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Research on the Supply Network of Camellia Oil in Anhui Province

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Abstract: Tea oil is becoming more and more popular in China. Based on a field investigation, this paper analyzes the supply network of Camellia oil in the local markets of Anhui. It is found that there are 3 network models of Camellia oil supply. The towns or counties with only one factory and sufficient Camellia seeds have the lowest risk and the best chance in oil supply. The towns or counties with just one factory and just enough Camellia seeds are at the greatest risk and have the least chance in oil supply. The towns or counties with two factories and Camellia seeds that can only supply one factory have a moderate risk and the tied best chance of oil supply. The network's primary limiting factor is the availability of Camellia seeds. The probability of the supply network can be considerably increased and the risk can be greatly decreased with more factories and sufficient Camellia seeds.

Keywords: supply network, Camellia oil, probability, fragility

1. Introduction

Through a field investigation launched in Anhui province in 2022, the author observed that people of Anhui like to eat Camellia oil and there are oil-pressing mills in almost all mountainous counties or towns. In some places, the oil pressing mills or factories have sufficient Camellia seeds for oil production, while in other places, there are too many factories but too few Camellia seeds. Anhui province is in a watershed region of Yangtse River and HuaiHe River where there are frequent drought and flood disasters [1]. This can result in risks in the Camellia seeds supply. The risk of the seed supply can be shifted to the whole supply network of Camellia oil [2,3]. To analyze the network fragility of the Camellia oil supply in Anhui province, the simple models in the O-ring theory [4] and the risk equation of Jarrow &Yu [5] are used to analyze the Camellia oil supply network in counties or cities of Anhui province. The research on the supply network can help avoid risks and provide a stable supply network [6,7].

2. Theoretical Background

O-rings theory was put forward by M. Kremer and was motivated by the Challenger Space Shuttle disaster [4]. Two failed rubber O-ring seals resulted in the disaster. Kremer noticed the strong complementary missing from standard production functions in macroeconomics. O-ring theory has been applied in many fields of economic management and social life [8-10]. The basic idea is that

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production is completed by a series of steps, and the final output depends on the quality of completion of all steps. There is a Toy model based on the O-Ring theory. The model includes three steps: the production of the final product a required the intermediate product b, and the production b required the intermediate product c. This simple model is very suitable for analyzing the supply network of Camellia oil including the final a (product refined and packed Camellia oil), the intermediate product b (crude pressed Camellia oil,) and the intermediate product c (the raw material Camellia seeds). The completion of every step may not be 100%, especially at the step of the Camellia seeds supply for that frequent drought and flood disasters can result in the reduction of seed yield [1]. The risk of the supply network of Camellia oil can be described as Poisson processes according to the theory of Jarrow &Yu [5]. The distribution of the risk r in time [0,t] is according to the equation [5].

3. Methodology

The data of Camellia oil production were obtained through a field survey on forest investment in Anhui province. The risk of the Camellia seed supply was estimated according to the data of Camellia seed production in Anhui province and the climate disaster frequency from 1996 to 2013 [1]. The supply network of Camellia oil was analyzed by using the simple models in the O-ring theory [4] and the risk equation of Jarrow &Yu [5].

4. Result and Analysis

Based on the author’ s observation, there are three supply network models in different counties or towns in Anhui province.

4.1. The First Supply Network Model

In some remote mountainous towns or counties, one oil pressing mill or factory has usually two or more Camellia seed suppliers, and each supplier can supply sufficient Camellia seeds. In these places, the Camellia oil supply network is usually a simple network which usually consists of two Camellia seeds suppliers (c1, c2), one oil pressing mill (b1) and one oil packer and seller (a1) (Fig. 1).

Camellia seed suppliers may be hit by shocks of climatic hazard or plant diseases and insect pests. The oil mill may be hit by shocks of mechanical failure or power supply etc. One oil packer and seller may be hit by shocks of transportation and storage problems. Suppose each firm is hit independently, with the probability of . So, with the probability x, it is unshocked.

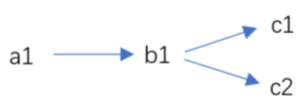

Figure 1: Supply network of Camellia oil (Note: a1 is the supplier of the final product Camellia oil; b1 is the producer of crude Camellia oil; c1 and c2 are the suppliers with sufficient Camellia seeds).

The probability that c (c1 and/or c2) can function is $1-(1-x)^2$

The probability that b (b1) can function is $x \cdot (1-(1-x)^2)$

The probability that a (a1) can function is $x^2 \cdot (1-(1-x)^2 = 2x^3 - x^4$

Therefore, the equation of the Camellia oil supply network is $y = 2x^3 - x^4$ (Fig. 2-1).

In fact, the main shock in the Camellia oil supply network in Anhui comes from the climate. Anhui is in the Jianghuai watershed area where there is a climate disaster every 5 years [1]. Therefore, the unshocked probability of c1 or c2 is about 0.8. During oil pressing, packing, and selling, disasters seldom happen and the unshocked probability can be more than 0.95.

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Based on the different probabilities: the probability that c (c1 and c2) can function is $1-(1-x)^2 = 1-(1-0.8)2 = 0.96$, and the probability of a is $0.95 * 0.95 * 0.96 = 0.87$

This means the unshocked probability of the Camellia oil supply in this area is 0.87 or the probability risk is 0.13. According to the risk equation of Jarrow &Yu [5], it can be known that the probability of the risk happening during [0-t] is $F(T) = 1 - e^{0.13t}$ (Fig. 3-1).

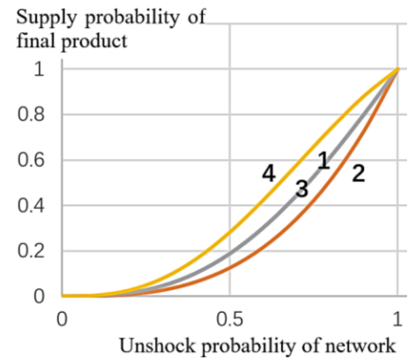

Figure 2: Probability of Camellia oil supply network (Note: 1 is the first model; 2 is the second model; 3 is the third model; 4 is the optimized model).

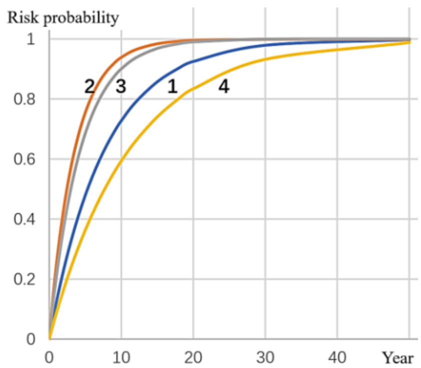

Figure 3: Probability of risk occurrence in Camellia oil supply (Note: 1 is the first model; 2 is the second model; 3 is the third model; 4 is the optimized model).

4.2. The Second Supply Network Model

Some towns or counties have big oil pressing factories which can use up all the Camellia seeds of different seed suppliers. In these places, the Camellia oil supply network is still a simple network which usually consists of two Camellia seed suppliers (c1, c2): one oil pressing factory (b1) and one oil packer and seller (a1). But a single Camellia seed supplier (c1 or c2) can only meet half the demand of the factory (Fig. 4).

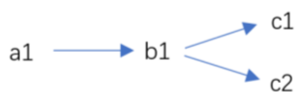

Figure 4: Supply network of Camellia oil (Note: a1 is the supplier of the final product Camellia oil; b1 is the producer of crude Camellia oil; c1 and c2 are the suppliers of insufficient Camellia seeds).

When c1and c2 can function, b (b1) can function. The probability of b is $x \cdot x^2$.

When one of c1 or c2 can function, b (b1) can half function. The probability of b is $x/2 \cdot ((x \cdot (1-x) + x \cdot (1-x)) = x^2 \cdot (1-x)$.

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Therefore, the probability of a1 is $x \cdot (x^3 + x^2 \cdot (1-x)) = x^3$.

The equation of the Camellia oil supply network is $y = x^3$ (Fig. 2-2)

The actual probabilities of a, b, and c (c1 and c2 together) are 0.95, 0.95, and 0.8, respectively. The probability that c can function is $x^2 + x \cdot (1-x) = 0.8$, and the probability of a is $0.95 * 0.95 * 0.8 = 0.72$.

This means the unshocked probability of the Camellia oil supply in this area is 0.72 or the probability risk is 0.28.

According to the risk equation of Jarrow &Yu (2001), it can be known that the probability of the risk happening during [0-t] is $F(T) = 1 - e^{0.28t}$ (Fig. 3-2).

4.3. The Third Supply Network Model

Because more and more people like to eat Camellia oil and its price is increasing, there are too many oil pressing factories established in some towns or counties. The Camellia seed supplier (c1 or c2) can not meet all the demand of the factories. For example, there are two factories (b1, b2) and two Camellia seed suppliers (c1, c2) in one county. Camellia seed suppliers (c1, c2) can meet only one of the factories’ demands (Fig. 5).

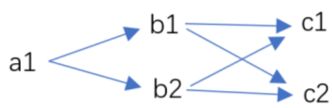

Figure 5: Supply network of Camellia oil (Note: a1 is the supplier of the final Camellia oil; b1 and b2 are the producers of crude Camellia oil; c1 and c2 are the suppliers of insufficient Camellia seeds).

A1 can produce if and only if b1 or b2 is unshocked (so with the probability of $(1-(1-x)^2)$); c1 and c2 are unshocked (so with the probability of x^2), or either c1 or c2 are unshocked (so with the probability of $2x \cdot (1-x)$; and a1 is unshocked. Because c1 or c2 can meet only half of demand of b1 or b2, therefore, the probability when either c1 or c2 is unshocked should be corrected as $x \cdot (1-x)$, and the probability that a1 can function is now $x \cdot [x^2 \cdot (1-(1-x)^2) + x \cdot (1-x) \cdot (1-(1-x)^2)] = x \cdot [x \cdot (1-(1-x)^2)] = 2x^3 - x^4$

The equation of the Camellia oil supply network is $y = 2x^3 - x^4$ (Fig. 2-3).

The actual probabilities of a, b, and c (c1 and c2 together) are 0.95, 0.95, and 0.8, respectively. The probability that c can function is $x^2 + x \cdot (1-x) = 0.8$. The probability that b can function is $0.8 * (1-(1-0.95)^2) = 0.8 * 0.9975 = 0.80$. The probability that a can function is $0.8 * 0.95 = 0.76$.

This means the unshocked probability of the Camellia oil supply in this area is 0.76 or the probability risk is 0.24.

According to the risk equation of Jarrow &Yu (2001), it can be known that the probability of the risk happening during [0-t] is $F(T) = 1 - e^{0.24t}$ (Fig. 3-3).

4.4. Optimized Supply Network Model

If all the Camellia seed suppliers (c1 and c2) can meet all the factories’ demands, the Camellia oil supply network will be much stable.

The probability that c (c1 and/or c2) can function is $1-(1-x)^2$

The probability that b (b1) can function is $(1-(1-x)^2) \cdot (1-(1-x)^2) = (2x-x^2)^2$

The probability that a (a1) can function is $x \cdot (2x - x^2)^2 = 4x^3 - 4x^4 + x^5$

Therefore, the equation of the Camellia oil supply network is $y = 4x^3 - 4x^4 + x^5$ (Fig. 2-4).

The actual probabilities of a, b, and c (c1 and c2 together) are 0.95, 0.95, and 0.8, respectively. The probability that c can function is $1-(1-x)^2 = 0.96$. The probability that b can function is $0.96 * (1-(1-0.95)^2) = 0.96 * 0.9975 = 0.96$. The probability that a can function is $0.96 * 0.95 = 0.91$.

This means the unshocked probability of the Camellia oil supply in this area is 0.91 or the probability risk is 0.09.

According to the risk equation of Jarrow &Yu (2001), it can be known that the probability of the risk happening during [0-t] is $F(T) = 1-e^{0.09t}$ (Fig. 3-4).

5. Discussion

From Fig. 2 and Fig. 3, one can see that the towns or counties with the sole factory and sufficient Camellia seeds have the lowest risk (Fig. 3-1) and the highest probability (Fig. 2-1) in the oil supply. The towns or counties with the sole factory and just enough Camellia seeds have the highest risk (Fig. 3-2) and the lowest probability (Fig. 2-2) in the oil supply. The towns or counties with two factories and Camellia seeds which can only meet one of the factories have the moderate risk (Fig. 3-3) and the tied best probability (Fig. 2-3) in oil supply.

The networks of model 2 and model 3 included 3 levels (e.g. a, b, and c), and had the same suppliers at the level of the Camellia seeds supply, but model 3 had a better probability and a lower risk in the Camellia oil supply. This suggested that two factories of model 3 can increase the stability of the network. This is consistent with the O-ring theory that more suppliers in one level can increase the stability of the supply network [4].

Although model 3 is a better network than model 2, it is worse than model 1 for that model 3 is restricted by insufficient Camellia seeds. If the suppliers of Camellia seeds can supply sufficient raw material, the supply network will be much better than all the models (Fig. 2-4, 3-4). Examining the models, one can see that the the maximum limiting factor of the network is the Camellia seeds supply. More factories can increase the stability of the supply network but the stability will be limited without sufficient Camellia seeds.

6. Conclusions

The above analysis showed that the Camellia oil supply network in Anhui province included three network models. The towns or counties with the sole factory and sufficient Camellia seeds have the lowest risk ($F(T) = 1-e^{0.13t}$) and the best probability ($y = 2x^3-x^4$) in the oil supply (model 1). The towns or counties with the sole factory and just enough Camellia seeds have the biggest risk ($F(T) = 1-e^{0.28t}$) and the lowest probability ($y = x^3$) in the oil supply (model 2). The towns or counties with two factories and Camellia seeds which can only meet one of the factories have the moderate risk ($F(T) = 1-e^{0.24t}$) and the tied best probability ($y = 2x^3-x^4$) in the oil supply (model 3). The main limited factor of the network is the supply of Camellia seeds. More factories and sufficient Camellia seeds can greatly increase the probability ($y = 4x^3-4x^4+x^5$) and decrease the risks ($F(T) = 1-e^{0.09t}$).

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