

Informatization and New Agricultural Cold Chain Logistics Mode

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Abstract In recent years, the development of agricultural cold chain logistics has made landmark progress. Before the advent of information technology, there were a large number of information islands in each link of agricultural cold chain logistics, which caused a large number of loss of fresh agricultural products in the circulation process, and caused a series of food safety problems. The problem of information asymmetry has become a long-standing pain point in the agricultural cold chain logistics industry. Taking agricultural cold chain logistics as one of the key factors affecting the nation's development, this paper made a thorough analysis of the informatization of agricultural cold chain logistics from the perspective of time and space and the close relationships between these two sectors, with the conclusion that information technology can promote new agricultural cold chain logistics mode, reduce the times on transfer, increase efficiency and lower cost. informatization, then made an empirical analysis. Since China agricultural cold chain logistics is still at a comparatively low level, governments shall help this industry setting up an industrial standard, support pilot enterprises and guide the development of the whole industry.

Keywords Agricultural cold chain logistics mode; Informatization; Spatial and temporal analysis

1. Introduction and Literature Review

There is a broad definition of agricultural cold chain logistics, which covers the whole process from agricultural products acquisition or fishing to their reproduction, storage, transportation and delivery to customers. The supply capacity of agricultural cold chain logistics can be reflected in two types of factors: tangible factors and intangible factors, the former is the capacity for warehousing and transportation; the latter is the refrigeration technology and information technology. After analyzing the development and changes in China agricultural cold chain logistics, we see that the intangible factors have been playing a much more significant role, especially after the industrial revolution.

In China history, agricultural cold chain logistics mainly refers to the storage and transportation of agricultural products since Zhou dynasty, but with time going by, refrigeration technology has shown its advantage, and then during the 1990s, information technology brought about huge changes, influencing the whole industry.

Informatization makes it possible for an integrated platform that connects all parts of agricultural cold chain logistics to optimize the allocation of resources, reduce losses and lower cost for a better funding system. Following this trend, agricultural cold chain logistics will see great improvement. This paper gave a spatial and temporal analysis on the informatization of agricultural cold chain logistics to find the obstacles that hinder the development of this industry and to provide practical solutions.

Informatization is the core of modern logistics, promoting its development and upgrading, attracting a great deal of researches and studies.

Dong Suqin (2006) regards logistics informatization as the overall coordination, control and management of the whole logistics process with the help of internet, meeting all the demands from front-end to terminal. Wang Zhitai thinks that logistics informatization is the usage of computer and communication technology, together with the internet through the whole processing and management of logistics^[1]. Yu Bo (2008) wrote that economic historians have proved that the lower cost of communication and transportation during the past 500 years has stimulated global economic development, highlighting the role of logistics informatization, which can: (1) reduce cost; (2) optimize logistics process; (3) enhance competitiveness^[2].

Agricultural cold chain logistics has been critical to China economy, however, before the 1990s, China agricultural cold chain logistics has been suffering the asymmetry of information and poor management, causing food safety problems and wastage. With the development of information technology, all the above problems can be solved properly and efficiently. Hong Lan (2010) pointed out that cold chain logistics needs special funds, and most enterprises usually don't have sufficient funding for this, thus, the government shall invest in the construction of an integrated agricultural cold chain logistics system that based on information technology^[3]. Bai Jing (2010) thinks that "From Farm Directly to Supermarket" program can be much effective, especially with support from information technology^[4]. Jin Jing (2012) did some research on cold chain technologies, studying its information system from the perspective of third-party agricultural logistics^[5]. Sheng Yan (2014) studied the application of internet of things in agricultural cold chain logistics, which can

help building a platform that based on information^[6]. Chen Yan (2011) pointed out that the outsourcing of logistics can be inefficiently, and the informatization of logistics will reduce cost to a large extent^[7].

Agricultural cold chain logistics is a high-end industry, in need of heavy and specialized investment in infrastructure. In economic activities, traditional ways with manual work are mixed with information technology concerning communication and management, and it will last quite a long period. In the future, the informatization of agricultural cold chain logistics will play the main role.

2. Informatization and The Spatial-temporal Evolution of Agricultural Cold Chain Logistics Mode

2.1 Stages of the evolution of agricultural cold chain logistics mode

Agricultural cold chain logistics has been a hot topic for researchers since ancient times, focusing on the role of supply capacity in logistics. In order to give a qualitative analysis, this paper divides this supply capacity into two parts, one was the tangible factors such as cold chain warehousing and transportation; the other was the intangible factors such as the refrigeration technology and information technology^[8].

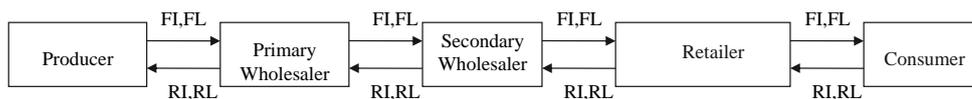
Based on different demands on agricultural cold chain logistics from all kinds of customers, this paper divides its development history into three stages, each with special features concerning the tangible factors and intangible factors.

Stage one: since Zhou dynasty, tangible factors such as ice storage has been playing an important role, with emphasis on warehousing and transportation; Stage two: in the 1750s, refrigeration technology was invented, upgrading cold chain logistics and asking for the increasing of supply capacities; Stage three: the twentieth century has witnessed leaps in information technology, which accelerated global economy and became the most advanced productivity. The informatization of agricultural cold chain logistics then connected all phases of logistics, increasing efficiency to a great extent, with which China has improved its logistics infrastructure and transportation facilities, driving the development of agricultural cold chain logistics.

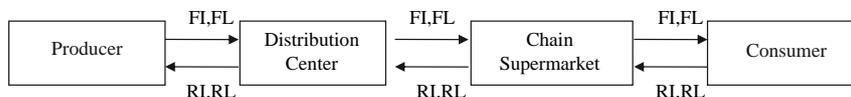
From stage one to stage three, the time and space needed for agricultural cold chain logistics have changed a lot. Related economic activities have expanded from regional to global level, and consumers can enjoy more diversified agricultural products from other regions. At the same time, consumers can reach these fresh agricultural products in less time thanks to new refrigeration technology and information technology.

2.2 The impact of informatization on promoting agricultural cold chain logistics mode

Traditional Wholesale Markets Mode



Chain Supermarkets Mode



Fresh Produce E-commerce Platform Mode

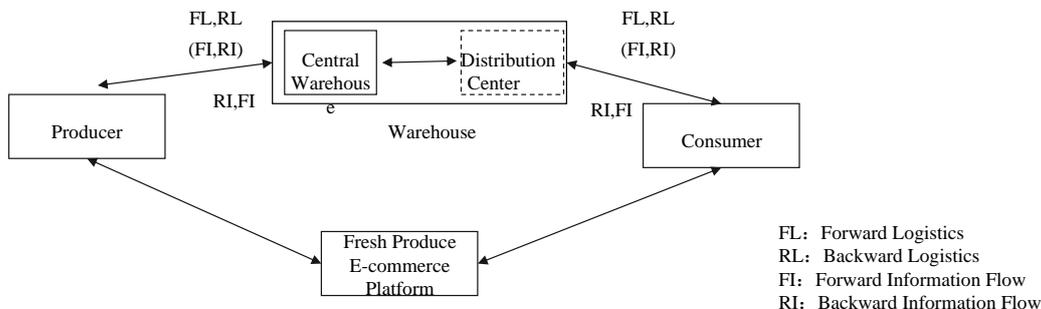


Figure 1 Agricultural cold chain logistics mode in different stages

Since the 1990s, information technology has optimized all sectors of agricultural cold chain logistics. as shown in figure 1, China agricultural cold chain logistics mode experienced three modes: wholesale markets,

retailers, supermarkets and fresh agricultural products e-commerce platforms. This paper chose wholesale markets, chain supermarkets and fresh agricultural products e-commerce platforms as objects of study, illustrating the role of information technology. Traditional wholesale markets mode were main agricultural products providers during China “Reform and Opening-up”, followed by primary and secondary market wholesalers, existing much inefficient transfer works among transportation, packaging, processing, distribution and information management. However, this mode was suitable under China special double-track system, when resources were on great shortage. But with the upgrading of people’s living standard, traditional wholesale markets were gradually replaced by supermarkets thanks to new information technology and management systems. Especially in the 1990s, supermarkets became the main agricultural products providers in large cities such as Shanghai, Beijing. This mode combined centralized purchasing with distributed sales, using information system and standardized and professional management skills to increase efficiency and competitiveness. And then in recent years, floods of fresh agricultural products e-commerce platforms appeared following the trend of internet, e-commerce and mobile terminal with e-commerce payments, which caters to the taste of young generation. This new convenient mode has been the top choice for most consumers nowadays.

It’s difficult for traditional wholesalers to share information with secondary wholesalers, and all sub-wholesalers have to do repeated processes of receiving, warehousing, registration, stock preparation and delivery. Supermarkets adopted new information system, which can realize the sharing of information, avoiding repetition. And e-commerce platforms have reduced much more time and space, connecting producers directly with consumers with electric business in terms of logistics flow, information flow and money flow^[9].

2.2.1 Analysis of spatial and temporal economic effects of the informatization of agricultural cold chain logistics

The distance from producer to consumer is settled regardless of logistics, but the time needed varies. The shorter the time spend, the better the economic effects will be. The time needed for an integrated agricultural cold chain logistics includes two parts, one is the travel time and the other is the transfer time. The latter mainly covers receiving, unloading, registration, temporary storage and delivery during transfer. Rong Chaohe (2011) presented the concept of temporal distance and displacement chain^[10].

$$T_{\text{链条}} = \sum_{i=0}^{n_1} T_{\text{衔接}i} + \sum_{i=1}^{n_2} T_{\text{运行}i}$$

In this formula, n_1 represents the number of joints on agricultural cold chain logistics chain, and n_2 represents the number of times that cold chain logistics runs uninterruptedly. The above three modes of agricultural cold chain logistics usually use highway transportation, with approximately the same running time, but the time spent on transfer works varies. The overall transfer time depends on the number of joints on cold chain logistics and the time needed in between.

Table 1 Main joints of three logistics mode and their spatial and temporal economic effects

Agricultural cold chain logistics Mode	Logistics chain	Numbers of main joints	Roles of information technology	spatial and temporal economic effects
Traditional wholesale markets	Multiple levels of wholesalers between agricultural producer and consumer	$n_1 \geq 3, n_2 \geq 4$	Undeveloped information technology causes repeated transfer works	Low efficiency and too much waste
Chain Supermarkets	Centralized purchasing and distribution, reducing transfer works	$n_1 \geq 2, n_2 \geq 3$	Information system became very important.	Reduced transfer works and increased efficiency

Table 1, cont.

Fresh agricultural products E-commerce Platform	Connect producer directly with consumers through centralized warehouse	$n_1 \leq 2, n_2 \leq 3$	Information technology and big-data have saved much time and space, leading to agricultural cold chain logistics revolution	Information technology has affected every sector of agricultural cold chain logistics, promoted efficiency greatly
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On the one hand, flat organization structure can reduce the number of joints, and on the other hand, information technology can reduce the transfer time. Apart from that, the coordination between different joints can affect the overall time greatly. Traditional logistics cannot share information effectively, highlighting the importance of information technology.

2.2.2 Conflict and coordination between information flows and agricultural cold chain logistics flows in terms of time and space

There are constant conflict between information flows and logistics flows, since the time and space needed are quite limited. However, information technology can coordinate these two flows properly.

Traditional wholesale markets experienced severe conflicts, because on the one hand, information flow and logistics flow are with the same direction, which means that logistics stops at every single joint to get fresh agriculture products registered, causing deterioration and other problems (see figure 2); and on the other hand, information that sent back from the next joint may delay, causing bullwhip effect with overstocking. Unlike normal products, fresh agricultural products have expiration date, with value changing due to time. During specific period of time, their value are particularly high.

In figure 2, abscissa represents different points of time: t_0 is the expected time on sale; t_1 is the time before expiration date; t_2 is the expiration date and t_3 is the time after expiration date. Value decreases gradually from t_0 to t_1 , such as tail goods, after which value decreases sharply, reaching zero at t_2 and becomes negative after it, when much works have to be done to deal with expired goods, and it costs time and money.

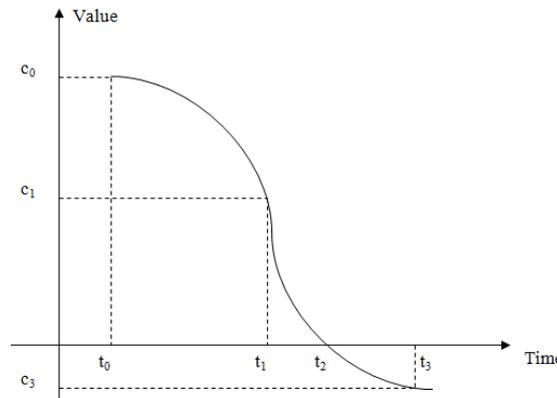


Figure 2 Value of fresh agriculture products in different times

Chain supermarkets applied information system to separate information from logistics, reducing the conflicts.

Fresh agricultural products e-commerce platforms make full use of the internet and e-commerce technology, building up a mechanism that can coordinate information and logistics, realizing the sharing of information and the separation of supply and demand. This kind of integrated system will be enhanced greatly with time going on.

2.2.3 Analysis of the replacement of cold chain logistics by information flows in terms of time and space

Fresh agricultural products e-commerce platform consists of two parts: the first was the online platform, on which customers can search for produce, place the order and complete payment; the second was the offline delivery. E-commerce has great advantage comparing to traditional wholesalers, but its delivery capability, especially the last-one-km delivery is not competitive due to the time limit on freshness and the centralizing of delivery needs. Thus, there is a limit for the effect of information technology, which means that it cannot replace traditional wholesalers completely. Many researches have shown that the extent of this replacement is the key to the development of e-commerce platforms.

Table 2 Comparison between the information flows time of M₁ and M₂

Agricultural cold chain logistics Mode	Component of the time spent on information flows	Ways of communication and overall time spent on information flows	Comparison between the information flows time of M ₁ and M ₂
Traditional wholesale markets(M ₁)	communication and feedbacks among buyers, sellers, secondary wholesalers, primary wholesalers and suppliers	accumulation of telephones, faxes and other ways of communication	T ₁ >T ₂
the combination of e-commerce with offline logistics (M ₂)	communication and feedbacks among buyers, sellers, third-party logistics companies and suppliers	relying on the Internet, sellers, third-party logistics companies and suppliers share the same information, with approximately no waste of time	

This paper analyzed the combination of e-commerce with offline logistics, by which consumers place an order online, and offline logistics do the delivery. By this way, cold chain logistics companies can offer timely delivery with the sharing of information. Below is the analysis of this combination from the perspective of the time spent on information flows, logistics transfer and logistics process.

In terms of information flows, traditional wholesalers mode (M₁) usually use telephone or fax for communication while the combination of e-commerce with offline logistics (M₂) use information system, the latter was much more efficient(see Tab 2).

In figure 3, as for the transfer agricultural product time, in M₁, there are many links from supplier to consumers, which include the time spent on loading in A, and repeated unloading and reloading in B, C and D. In M₂, when consumers place an order online, the third-party logistics company will deliver the goods. Its transfer time only include the time spent on loading in A and unloading and reloading in E. Thus, transfer time of T₁ = Ob+cd+fh+hj, transfer time of T₂=Oa+eg. Obviously, transfer time of T₁ > transfer time of T₂.

We see that T₂ can generate great economic effects, increasing logistics efficiency greatly.

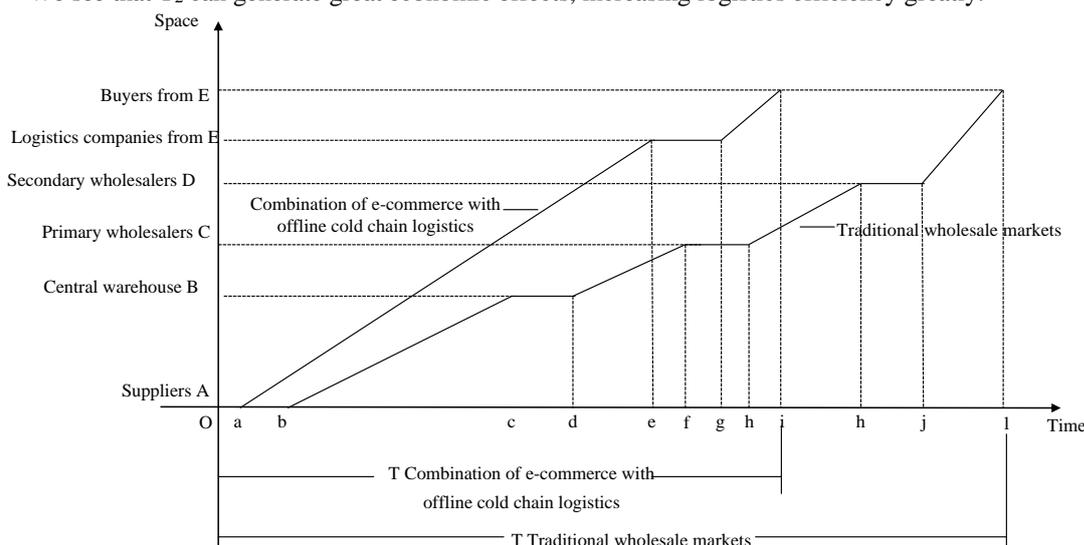


Figure3 Comparison between M₁ 's and M₂'s cold chain logistics transfer time

It can be concluded that T_{S2}(summation of the time spent on information flows, logistics transfer and the logistics process) is smaller than total T_{S1}. And T_{S2} can save much space in logistics, transforming some parts of logistics into information flows. The time saved ($\Delta T=T_{S2}-T_{S1}$) will be critical to modern cold chain logistics, which can represent the replacement of cold chain logistics by information flows^[11].

In conclusion, information technology has played a significant role in agricultural cold chain logistics, without which logistics will meet many obstacles. Luckily, we are witnessing the development of agricultural cold chain logistics, since information technology can optimize the whole industry, reducing conflicts and transfer works and saving time as well as space for both suppliers and consumers. Being the source of innovation, information technology has been an irreplaceable part of agricultural cold chain logistics.

3. Empirical Analysis of The Impact of Informatization On Agriculture Cold Chain Logistics

In order to describe the effect of informatization on agricultural cold chain logistics, this paper selects the development level of informatization as the explanatory variable (X_1), and the efficiency value of agricultural cold chain logistics industry as the dependent variable (Y), establishes the econometric regression model, and makes regression analysis. In view of the availability of data, this paper selects fresh agricultural annual turnover \times annual total agricultural product logistics costs / annual agricultural product turnover (hundreds of millions yuan/year) as a variable to measure the efficiency of China agricultural cold chain logistics industry. The information level of agricultural cold chain logistics in China is measured by the annual per capita income of software and information technology services (yuan/person/year). In order to ensure the reliability and authority of the data, this paper selects indicators from the "Statistical Yearbook of China". Compared with other industries, the application rate of information technology in China agricultural cold chain logistics industry is relatively low. In 2010, the National Development and Reform Commission issued the "Agricultural Cold Chain Logistics Development Plan", under the policy incentives, China agricultural cold chain logistics industry informatization has been achieved rapid development. Therefore, this paper selects the data from 2010 to 2016, more truly reflects the impact of information technology on the agricultural cold chain logistics industry.

Table 3 Regression results of models

Dependent Variable: Y				
Method: Least Squares				
Date: 08/17/18 Time: 19:05				
Sample: 2010 2016				
Included observations: 7				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	775.3363	131.3504	5.902808	0.0020
X1	0.565710	0.112182	5.042804	0.0040
R-squared	0.835688	Mean dependent var	1399.671	
Adjusted R-squared	0.802825	S.D. dependent var	261.4031	
S.E. of regression	116.0743	Akaike info criterion	12.58130	
Sum squared resid	67366.27	Schwarz criterion	12.56584	
Log likelihood	-42.03453	Hannan-Quinn criter.	12.39028	
F-statistic	25.42987	Durbin-Watson stat	1.457621	
Prob(F-statistic)	0.003957			

In this paper, Eviews econometric method is used to analyze the efficiency and informatization of agricultural cold chain logistics in China from 2010 to 2016 (see Table3).

Based on the regression analysis of OLS with the above fixed effects, the R-squared is 0.835, the Adjusted R-squared is 0.802, the statistical value of F-test is 25.42, and the prob significance level is 0.004. The significance reaches the significant effect under 1% level. Informatization has a significant impact on the efficiency of agricultural cold chain logistics, and the correlation between them is very strong. From the above table, we can see that the level of information technology has a positive effect on the efficiency of agricultural cold chain logistics industry, and its elastic impact coefficient is 0.565. This is because the improvement of information technology will promote new agricultural cold chain logistics mode, thus promote operation efficiency of agricultural cold chain logistics, reduce the cost of agricultural cold chain logistics, optimize the input-output structure and management mode of agricultural cold chain logistics industry, thereby improving the efficiency of agricultural cold chain logistics industry.

4. Countermeasures and Suggestions

Seeing the fast development of agricultural cold chain logistics industry, the governments and companies have paid more attention to it. But the development of agricultural cold chain logistics in different cities varies. Agricultural cold chain logistics informatization in developed areas is also developing rapidly, and the agricultural cold chain logistics informatization in Northwest China is developing slowly. In all kinds of superior agricultural products areas, the public information platform of agricultural cold chain logistics has been established, which is helpful to realize the data exchange of agricultural cold chain logistics and optimize the logistics resources of agricultural cold chain. These practices have laid a good foundation for promoting the development of regional agricultural products cold chain logistics.

Agricultural cold chain logistics is a part of logistics, but researches on this topic are less, thus, this paper can provide some insight on this area, contributing some analysis for further study.

As a matter of fact, the development of China agricultural cold chain logistics is comparatively slow. Part of refrigerated transport vehicle vehicles are not equipped with temperature monitoring, and only a few companies can afford Warehouse Management System(WMS), Transportation Management System(TMS) or Order Management System(OMS), lacking overall monitoring and suffering from “broken chains” constantly.

After analyzing the problems of informatization on agricultural cold chain logistics, this paper provides the following three suggestions for a better future of China agricultural cold chain logistics and a leading information system for this industry.

4.1 Build a strong agricultural cold chain logistics information system

An integrated information platform can gather all parts of agricultural cold chain logistics (including suppliers, cold chain logistics companies, processors, distributors, organizations and consumers) to integrate, coordinate and share the information, which will enhance a transparent management system that can share information and realize win-win results. This kind of platform needs huge investment, and the government or a third-party institution shall take this responsibility.

4.2 Establish local pilot enterprises with high level of information technology for agricultural cold chain logistics

With great influence, leading enterprises can set a good example for local companies for the upgrading of logistics. Local governments shall support and establish several leading enterprises, providing them with funding and technology to lead other companies.

4.3 Governments shall play the main role in promoting the informatization of agricultural cold chain logistics

Governments should be the supervisor and guide to building an information mechanism, First of all, the policy of encouraging the application and development of high-tech information technology is introduced to promote the development of agricultural cold chain logistics industry;secondly, the government takes the lead in coordinating the informatization industry norms and promoting the development of informatization industry norms and standards; furthermore, the government provides financial support, the relevant government departments can invest funds to develop some low cost or even free practical information systems suitable for small and medium-sized agricultural cold chain logistics enterprises. Governments provide free maintenance services for follow-up system to solve their worries.

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