Chaos, Solitons and Fractals 89 (2016) 105–114

Contents lists available at ScienceDirect

Chaos, Solitons and Fractals

Nonlinear Science, and Nonequilibrium and Complex Phenomena

journal homepage: www.elsevier.com/locate/chaos

The research on optimization of auto supply chain network robust model under macroeconomic fluctuations

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ARTICLE INFO

Article history:
Available online 6 November 2015

Keywords:
Macroeconomic
Supply chain network design
Robust optimization
Auto industry
Competitive strategies

ABSTRACT

Considering the uncertainty of the macroeconomic environment, the robust optimization method is studied for constructing and designing the automotive supply chain network, and based on the definition of robust solution a robust optimization model is built for integrated supply chain network design that consists of supplier selection problem and facility location–distribution problem. The tabu search algorithm is proposed for supply chain node configuration, analyzing the influence of the level of uncertainty on robust results, and by comparing the performance of supply chain network design through the stochastic programming model and robustness optimize model, on this basis, determining the rational layout of supply chain network under macroeconomic fluctuations. At last the contrastive test result validates that the performance of tabu search algorithm is outstanding on convergence and computational time. Meanwhile it is indicated that the robust optimization model can reduce investment risks effectively when it is applied to supply chain network design.

1. Introduction

Automobile industry, the pillar industry of Chinese national economy, is becoming a key symbol in measuring development level of a nation. Statistics show that automobiles international trade, only behind tourism and oil, has accounted for 12–15% of world total international trade. It is predicted that in the coming 10 years, demand of China's automobile market will increase by 10–15%. Modern enterprises are usually included in multiple supply chains. Thus complicated enterprises competition and interpenetrating supply chains have formed the supply chain networks. It is inevitable for manufacturing industry to promote efficiency of supply chain networks and to pursue innovation.

The supply chain of automobile industry is no longer a single but complex multi-commodity supply chain networks. It is necessary for enterprises to combine core resource and form supply chain network structure suited to Chinas national situation. Thus complementary advantages, sharing resources and reducing cost should be realized. Consequently, it is important to study the characteristics of each member of supply chain in automobile industry, such as decision making, structure stability, and competition strategy.

Therere abundant research achievements in supply chain, however, the study on automobile supply chain or network remains few. The performance, risk, and design of automobile industry supply chain have been studied from the sustainable perspectives of low carbon, climate, environment and green [1–7]. For example, Gholamreza [6] measured the efficiency of enterprise operation from the perspective of environmental supply chains management. The work was based on Italian automobile supply chain, using improved game theory and balance scorecard method to study finance, customers, corporate growth and business process. Besides,

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http://dx.doi.org/10.1016/j.chaos.2015.10.008
0960-0779/

Olugu [8] studied the green closed-loop automobile supply chain, using Visual Basic.Net to set up expert performance evaluation system based on fuzzy rules. Hernndez [9] set up a decision model of automobile supply chain network based on DGRAI, including reverse logistics collaboration. Effect of quality evolution and economic indicators on process and performance of supply chain was also simulated. The authors in [10–13] set up correlation models on inventory of automobile supply chains. Besides, design and executive strategy were provided. For example, Jia [10] analyzed inventory and breakdown cost, setting up best buffer stock model on automobile supply chains. The model was based on the theory of constraints and aimed at agility and stability of automobile assembly line. The work considered both logistics cost and consistency, lowing running cost and improving whole efficiency of automobile supply chain. Aigbedo [11] considers an OEM-parts suppliers system for an automotive supply chain where parts are delivered to the assembly line several times a day in a just-in-time environment, assesses the effect of mass customization on the level of inventory the supplier needs for each variant in order to prevent stockouts by simulating varying assembly schedule and parts delivery schemes. Conclusions show that, among other things, that as the level of mass customization increases, there tends to be an increase in the level of inventory the supplier needs to maintain for each part variant in order to prevent stockouts. Theoretical support is provided for the phenomenon.

In addition, many scholars also done a lot of research on how to improve the performance of the automotive supply chain [15–18]. For example, Jammernegg [14] came up with a strategy on performance improvement through simulation collaborative inventory management and capacity management. The work was based on a country with low labor costs and high worker deployment flexibility. Besides, Sudhir Kumar and Bala Subramanya [15] studied the effect of subcontracting on innovation and economic performance through demonstration methods. The work, however, was based on Indian medium and small automobile enterprises. Another scholar named Behrouzi [16] evaluated performance measures of supply chains, providing corresponding management measures according to different agility levels. Therefore, the work aimed at the random and obscure agility level circumstances of automobile enterprises.

By the method of system dynamics model, Pierreval [18] studied the French automobile industry supply chain and behavior of the members. The work determined the optimal competitive strategy and improved the benefit of supply chain. The competence of supply chain was studied by Joshi [17] aiming at Indian manufacturing enterprises of automobile components. Factors and competitive strategy affecting supply chain performance were provided in the work.

Currently, most researches on automobile industry supply chain in China are based on supply chain networks. Therere some aspects that draws much attention: site selection, equilibrium competitive policies, network robustness, development patterns and so on [19–23].

Previous literatures show that supply chain network of automobile industry has the characteristics of long chain, deep influence, complex environmental change and high uncertainty. Affected by macro-economic fluctuation, cost and risk become uncertain, further affecting the structure and stability of automobile supply chain network. The uncertainty of automobile industry has great relationship with macro-environment, especially in America, Germany, Japan and Korea. So, it is of great significance to study optimal design and stability condition of supply chain networks of automobile industry. Nowadays, most researches focus on single stage facility location and inventory, but studies on construction and optimal design of supply chain network remain few.

Considering the uncertainty of macro-economic factors, this work employed robust optimization in studying structure and design of supply chain networks [24]. By this method, rational distribution was established, including supplier selection, facility location and demand distribution. Thus performance analysis of supply chain networks could be obtained.

2. Problem description

The operation process of automobile supply chain network was assumed as Fig. 1 for convenience. Parts suppliers got the demand information from the consumers, then manufacturers purchased components from parts suppliers in order to finish the automobile assembly. After that, the whole automobile and components were allocated to distributor, including multi-functional automobile 4S and 5S shops, and finally to consumers. At the same time, consumers give information feedback to the distributors. The consumer demand and cost of manufacture and distribution spot were affected by macro-economy.

3. Model assumption

Under the circumstance of macro-economic fluctuation, assumed conditions for building models were included as follows: (1) large-scale automobile manufacturers were core enterprises that determined the establishment of manufacture and distribution spot. The objective is the lowest cost of supply chain network system. (2) Manufacture and distribution spots were fixed. The flow remained zero when the manufacture spot had no exchanges with supply spot, or distribution spot with consumers. (3) One supply spot could provide multiple components, and one manufacture spot corresponded with multiple supply spots. So did the relationship between manufacture and distribution spots distribution spots and customer. (4) Affected by macro-economic impact, operational risk cost was taken into account in measuring the opening up of manufacture and distribution spots. Besides, inventory risk cost was considered in finished automobile inventory. These two costs were determined by macro-economy. (5) Affected by macro-economic impact, safe inventory was set in advance though manufacture and distribution spots tried to reduce inventories. (6) Demands of consumers were totally satisfied.

4. Model building

With the uncertainty of the locations and numbers of parts supplier, manufacturer and distribution, the problem was to establish the following issue: (1) optimal site, scale