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# Optimization of distribution lines based on "Farm-link-supermarket"

***Abstract:*** *"Farm-link-supermarket" (FLS), that is "peasant households + specialized farmers cooperatives + supermarkets", is a modern distribution model which facilitates the flow of fresh and live agricultural products from farm to supermarket, with the lowest price and the best quality. The implementation of this creative model requires the support of modern logistics, which includes the integration of cash flow, logistics and information flow, the proper arrangement of transportation, warehousing, distribution and etc, as well as the implementation of supplying and logistics agreement among farmers, suppliers in all levels, and supermarkets. Based on the analysis of FLS mode, this paper applies Sierpinski curve algorithm to optimize the TSP problem. The purposes of it are to reduce circulation cost, and improve the efficiency of distribution and service level.*

***Streszczenie.*** *W artykule przedstawiono model dystrybucji towarów rolniczych na rynek. Wzięto pod uwagę wszystkie czynniki, mające przełożenie na sprzedaż produktu, jak czas i koszty transportu, składowania, ogólny przepływ pieniędzy. W rozwiązaniu zastosowano algorytm krzywej Sierpińskiego, który pozwala na optymalizację problemu komiwojażera. Model pozwala na redukcję kosztów obrotu towaru i zwiększenie efektywności. (**Optymalizacja drogi dystrybucji modelem „Farm-Link-Supermarket"**).*

**Keywords:** Farm-link-supermarket；Sierpinski curve algorithm；TSP
**Słowa kluczowe:** Farm-link-supermarket, algorytm krzywej Sierpińskiego, problem komiwojażera.

## 1. Introduction

In most regions of China, the rapid development of large-size chain supermarkets and specialized farmers cooperatives (SFCs) provide the basic conditions for the direct flow of fresh and live agricultural products from farm to supermarket, therefore the "Farm-link-Supermarket" (FLS) mode appear. In December 2008, the Ministry of Commerce and the Ministry of Agriculture launched the pilot program of FLS, in order to promote the development of new distribution mode which is "supermarkets + agricultural base", and guide supermarkets directly procure agricultural products from the SFCs.

FLS will have far-reaching impacts on the distribution of agricultural products and the procurement management of supermarkets. It is obvious that the key factors for achieving the success of FLS mode are the appropriate logistics mode and the routing optimization in the process of distribution. This paper mainly focus on TSP optimization, since it is crucial for decreasing circulation cost and improving efficiency of distribution [1, 2].

## 2. The concept of FLS mode

The so-called "Farm-link-Supermarket" refers that peasant households and merchants sign an intention agreement, and then peasant households directly supply agricultural products to supermarkets, grocery stores and convenience stores. This new circulation mode set up a platform for the flow of good quality agricultural products to supermarkets. FLS reveals two problems, one is the buying-selling problem between farm and supermarket, and another is the production-selling linkage problem between agriculture and commerce. The essence of FLS is the direct link between agricultural production and markets. In other words, it is a direct connection among peasant households, SFCs, and supermarkets, which is an optimal supply chain of agricultural products. Its basic mode is "peasant households + specialized farmers cooperatives + supermarkets" [3, 4].

### 2.1 The distribution mode of FLS

The main purpose of FLS is to achieve consolidating transportation, ensure the quality of agricultural products, improve the quick response to market, reduce the segments of circulation, decrease the distribution cost of agricultural products, grantee the food safety of customers, and increase farmers' income. The distribution mode of FLS is shown as follows.

It can be seen from figure 1, FLS mode significantly shorten the supply chain of agricultural products, reduce the distribution channels, achieve centralized purchasing, distribution and pricing, reduce the circulation cost of agricultural products, and benefit both farmer and customers.

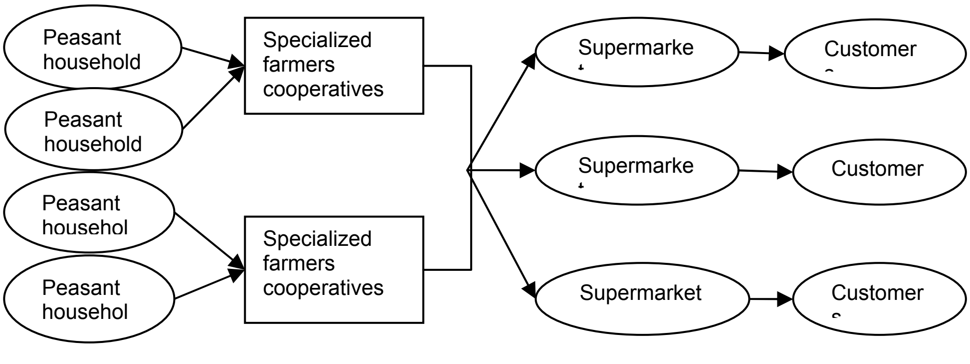


Fig. 1 Distribution Mode of FLS

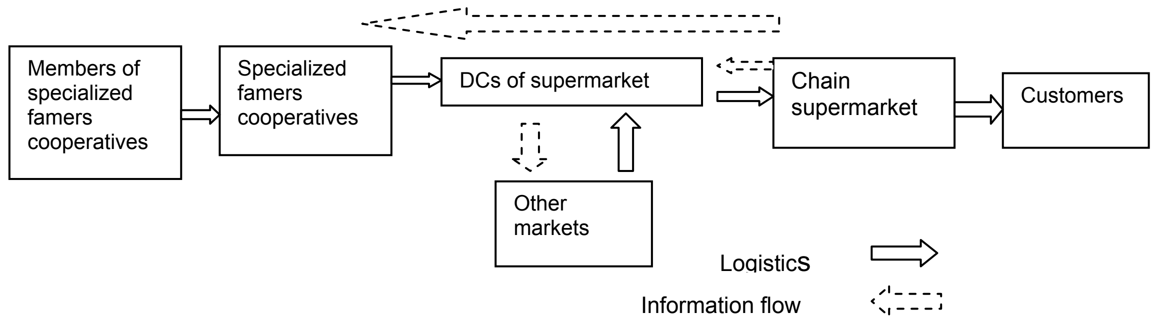


Fig. 2 Flow Chart of FLS

**2.2 The process of FLS**

The process of FLS refers that peasant households sign an intention agreement with merchants, then directly supply agricultural products to supermarkets, grocery stores and convenience stores. This new pattern of distribution is shown as in Fig.2.

**2.3 Comparison between FLS mode and traditional procurement process**

Table 1 Comparison between FLS mode and traditional procurement process

| Comparison between FLS and traditional procurement process | | |
|---|---|---|
| | Traditional procurement mode | FLS mode |
| Procurement process | Harvest of agricultural products<br>Small dealers collect agricultural products at farms<br>Agricultural products are delivered to local markets<br>Agricultural products are collected by big dealers<br>Agricultural products are delivered to large-size wholesaler market<br>Supermarket procurement<br>Agricultural products are sold by supermarkets | Harvest of agricultural products<br>Agricultural products are collected by Specialized Farmers Cooperatives<br>Agricultural products are sold by supermarkets |
| Transit period | Over 3 days | No more than 24 hours |
| Cost price | Increase 5%-10% in each stage | Decrease 15% |
| Farmers income | The selling price of agricultural products is determined by dealers | The average selling price increase 15% |

**2.4. TSP (Traveling Salesman Problem) optimization**

From the above sections, we can see that the basic model of FLS is "Peasant Households + Specialized Farmers Cooperatives + Supermarkets". In order to reduce the circulation cost, and improve the efficiency of distribution and service level, the key is to improve the distribution efficiency between SFCs and supermarkets. In essence, it is a TSP optimization problem between SFCss and supermarkets [5, 6].

Multi-layout of supermarket makes distribution become an important component of FLS. In delivery process, the most important research problem is route plan, which determines the number of vehicles and distribution routes on the basis of cargo volumes. For instance, in Kunming, the conditions for inner city distribution is very complex, especially for those who work for the distribution of agricultural products, because of excessive freight stations, various good categories, complex road network, and the unbalanced distribution of transportation network. To reduce transportation cost, it is necessary to optimize delivery routes, and improve the effective utilization of vehicles.

**3. Optimization of distribution routes**

**3.1. Logistics mode of FLS**

(1) Mode of common delivery

Common delivery is a way of cooperation among many enterprises in certain area. This delivery mode requires that all enterprises have common delivery plan, use same vehicles, share common profits, and bear common transportation risks. Specifically, in this paper, the common delivery refers that a number of SFCs join together to deliver agricultural products to supermarkets in certain area. The delivery process is shown as below:

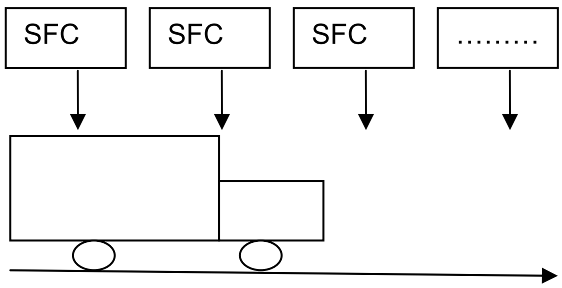


Fig. 3 Sketch Map of Common Delivery (Loading Process)

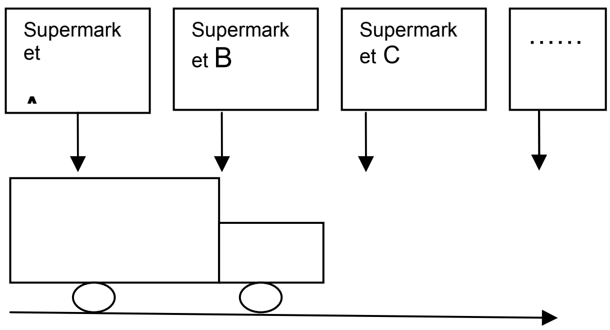


Fig. 4 Sketch Map of common delivery (Unloading Process)

(2) Touring pickup mode of supermarket

Touring pickup model of supermarket refers that, according to the sequence of orders, supermarkets organize delivery vehicles to pickup agricultural products from the depots of SFCs, and then return to supermarket. This process is shown in figure5.

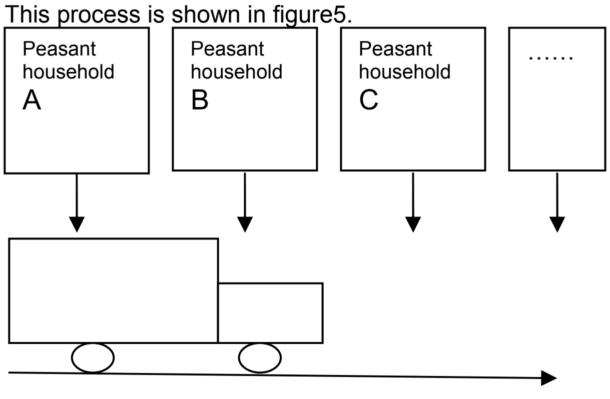


Fig. 5 Touring pickup mode of supermarket

For above TSP models, we can use Sierpinski curve algorithm to solve the optimal solution.

### 3.2. Optimal solution for TSP

Sierpinski curve is appropriate in solving practical TSP problems, since it has following characteristics: full symmetry, high density in space-filling, and more accuracy in space partition.

(1) Theoretical principle of Sierpinski curve algorithm

In the close-loop of Sierpinski curve, we choose any point as the starting point of delivery, as well as the end-point. If we take 1 unit as the circumferential distance along the fractal curve, then any point along the delivery route correspond to a value between 0 and 1. After marking the point along the curve, we get the sequence of the point, and then connect all points following the sequence to get the optimal route. Sierpinski curve is a symmetric curve, dividing it into 2 parts, if we start from the lower-left corner, then go upward along the curve, those points included in the upper-left part have precedence over those in lower-right part. Since the image is self-copied, the half plane can be recursively segmented. For any 2 points, there exit a segmentation which make them to locate in different small half plane, then the distribution sequence can be determined.

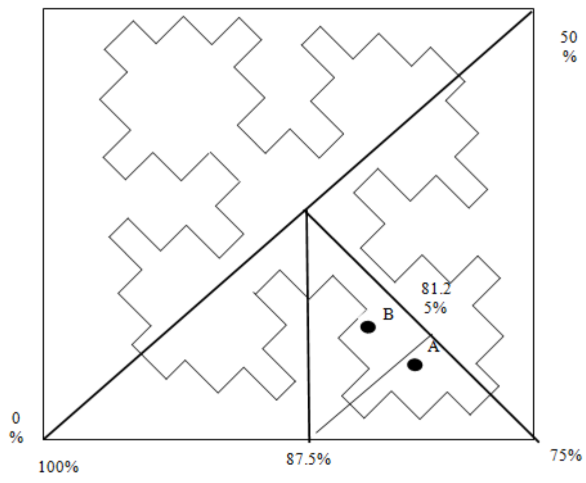


Fig.6 Four segmentations of Sierpinski curve

Specifically speaking, the steps of Sierpinski curve algorithm are: in the first segmentation, staring from the lower-left corner (0,0) to the upper-right corner (1,1) of unit square correspond to 50%, then back to starting point which correspond to 100%. Thereby, we know that the sequence value of point A and point B range between 50% and 100%. In the second segmentation, the lower-right correspond to 75%, we further know the sequence value of point A and point B range between 75% and 100%. In the third segmentation, the sequence value of point A and point B range between 75% and 81.25%. In the forth segmentation, point A's sequence value is between 75% and 81.25%, and point B's sequence value is between 81.25% and 87.5%. Therefore, A has precedence over B, which is shown in figure 6.

(2) Modified Sierpinski curve algorithm

For multi-vehicle delivery, Sierpinski curve algorithm should be modified. Assuming there are two delivery vehicles A and B, and 10 customers, vehicle A is responsible for delivering goods to 5 customers who are located on the left of routing graph, and vehicle B is responsible for another 5 customers who are located on the right. Each vehicle follows the planned sequence. In addition, the number of vehicles may fluctuate because of various cargo volumes (Ex. With the increase of cargo volume in holiday, the number of vehicles increases too, at this time, we only need to regroup it). As shown in figure 7, D represent distribution center.

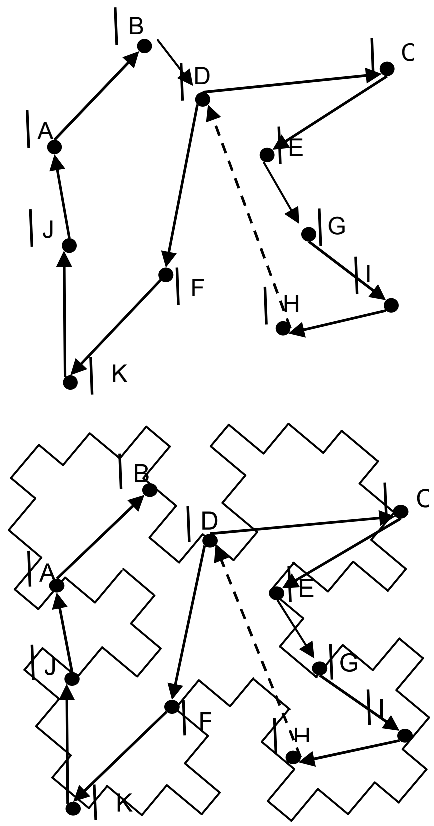


Fig. 7 Multi-vehicle delivery in Sierpinski curve algorithm

Each vehicle is assigned similar number of customers, but the transportation distance is different, so the delivery time is uneven. However, as long as the distribution scope of customers is even, through using Sierpinski curve to decide the customer sequence, and then assigning cargo volume to each vehicle, we can make each vehicle has similar total transportation distance.

In addition, in the process of delivery, there are some unexpected orders. Usually, enterprises may accumulate orders, or postpone the implementation of orders. Sometimes, in order to not disturb the existing delivery route plan, companies may arrange additional vehicles to deliver goods. However, with the application of Sierpinski curve algorithm, if there are any new customers make orders, we only need to make sure the sequence value on the graph, and insert it in the existing sequence.

Modified Sierpinski curve algorithm can be used to find the optimal solution of TSP, which could reduce delivery cost, and improve the efficiency of distribution. This method can be easily applied in practical situation, and more accurate than the others.

## 4 Concluding remarks

From the perspective of logistics, this paper analyzed the concept, essence, process and delivery mode of FLS, and compared the traditional procurement process with FLS, then find out that one of main factors of achieving the success of FLS is optimizing the delivery route, which is also the key to reduce circulation cost, and improve distribution efficiency and service level. Taking two logistics operating models as examples, we use Sierpinski curve algorithm to find the optimal solution for TSP. This could reduce delivery cost, improve the efficiency of transportation, and deliver agricultural products to customers in the shortest time. TSP optimization helps enterprises to improve delivery efficiency, strengthen competitiveness, and optimize social resource allocation,

Since lack of real data, we cannot apply the Sierpinski curve algorithm to optimize TSP in practical situation. In future research, we will collect real data in order to apply this method to make further quantitative analysis in real situation.

Acknowledgements

*The first and the third author wish to thank the research fund of Humanities and Social Science, the Ministry of Education (09XJA630006), for financial support.*

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