Analysis on Petri Net Modeling and Performance of Tea Supply Chain - A Case Study of Tea in South Anhui

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Abstract: As a typical agricultural product, tea is one of the world's three drinks. Tea supply chain is established around tea, and its efficiency is conducive to the development of agriculture in China. As China's major tea producing area, the low efficiency of the supply chain in South Anhui has been one of the constraints of the development of tea trade, this paper explores the reconstruction of Petri Net tea supply chain using stochastic Petri Net tea supply chain to improve the efficiency of tea supply chain link joint, but also to improve the overall performance and efficiency.

Introduction

Tea is similar to other agricultural products. Depending on the difference cores of supply chains of enterprises, they are generally divided into four types, namely the four basic forms of wholesale market as the center, processing enterprises as the core, retail enterprises as the core and logistics enterprises as the core. The supply chains of processing enterprises as the core should be combined with historical data, establish a sound procurement and production plans to effectively control operating costs; secondly, a rough and deep processing have achieved the value added of tea, also increased the employment of local idle labor. Since the initial large fixed investment of processing enterprises on purchase of equipment and the construction of factories and seasonal agricultural production and other issues also easily lead to inadequate supply and breach of orders, etc., that requires processing enterprises pay attention to the performances of their supply chains.

Nowadays, since tea supply chain is characterized in that there are more inventory and driving models, the demand-driving of orders should be improved and its efficiency of supply chain is not high. The driving of orders can effectively reduce the order-driven market and reduce inventory levels, and optimize production processes of agricultural enterprises. Compared to the wholesale market as the center, the advantages for supply chains of the tea processing enterprises as the center are concentrated and embodied in the economies of their business scales. The supply chains of the primary wholesale markets as the core is used for sales according to the quantities based on marketing sales models, and there is no uniform production planning; in form of organization, it is mainly based on farmers, more loosely organized and it cannot form a strong competitive edge; compared to the tea of logistics enterprises as the core, processing enterprises stands at the middle position of the supply chain, and their good development statuses can contribute to the supply chain and processing enterprises central position, so as to better serve the upstream suppliers and downstream distributors.

According to "2014 China Tea Yearbook", it shows that China, as one of the tea producing countries, its domestic sales is the main factors for driving new tea sales, and its export is the main factor pulling Chen tea sales. During 2003 to 2014, the domestic sales of tea rose from 500,000 tons

to 1300,000 tons, the domestic sales of new tea gradually expanded, indicating the number of tea drinkers and the acceptance of tea were gradually increasing. Compared fermented tea WITH other non-fermented tea, the green tea accounted for the largest domestic sales of 715000 tons. In tea exports, according to Customs statistics: the tea exports in China 3130000 tons in 2012 with unit exports amount of 10.42; tea exports in China are increased by 7% in 2013, larger provinces of exports include Hunan, Anhui, Fujian, mainly importing countries include Japan, Morocco, Uzbekistan, the United States, etc. Therefore, improving the operational efficiency of the supply chain of tea will effectively promote the agricultural development.

Research Status of Tea Supply Chain at Home and Abroad

Based on the characteristics of agricultural products, related scholars had studied on agricultural products. Liu Jiangpeng (2010) [1] pointed out that the agricultural supply chain was composed of agricultural producers, processing enterprises, agricultural product logistics, wholesalers, retailers and consumers to work together to build a chain mesh, Zhu Yihua (2004) [2] believed that the supply chain of agricultural products was mainly related to the supply chain, production, logistics, demand four areas, with more participants. In addition to the definition of agricultural products as well as research participants, the agricultural supply chain to consumer demand to guide, through the rational flow of goods, capital and information flow, Wang Jing (2012) [3] studied on a whole research operation by consumer demand and the supply chain, noted that the competitive advantage of agricultural supply chain downstream achieve should pay attention to funds and circulation of agricultural products with examples of the loss rate of fruits and vegetables during the circulation as high as 25-30%, even much higher than in developed countries.

Based on tea, this typical agricultural product, related scholars have conducted a detailed study. Shi and Qin (2014) [4] made the theoretical study on the tea industry in the current situation of the theoretical study, pointed out that today's tea supply chain logistics concept is now lacking, the government should increase its efforts to support the leading tea companies, tea supply chain to build the core processing enterprises. Huo Red (2015) [5] made an analysis from the perspective of tea quality and safety issues that the current tea quality supervision departments will coordinate low and certification system is not standardized. Jiang Rong (2015) [6] and Duan Tiejian (2015) [7], made an analysis from the system dynamics and the angle of Petri Net tea supply chain were studied to establish a tea supply chain evaluation model for the evaluation of the tea supply chain It provides a model approach. Zheng Xuyuan (2015) [8] studied on the tea supply chain organizational model, from the perspective of the tea vendor noted China's tea supply chain modes include three modes of tea farmers, cooperatives, processing enterprises.

From abroad aspect, scholars studies mainly from the perspective of agricultural products. Scholar Moses Bukenya (2012) [9] pointed out that the main challenge faced by agricultural SMEs from the capital, as well as their own personal property financing business reputation is an effective way to solve the financial difficulties. Bernard (2012) [10] studied on agricultural products and financial relations, indicating in combination with agricultural finance is the current direction of agricultural development, agricultural enterprises involved in the financing behavior, improve operational efficiency. Ashok (2012) [11] studied on the driving force of American agriculture to optimize the combination of the government, farmers, businesses and financial institutions can improve the effect of inventory financing. Virgil (2013) [12] pointed out that the supply chain demands should be in the form of a flexible organization should focus on the linkage of processing and production sales platform of raw materials and other related products.

In conclusion, the supply chain and supply chain produce tea should be mainly studied in the form of operation, evaluation model, organizational form, and less for today's tea supply chain inefficiencies Improvement.

Evaluation Method for Stochastic Petri Net

Stochastic Petri Net (SPN) is subject to a certain time introduced into the Petri Net, time is exponential distribution, which enable the change and change at supra section assigned the same. According to the literature [13], stochastic Petri Net is defined as follows:

The type consists of six basic elements, specifically as follows:

SPN = {P，T，I，O，m_0，λ}

λ is the transition firing rate in a unit time, and is the non-negative exponential distribution, λ= {λ1，λ2，λ3，…，λm}.

Because of the stochastic Petri net and Markov chain are isomorphic to the performance of stochastic Petri Net to solve [13] by Markov chain; steady-state probability of each state using Markov stochastic probability matrix is a more convenient method [14].

Tea Supply Chains and Petri Net

This paper is established on order-driven export tea supply chain model, due to the single requirements for export of raw materials, only tea supply chain model for raw material supply is established, the model framework is shown in Figure 1:

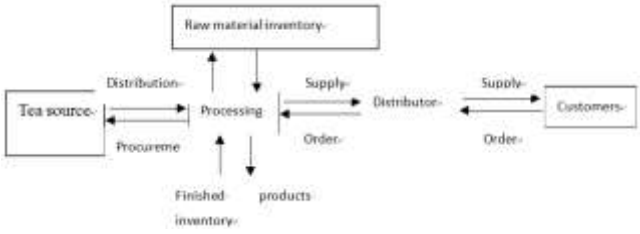

Figure 1: Structure chart for supply chains of tea-core process enterprises

The supply chain of tea describes the process of the procurement of materials, processing of raw materials and finished product sales of enterprises and based on material flow, capital flow and information flow is determined. To reduce the complexity of the model, highlighting the general tea supply chain model represents farmers in the supply chain, base, cooperatives, other provinces supplier supplied with a supply of tea; processing stages using mechanical filter represents a long screen machine, sieve element machines, other processing areas including uniform heap, dehydration, laser screening, packaging is not as simplified; the sales process to meet order demand by the finished product and sales information feedback to the enterprise. Construction of Petri Net model is shown in Figure 2:

Figure 2 General structure of the graphic tea supply chain, each Inventory clinics Changes are described in Table 1 below:

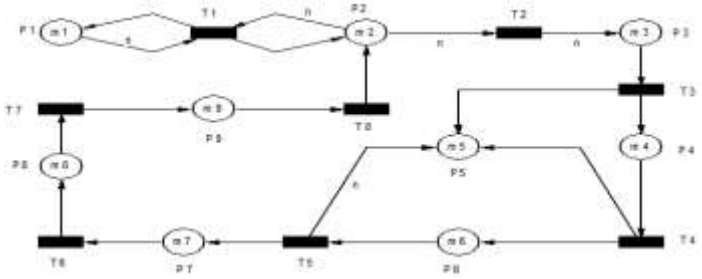

Figure 2 Diagram of Petri Net of tea supply chain

Table 1 Table of meanings for changes of Petri net of tea supply chain

Inventory Location	Meaning	Changes	Meaning
P1	Supply source Inventory	T1	Supplies - Procurement
P2	Raw materials inventory	T2	Start processing (material transfer)
P3	Production of order	T3	Mechanical screening
P4	First screening Maocha	T4	Drying
P5	Screening of tea stems, water and other impurities	T5	Laser screening
P6	Drying tea	T6	Packaging
P7	Secondary screening tea	T7	Supply order
P8	Finished product inventory	T8	Supply feedback
P9	Demand of order		

Tea supply chain describes the general aspects of the supply, processing and sales orders. This section constructs Petri net model diagram on this basis to lay the theoretical foundation for the later application.

Application Example of Tea Supply Chain in South Anhui

Southern tea supply chain application examples Anhui Liang Qi Tea Co., Ltd. (hereinafter referred to as Liang QI) is located in the national ecological demonstration area - Yuexi County Yao Township, was established on October 17, 2003, the company is a tea provincial-level agricultural industrialization leading enterprises with a registered capital of 10 million Yuan. The sales mode of company is divided into domestic and export sales, local domestic tea green tea-based, export tea sourced from local, Zhejiang, Jiangxi and other places. The company is a major tea export and domestic sales combined. Domestic sales channels are mainly operated through franchise stores, distributors and online sales. The company has five stores around Yuexi, Anqing and Hefei.

We test according to the company export orders historical data K-S (Kolmogorvo-Smirnor), which with mean is 49723.69, and standard deviation of the normal distribution is 25819.45. Order a monthly basis, whichever is the monthly average monthly orders volume order processing, taken 30 days a month, the average daily treatment capacity of 1657.5kg, taking 17 orders for the initial token represents the company's daily production. According to the research of the company, the transition firing rate is determined by the supply chain system time consumed to obtain:

$\lambda=\{\lambda_1, \lambda_2, \lambda_3, \lambda_4, \lambda_5, ,\lambda_6, \lambda_7, \lambda_8, \lambda_9, \lambda_{10}, \lambda_{11}, \lambda_{12}\}=\{1，1，4，3，3，2，0.2，0.2，0.1，0.1，1，1\}$

Because the order sales of finished products, according to company research, raw tea leaves in tea stems and water accounts for the low weight, the weight screening and dewatering to 1. Companies Maocha suppliers of raw materials including base, farme4rs, cooperatives and other provinces tea into four categories, according to company research suppliers supply ratio is about: 20%: 10%: 20%: 50%; to facilitate the modeling and according to company research Inventory 17 the finished products need 21 tokens of raw tea leaves, so the use of raw materials Maocha modeling in the model. Construction company original structure is as shown in Figure 3:

The meanings for libraries and changes as given in Table 2 below:

Table 2 Table of meanings for changes and Inventory of Petri Net of Liang Qi's supply chain

Inventory	Meaning	Changes	Meaning
P1	Market orders	T1	Development of Maocha requirements planning
P2	Maocha demand	T2	Procurement planning
P3	Tea farmers supply	T3	Transport process for tea farmers
P4	Cooperatives tea supply	T4	Transport process for tea cooperatives
P5	Base tea supply	T5	Transport process of base
P6	Supply of other provinces	T6	Transport process of other province
P7	Raw material inventory	T7	Yuan sieve
P8	First screening of tea	T8	Long sieve
P9	Tea stems water	T9	Drying
P10	Secondary screening of tea	T10	Laser screening
P11	Dry tea	T11	Packaging
P12	Three-times screening of tea	T12	Sales/order demands
P13	Finished product inventory		

We can be seen from the original company primary supply chain: in the supply chain, the suppliers to their distribution plant Maocha, time and efficiency in the supply to this whole supply chain efficiency is not high; the more busy processing sectors, based on these two reasons, supply chain logistics center functions to achieve through the base, the raw tea farmers and cooperatives were unified by the base distribution, so as to streamline vendor and improve operational efficiency. Processing sectors in order to improve operational efficiency and facilitate inventory financing regulation, the serial processing sectors to long filter screening machine, sieve element parallel machine, screening machine for the same length and meta sifter rate, raw material raw tea leaves after a process of any of its direct into the next device for screening. When raw material storage warehouse will be uniform heap weight of standard treatment, improve Maocha warehouse standardization. Reconstruction of Petri net structure is shown in Figure 4:

Reconstruction of the logistics center of the company increased as part of centralized distribution and processing sectors through the production process changes, additions and deletions links, reconstructed the existing processes. Each Inventory clinics Changes are described in Table 3 below:

According to the literature [13], after the establishment of the system of stochastic PN network model, and then generate up view of an initial identification, in order to obtain and Markov chain

analysis. Identified by calculating the transfer of variables and Markov chain steady-state probability, we have to reconstruct the original supply chain Π and steady-state probability of supply chain Π as follows:

=(0.00813,0.04065,0.01016,0.01358,0.01358,0.02033,0.40650,0.20325,0.08008,0.19308,0.00968,0.00016,0.00049)

$\Pi' = Y\pi_0'I\pi_1'I\pi_2'I\pi_3'I\pi_4'I\pi_6'I\pi_7'I\pi_8'I\pi_9'I\pi_{10}'I\pi_{11}'Y$ =(0.03675,0.01838,0.03969,0.00928,0.24255, 0.12127,0.06063,0.03050,0.36751， 0.03675,0.03675).

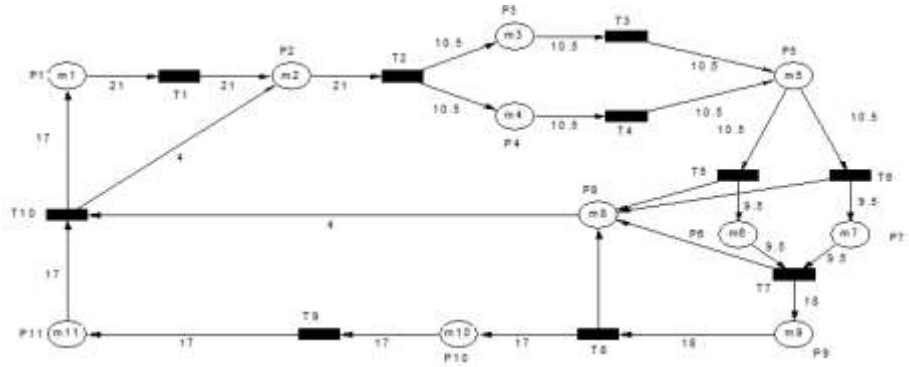

Figure 4 Reconstruction Figure of Liang Qi's Supply Chain

Table 3 Table of meanings for reconstruction of Petri

Inventory	Meaning	Changes	Meaning
P1	Market ordering	T1	Development of Maocha requirements planning
P2	Maocha demand	T2	Procurement planning
P3	Supply of base logistics center	T3	Transport of base logistics center
P4	Supply of other provinces	T4	Transport process of other province
P5	Raw materials inventory	T5	Yuan sieve
P6	Secondary screening of tea	T6	Long sieve
P7	Secondary screening of tea	T7	Drying
P8	Tea stems water	T8	Laser screening
P9	Dry tea	T9	Packaging
P10	Three-time screening of tea	T10	Sales/order demands
P11	Finished product inventory		

Conclusion

Utilization of the system can be represented by the busy, busy is the higher the higher utilization. Busy steady-state probability system can reflect the system, the original supply chain and supply chain Reconstruction key comparison in Table 4 below:

Table 4 Comparison the original supply chain with using of reconstruction of key supply chain

Comparison	Original Supply Chain	Reconstruction of Supply Chain
Logistics utilization	$P_{T7}=P(m_6)=0.20325$	$P_{T5}=P(m_4)=0.24255$

Three-time screening of Maocha	$P_{T10}=P(m_{10})=0.00968$	$P_{T8}=P(m_8)=0.36751$
Finished products	$P_{T11}=P(m_{11})=0.00016$	$P_{T9}=P(m_9)=0.03675$

In addition to improving key utilization, supply chain efficiency is also a key indicator analysis. Petri Net supply chain efficiency is mainly based on the rate and steady-state excitation probability for analysis [33]. The original supply chain, inspired by the changes of T11 represents production of finished products, T11 Changes in the variable representing m1, m2, m3, m4, m5, m6, m7, m9, m10, m11 enabled with the finished product Productivity:

$$\lambda_{11}(m_1+m_2+m_3+m_4+m_5+m_6+m_7+m_9+m_{10}+m_{11})=0.91\text{kg/unit time}$$

Reconstruction after the supply chain of finished products T9 excited by change, in the identification variables m1, m2, m3, m4, m5, m6, m8, m9, m10 enabled productivity have reconstructed:

$$\lambda_9(m_1+m_2+m_3+m_4+m_5+m_6+m_8+m_9+m_{10})=1.39\text{kg/unit time}$$

We can be seen that the reconstructed key supply chain can improve the efficiency and increase productivity. In order to better develop the tea supply chain, the government should also focus on government efforts to support the processing enterprises, and the enterprises should provide the level of information to reach the win-win purpose of tea supply chain.

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