Harrison TP et al (1995) Global supply chain management at digital equipment corporation. Interfaces 25(1):69–93

48. Thomas DJ, Griffin PM (1996) Coordinated supply chain management. Eur J Oper Res 94 (1):1–15
49. Cheung RKM, Powell WB (1996) Models and algorithms for distribution problems with uncertain demands. Transp Sci 30(1):43–59
50. Hill RM (1997) The single-vendor single-buyer integrated production inventory model with a generalized policy. Eur J Oper Res 97(3):493–499
51. Beamon BM (1998) Supply chain design and analysis: models and methods. Int J Prod Econ 55(3):281–294
52. Fumero F, Vercellis C (1999) Synchronized development of production, inventory and distribution schedules. Transp Sci 33(3):330–340
53. Escudero LF, Galindo E, Garcıa G et al (1999) Schumann, a modeling framework for supply chain management under uncertainty. Eur J Oper Res 119(1):14–34
54. Von Lanzenauer CH, Pilz-Glombik K (2002) Coordinating supply chain decisions: an optimization model. OR Spectrum 24(1):59–78
55. Bredstrom D, Ronnqvist M (2002) Integrated production planning and route scheduling in pulp mill industry. In: Proceedings of the 35th annual Hawaii international conference on system sciences, HICSS, pp 1606–1614. IEEE, Jan 2002
56. Gupta A, Maranas CD (2003) Managing demand uncertainty in supply chain planning. Comput Chem Eng 27(8):1219–1227
57. Luh PB, Ni M, Chen H et al (2003) Price-based approach for activity coordination in a supply network. IEEE Trans Robot Autom 19(2):335–346
58. Pibernik R, Sucky E (2006) Centralised and decentralised supply chain planning. Int J Integr Supply Manag 2(1):6–27
59. Peidro D, Mula J, Poler R et al (2009) Quantitative models for supply chain planning under uncertainty: a review. Int J Adv Manuf Techno 43(3–4):400–420
60. Chen ZH, Wang YF, Ma SH (2000) Management mechanism of supply chain-production planning and control. Ind Eng Manag 5(2):22–25
61. Zhou JH, Wang DW, Xu Y (2001) Soft computing JIT production planning supply chain of multi-location manufacturing system. Control Dec 16(6):894–897
62. Zhou JH, Wang DW (2001) Production planning model for supply chain for multi-location plants and distributors. Inf Control 30(2):169–172
63. Hou KH, Hu ZW (2002) Supply chain planning in supply chain management. Ind Eng J 5 (5):21–25
64. Sun HJ, Gao ZY (2002) Production planning model of two-echelon distribution network in supply chain based on distributed plant. Chin J Manag Sci 10(6):40–43
65. Yao JM, Zhou GH (2003) Analysis of supply chain optimization planning and scheduling in mass customization. J Manag Sci China 6(5):58–64
66. Yang HH, Wu ZM (2003) Two-level GA-based approach to the capacitated lot sizing problem for multi-plants supply chain. J Shanghai Jiaotong Univ 37(4):473–478
67. Zhu BL, Yu HB, Huang XY (2004) Collaboration planning modeling based on game theory for supply chain. J Northeast Univ (Nat Sci) 25(7):703–706
68. Li JX, Tang LX, Wu HJ (2004) Modeling of the coordinated production planning of a two-stage mineral industry supply Chain. J Northeast Univ (Nat Sci) 25(4):352–355
69. Li JX, Tang LX, Wu HJ (2005) Collaborative production planning in a three stage steel supply chain. Comput Integr Manuf Syst 11(3):375–380
70. Chen HL, Zhang J, Ma DZ (2004) Research on supply chain collaborative based on cost and time balance optimization. Comput Integr Manuf Syst 10(12):1518–1522
71. Ma B, Song FG (2004) The design of supply chain-based garment enterprise integrated planning management system. Comput Syst Appl 9:47–49
72. Cheng HN, Xiang SG, Yang X et al (2004) Supply chain planning model under uncertainty. Comput Appl Chem 21(1):97–102
73. Yang WS, Ma SH, Li L (2004) Coordinated planning model based on response time of supply chain. Forecasting 23(5):52–56

74. Lin ZW, Lin XH, Ding QL (2004) The research of production planning and control for supply chain. Ind Eng 7(4):22–25
75. Ge J, Li YF, Xia GP (2005) Research on global supply chain production planning under uncertain environment. Comput Integr Manuf Syst 11(8):1120–1126
76. Zhou W, Jin YH (2005) Coordination method for multi-plant supply chain planning optimization based on augmented Lagrangian relaxation. J Tsinghua Univ (Nat Sci) 45 (10):1324–1327
77. Jiang M (2005) The study of supply chain enterprises' production planning system resolution model. Mech Des Manuf 12:162–164
78. Chen ZX (2005) Influence of supply chain information uncertainty on production planning and improving methods. Group Technol Prod Modernization 22(4):10–13
79. Li YF, Xia GP, Yang YX et al (2005) Global supply chain tactical planning model based on fuzzy stochastic expected value programming. Syst Eng Theory Pract 8:1–9
80. Wang HJ, Ma SH, Zhao Y (2005) Prototype software system of production planning for mass customization in the supply chain. Ind Eng Manag 10(3):78–81
81. Yu HF, Wang DW (2005) Food-chain algorithm and application to supply-chain planning. J Syst Simul 17(5):1195–1199
82. Nie LS, Xu XF, Zhan DC (2006) Collaborative planning in supply chains based on Lagrangian relaxation and genetic algorithm. Comput Integr Manuf Syst 12(11):1869–1875
83. Kong LF, Luo TD (2006) Agent-based distributed negotiation algorithm for dynamic scheduling problem. Comput Integr Manuf Syst 12(7):1128–1133
84. Du SF, Liang ML (2006) GBOM-based Supply chain network and its integrated production planning model with capacity constraints. Chin J Manag 3(2):143–147
85. Su S, Zhan DC, Xu XF (2007) Manufacturing supply chain planning based on extended state task network. J Softw 18(7):1626–1638
86. Ma SH, Shen W (2007) A planning model and analysis for logistics capability in a multi-stage supply chain. Chin J Manag Sci 15(4):83–88
87. Shen W, Ma SH (2007) A scheduling model for logistics capability in a time-based multi-stage supply chain. Oper Res Manag Sci 16(3):20–25
88. Fang XH, Wang WJ, Tang BY (2007) New technology for supply chain integration—collaborative planning forecasting and replenishing. J Donghua Univ (Nat Sci) 33(2):191–195
89. Ji XL, Zhu HM, Wang NS (2004) Study on three-stage supply chain integrated planning based on GA. J Nanjing Univ Aeronaut Astronaut 36(5):550–555
90. Xiao L (2007) Distributed model for the process of supply chain logistic plan based on integration of knowledge context. Sci Technol Progr Policy 24(7):132–135
91. Li JZ, Liu CL (2007) Study on mass customization planning model of cluster supply chain. Industr Eng Manag 12(3):40–46
92. Zhao JH, Bai JD, Wei XF et al (2007) Fuzzy supply chain problem for lot sizing production planning. Syst Eng Electr 29(8):1299–1304
93. Cai ZY, Xiao RB, Tan Y et al (2008) Fuzzy adaptive production plan dispatching of cycle supply chain under uncertainty conditions. Control Dec 23(5):525–529
94. Fu YY, Pan XH (2008) Optimization of multi-part inventory control and production lot under fuzzy uncertainty. J Zhejiang Univ (Eng Sci) 42(6): 1046–1050
95. Shao XF, Ji JH (2008) Research on pricing and capacity planning coordination based on reimbursement contracts. Chin J Manag Sci 16(4):62–68
96. Bitran GR, Yanasse HH (1982) Computational complexity of the capacitated lot size problem. Manage Sci 28(10):1174–1186
97. Chen WH, Thizy JM (1990) Analysis of relaxations for the multi-item capacitated lot sizing problem. Ann Oper Res 26(1):29–72
98. Karimi B, Ghomi SF, Wilson JM (2003) The capacitated lot sizing problem:a review of models and algorithms. Omega 31(5):365–378
99. Drexl A, Kimms A (1997) Lot sizing and scheduling-survey and extension. Eur J Oper Res 99(2):221–235

100. Barany I, Van Roy T, Wolsey LA (1984) Uncapacitated lot-sizing: the convex hull of solutions. Springer, Berlin, pp 32–43
101. Karni R, Roll Y (1982) A heuristic algorithm for the multi-item lot sizing problem with capacity constraints. IIE Trans 14(4):249–256
102. Guo QS, Yang XY, Wang XG (2006) System modeling. National Defense Industry Press, Beijing
103. Minsky M, Papert SA (1969) Perceptrons. MIT Press, Cambridge
104. Cybenko G (1989) Approximations by superpositions of a sigmoidal function. Math Control Signals Systems 2(4):303–314
105. Hornik K, Stinchcombe M, White H (1989) Multilayer feedforward networks are universal approximators. Neural Netw 2(5):359–366
106. Liu PY (2003) Regular fuzzy neural network as universal approximator of fuzzy valued function. Control and Decision 18(1):19–28
107. Holland JH (1975) Adaptation in natural and artificial systems: an introductory analysis with applications to biology, control, and artificial intelligence. University of Michigan Press, Michigan
108. Xuan GN, Cheng RW (2004) Genetic algorithms and engineering optimization. Tsinghua University Press, Beijing
109. Koza JR (1992) Genetic programming. MIT Press, Cambridge
110. Koza JR, Rice JP (1994) Genetic programming, 2nd edn. MIT Press, Cambridge
111. Michalewicz Z (1996) Genetic algorithms + data structures = evolution programs, 3rd edn. Springer, Berlin
112. Raman S, Patnaik LM (1997) Optimization via evolutionary processes. Adv Comput 45: 155–196
113. Tzeng HW, Chen JL, Chen NK (1999) Traffic grooming in WDM networks using genetic algorithm. In: IEEE international conference on systems, man, and cybernetics. IEEE SMC'99 Conference Proceedings, vol 1. IEEE, pp 1003–1006
114. Golberg DE (1989) Genetic algorithms in search, optimization, and machine learning. Addison Wesley, Boston
115. Chen CW, Dong SH, Ding WY (2006) Optimization of multi-stage production planning in ERW pipe manufacturing. J Univ Sci Technol Beijing 28(7):691–695
116. Vasconcelos JA, Ramirez JA, Takahashi RHC et al (2001) Improvements in genetic algorithms. IEEE Trans Magn 37(5):3414–3417
117. Wang DW, Fang SC (1996) Just-in-time production planning with semi-infinite programming model and genetic algorithm. Control Deci 11(4):446–451

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