A B2C AGRICULTURAL PRODUCTS SELF-DISTRIBUTION SYSTEM IN E-COMMERCE ENVIRONMENT

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Abstract - With the advent of Internet plus age, agricultural products home delivery mode has been concerned more and more. In this study, an optimized e-commerce distribution system was designed against the problems existing in the traditional agricultural products distribution process. The distribution structure and technology, operation process and profit model were analyzed based on business to customer (B2C) mode. Moreover the self-distribution system was optimized. As to the problem of distribution route, the concept of time window was added for restriction, hypothesis was proposed, and the role of saving algorithm for distribution route was analyzed. An example was demonstrated to verify that adding time window constraint saving algorithm into B2C mode based self-distribution system could optimize distribution route and enhance distribution efficiency. The application of the algorithm can save distribution cost and improve economic benefits.

Keywords: B2C Mode, Distribution Route, Time Window, E-commerce Environment.

1. Introduction

With the development of e-commerce, the mode of market trade has gradually changed from the traditional customer-to-customer (C2C) e-commerce mode to the business-to-customer (B2C) e-business mode. B2C trade process costs low and moreover is featured by concise flow and obvious temporal-spatial traits.

B2C is a mode which directly sells products or services to customers based on network platform; a series of consumption behaviors such as online purchase and payment can be realized via Internet. Zhang et al. [1] studied the integrated online scheduling of order batching and delivery in B2C e-commerce, put forward several new rules based solutions, and evaluated the solutions through a series of experiments. They found that the new algorithms could lead to a significant increase in the number of orders. Höglund and Wikman [2] developed a simple model to evaluate the influence of B2C sharing on consumers.

They found that goods were utilized more when they were shared, introducing a sharing market might decrease consumption of new goods, despite enabling new consumers to enter the market, and consumer surplus increased when the sharing price was lower than the ownership price. In the aspect of B2C cost, products can be distributed to more customers via Internet with less cost. Distribution of agricultural products based on B2C mode can reduce the middle links and cost and increase sales, but there are usually many problems in the link of distribution.

Aiming at the problems of high cost and unreasonable layout of the self built logistics system of B2C e-commerce company, Li et al. [3] proposed an optimization plan of B2C logistics distribution. A mathematical model was established based on various costs, taking into account economies of scale and standard service levels. A hybrid genetic simulated annealing algorithm was proposed to solve the problem of NP-hard complexity of the model. To save distribution cost and improve economic benefits, distribution routes were optimized based on B2C mode for agricultural products distribution system platform in this study.

2. The Traditional Logistics Distribution of Agricultural Products

Figure 1 shows that the traditional logistics distribution of agricultural products involves many links. Agricultural products which are purchased by customers may arrive destinations after multiple trade links [4]. Agricultural products may get bad during transportation because of the redundant logistics links and short refreshing time of products, which will cause loss to merchants; as a result, transportation cost and loss will be added to the purchasing price.

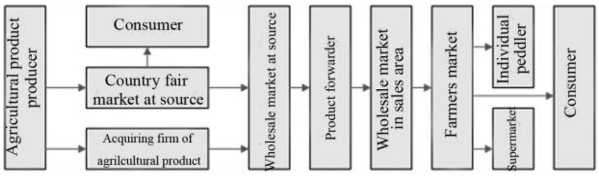

Figure 1: The traditional logistics distribution mode of agricultural products

The traditional agricultural products logistics distribution has the following disadvantages [5]. Firstly, the long agricultural products supply chain and lack of efficient transportation equipment in most areas result in high damage rate of agricultural products. Secondly, China's current agricultural logistics distribution system is still not perfect, the relevant interests parties in the distribution process are lack of instant communication, and organization and management are also not coordinated, resulting in inefficient logistics and distribution. Thirdly the less developed areas fail to adjust the agricultural production in time and scientifically because of the lack of network or other means which can help understand market information. As a result, production and consumption are unbalanced, which is shown as insufficient transportation volume in the peak season of agricultural products and surplus transportation volume in the weak season.

3. Analysis on B2C

With the rapid development of Internet, new electronic commerce has begun to appear and has gradually replaced the traditional business mode because of its advantages of convenience and high efficiency. To solve problems existing in the traditional distribution logistics of agricultural products, B2C mode in e-commerce was applied to optimize the distribution logistics of agricultural products.

B2C mode based distribution structure

Figure 2 demonstrated that the subjects of B2C mode based logistics distribution include producers, electronic commerce enterprises, logistics center and customers, and the communications between them are managed by e-commerce information management platform [6]. Compared with the traditional logistics distribution structure, the link of the B2C based structure is obviously simpler, and the cost of agricultural products is also greatly reduced because the number of transshipment is greatly reduced. Moreover enterprises can directly receive demand feedback from consumers and adjust the management strategy in time after analysis on the feedback because of the unified management of logistics information.

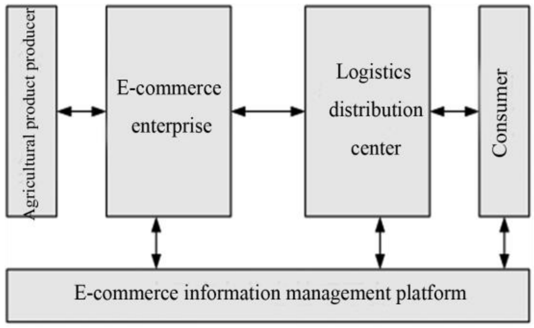

Figure 2: The B2C mode based agricultural products logistics distribution structure

B2C distribution technology

Distribution technologies of agricultural products in e-commerce environment are shown in Table 1.

Table 1. Distribution technologies of agricultural products in e-commerce environment

Distribution technologies	Description
Cold-chain logistics technology [7]	Cold chain refers to a system project which keeps agricultural products at low temperature in links from output to purchasing. Its function is to maintain the freshness of foods and reduce food loss. The specific management content of cold chain includes keeping the quality and safety of source, extending the storage life of agricultural products by using proper technologies in processing, extending the preservation time using automatic refrigeration storage technology, ensuring excellent transportation technologies and equipment and ensuring the real-time update of agricultural food on e-commerce management platform.
Quality inspection technology [8]	Currently the standard quality inspection system has not been established in the production of agricultural products in China; hence it is difficult to make a reasonable and effective judgment on agricultural products that need to be transported in logistics distribution. Therefore, in order to realize basic functions of of B2C e-commerce platform, i.e., consultation sharing, transaction connection and information interaction, the government should learn from international standards or advanced foreign standards to speed up the construction of agricultural standard system, set up a

	standard monitoring system, and establish a sound international quality management system and food safety and health certification system.
Product traceability technology [9]	Product traceability technology is applied in the whole process of agricultural product logistics distribution, including stages of production and final purchase. Customers can know information of agricultural products at different stage via the technology. Product traceability technologies includes sensing technology, perception and recognition technology, GPS positioning technology, two-dimensional code technology, etc., among which radio frequency identification (RFID) has been widely used in quality traceability, information collection and storage management of agricultural products in the process of logistics. The technology does not require manual intervention at work, and can adapt to various working environments.

B2C operation flow

As shown in Figure 3, the first step is purchasing agricultural products from producers, processing agricultural products by enterprises themselves or entrusting a third party and releasing relevant information of the purchased agricultural products on e-commerce information management platform [10]. Then customers put commodities that they want into virtual shopping cart after browsing the information of products on the e-commerce information management platform, input information which is needed in distribution and confirming orders. After receiving the orders from the platform, enterprises will categorize the orders using computers and arrange corresponding commodities. Then the quality of the arranged commodities are inspected. Next transportation temperature is adjusted according to the categories of the commodities. The six step is loading the qualified commodities onto trunks. The seventh step is planning distribution routes according to order requirements. The eighth step is distributing goods according to the planned routes. The ninth step is payment.

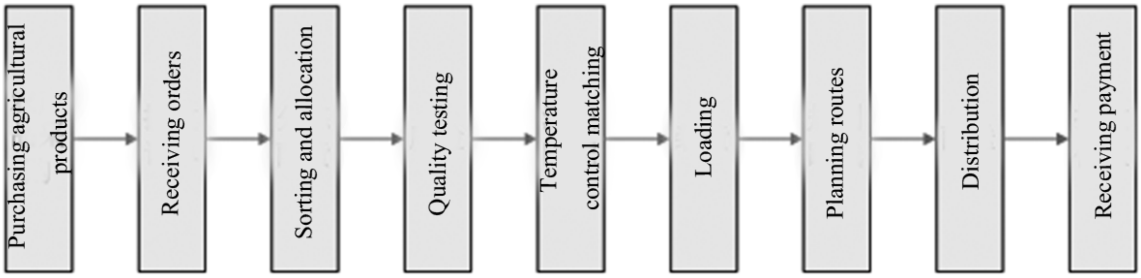

Figure 3: The B2C operation flow of agricultural products

B2C profit pattern

There are three profit patterns of B2C mode based distribution of agricultural products in e-commerce environment [11]. The first is reducing transaction cost through reducing links in supply chain and logistics distribution cost or using unified purchasing and business accounting. The second is releasing green organic and nuisanceless agricultural products for consumers who have middle or higher income and focusing on long-term brand building, i.e. catering to their pleasure. The third is establishing long-term e-commerce distribution supply chain taking fixed groups such as families, enterprises and hotels as the subjects and making scientific planning to reduce distribution cost. Moreover the application of cold chain can reduce damage of goods and increase the quality safety and added value of agricultural products.

E-commerce system platform

The composition of the B2C system platform is shown in Figure 4. The modules are divided into three layers, foreground operation, background operation and decision support. Foreground operation is facing consumers; background operation is facing enterprise operation users; decision support is facing enterprise senior management.

The detailed functions of different modules in the three layers are shown in Table 2.

Table 2. The modular architecture of the B2C system platform

Level	Function module	Function
Foreground operation	User registration	Provide functions such as user registration and information management for users. Users have rights of query and modifying their information.
	Merchandise Query	After user registration, users can query related commodity information in their own interests or query some key information about commodities.
	Order management	Manage, query, modify and print the orders released by users and feedback the information which has been processed by the business department to users.
Background operation	Commodity management	Manage the information of agricultural products displayed on the website.
	Order control	Receive order information and inventory information, classify according to clients and importance degree, configure inventory in different places, and determine delivery time
	Logistics management	Here self-distribution, distribution by producers is discussed. In such a distribution mode, enterprises will have an accurate control of logistics information.
	Settlement management	Support platform capital flow.
Decision support	Market analysis and prediction	Provide data support for senior decision makers in enterprises through analyzing trade information in the platform.

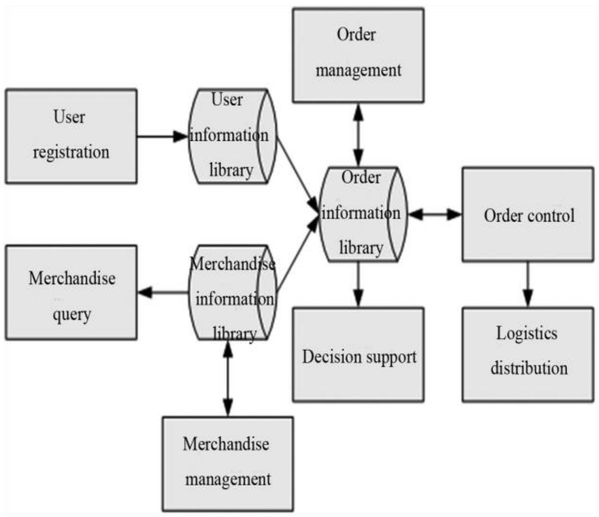

Figure 4: The relationships between different modules of the B2C system platform

4. B2C Mode Based Route Optimization

Logistics distribution as the core of B2C distribution mode has an important position. In the the traditional logistics distribution mode, dispatchers mark all delivery places on a map and then classify places which are close or on the same way to the same route [12]. Such a scheduling means will extend distribution distance and cause surplus transport capacity on some routes and insufficient transport capacity on other routes.

Time window

In addition to meeting the customers' demand for products, the distribution in the electronic business environment must also satisfy the customers' time window requirements, that is, delivery on time. Time windows can be divided into three types: soft, hard and mixed time windows [13]. The relationships between penalty function Q (T) of time windows and time t are shown below.

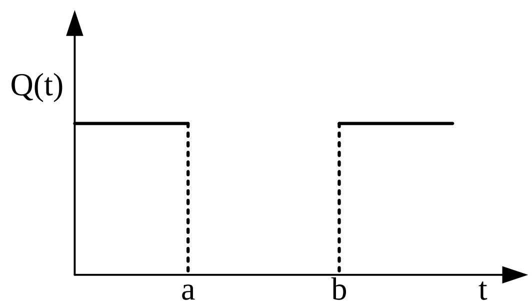

Figure 5: Hard time window

Figure 5 exhibits the relationship between the penalty function of hard time window and time t. Hard time window means that goods must be delivered before the prescribed time.

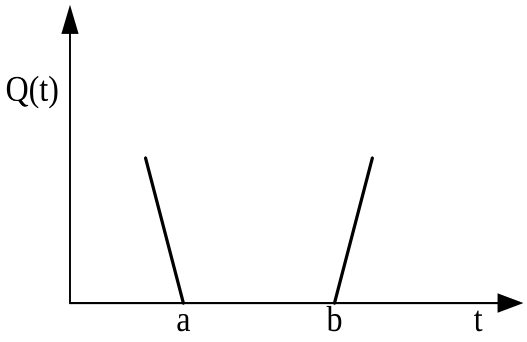

Figure 6: Soft time window

Figure 6 exhibits the relationship between the penalty function of soft time window and time t. The requirement of soft time window on the delivery time is looser than hard time window. If goods are not delivered before the specified time, punishment will be given according to the delay time. The degree of punishment is decided by the two parties [14]. Achieving lower delivery cost at the expense of small penalty cost of delay is allowed.

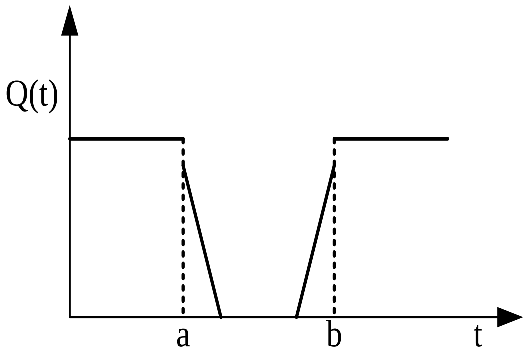

Figure 7: Mixed time window

Figure 7 exhibits the relationship between the penalty function of mixed time window and time t. Mixed time window means that delay for some time is allowed, but goods will be rejected if goods are delivered after a specified time point.

Time window constraint based saving algorithm

Saving algorithm as one of heuristic algorithms can improve the utilization rate of vehicles through scientifically planning distribution routes [15]. Saving algorithm which is featured by simple operation and high calculation speed can greatly shorten transportation distance compared to the traditional algorithms. But transportation cost and delivery time are often neglected due to the excessive emphasis on transport mileage. The basic principle of the algorithm is shortening transportation distance and reduce delivery time through planning the shortest route and reasonably allocate vehicles on the premise of high cargo load factor.

But the delivery time specified by customers needs to be considered in actual application, i.e., time window constraint. The computational formula of time window constraint is:

$$Y_b = X_a + Z_b + t_{ab} - X_b \tag{1}$$

where Y_b stands for the variation of time from point a to point b, X_a stands for the earliest time when delivery is completed at point a, Z_b stands for the time of completing unloading and other services, tab stands for the time of transportation from point a and b, and X_b stands for the latest time when delivery is completed at point b. When Y_b is smaller than 0, it means that vehicles complete tasks before the specified time; when Yb is equal to 0, it means that vehicles complete tasks at the specified time; when Yb is larger than 0, it means that vehicles complete tasks beyond the specified time. The procedures of formulating distribution routes are as follows. The saved distance between the starting point and destination is calculated using saving algorithm and the table of the shortest distance; then the saved distances are ranked, from large to small. Distribution route is formulated according to the specified time released by distribution center and the ranking table of the saved distances. Then whether networks on the distribution route can satisfy the specified time window is determined by checking departure order. Networks which cannot satisfy time window constraint condition will be excluded one by one until all the networks on the designed route satisfy the constraint condition.

5. Instance Analysis

Introduction of the case enterprise

A Agricultural Development Co., Ltd., (enterprise A for short), was set up in Xi'an, Shaanxi, China, in 2010. It has organic agricultural products sales business in Xi'an. The initial marketing idea of enterprise A is "from farmland to dining table". It advocates green and environment-friendly life concept and persists in providing safe and natural organic agricultural products to consumers. The company is committed to producing fresh foods at its own production base. To ensure timely delivery of products, the company has established several production bases throughout China. 80% of the logistics distribution of enterprise A is completed by the self-support team, and other distribution tasks are completed by other logistics enterprises. The order pattern of enterprise A is instant distribution after purchasing. Self-distribution is mainly carried out in Xi'an, and the delivery time is specified by clients.

Related distribution information

Table 3. Order information

Destination specified by customers	Demand (1/2 kilogram)	Time specified by customers
A	500	7:00-16:00
B	600	7:00-10:00
C	600	7:00-16:00
D	1200	7:00-12:00
E	600	7:00-7:30
F	500	7:00-16:00
G	1000	7:00-16:00
H	1000	7:00-10:15
I	700	7:00-8:00
J	800	7:00-13:00

Table 4. Matrix of distances between different distribution sites

O										
24	A									
61	46	B								
27	14	37	C							
13	15	49	14	D						
19	43	78	44	30	E					
48	48	36	30	39	53	F				
30	38	51	28	19	31	21	G			
36	48	52	35	34	33	21	9	H		
16	29	75	39	25	28	65	45	53	I	
67	36	15	30	43	78	43	51	58	75	J

Table 3 shows the order information, which are taken as time window constraint conditions. Table 4 shows the distance between different distribution sites, which are used for creating a table of saved mileage.

Relevant information of logistics distribution department are as follows. The distribution vehicle is a medium cold-chain truck with the maximum loading capacity of 2t and average transportation speed of 25 km/h. The truck departures at 6 am every day. The distribution service time is 0.25 h. The freight charge is 250 yuan each time. The oil cost and salary of driver are 3 yuan/km. The quality of agricultural products produced by enterprise A can satisfy the requirements of customers, and hard time window is used.

Solution of saving algorithm based on hard time window constraint

The saved mileage between different sites was calculated according to the matrix of distances between different distribution sites shown in Table 4 and then ranked from small to large. Finally a ranking table of the saved mileage is obtained (Table 5).

Table 5. The ranking table of the saved mileage

No.	Route	Saved mileage	No.	Route	Saved mileage
1	BJ	113	24	AD	22
2	BF	73	25	DF	22
3	FJ	72	26	EH	22
4	CJ	64	27	EG	18
5	FH	63	28	AG	16
6	FG	57	29	DH	15
7	GH	57	30	EF	14
8	AJ	55	31	AH	12
9	BC	51	32	AI	11
10	GJ	46	33	EJ	8
11	BH	45	34	IJ	8
12	CF	45	35	EI	7
13	HJ	45	36	CI	4
14	BG	40	37	DI	4
15	AB	39	38	CE	3
16	AC	37	39	BE	2
17	DJ	37	40	BI	2
18	CG	29	41	DE	1
19	CH	28	42	GI	1
20	CD	26	43	AE	0
21	BD	25	44	FI	0
22	AF	24	45	HI	0
23	DG	24			

The initial distribution route is formulated according to Table 3 and 5. Then whether different networks can satisfy the time specified by customers are determined according to the time window constraint formula. Networks which cannot satisfy the time window will be removed from the distribution route, and then networks which can satisfy conditions are searched using saving algorithm.

Finally three routes are determined, i.e., (1) $O \rightarrow B \rightarrow F \rightarrow H \rightarrow G \rightarrow C \rightarrow O$, (3) $O \rightarrow I \rightarrow A \rightarrow J \rightarrow O$ and (3) $O \rightarrow E \rightarrow D \rightarrow O$.

The distribution data of the three routes are shown in Table 6.

Table 6. Distribution data

Distribution route	(1)	(2)	(3)
Loading rate/%	92.4	51	44
Transportation distance/km	182	148	63
Freight charge/yuan	796	694	439

Table 6 shows that logistics distribution strictly following time window will decrease the average loading rate of vehicles, increase transportation distance, and improve freight cost, leading to increase of distribution cost; distribution cost will be reduced if customers can allow a slight delay of delivery and give corresponding punishment to the delay, i.e., using mixed time window based saving algorithm.

Solution of mixed time window based saving algorithm

The concept of mixed time window is that customers allow slight delay of goods delivery, but goods will be rejected if the delivery time exceeds a limit. Taking the case mentioned above as an example, if 25 min of delay is allowed, customers will reject goods if goods are delivered after the limit, and will make economic punishment on the enterprise if goods are delivered within 25 min after delivery time.

The solving steps of mixed time window based saving algorithm were similar to the solving procedures of hard time window based saving algorithm. Firstly the table of saved mileage is edited, i.e., Table 5. Then the initial distribution route was formulated according to table 5 and constraint conditions. Differing from hard time window based saving algorithm, $Y_b < 0.42$ is defined as executable distribution scheme which satisfies constraints, and unqualified schemes were removed. Then the next qualified network is searched according to the table of saved mileage. When Yb was between 0 and 0.42, there is economic punishment, 40 yuan/time in the case mentioned in this study.

Finally two routes were determined, i.e., (1) $O \rightarrow B \rightarrow F \rightarrow H \rightarrow G \rightarrow J \rightarrow O$ and (2) $O \rightarrow E \rightarrow I \rightarrow A \rightarrow C \rightarrow D \rightarrow O$. The related distribution data are shown in Table 7.

Table 7. Distribution data

Distribution route	(1)	(2)
Loading rate/%	98	91
Transportation distance/km	245	117
Freight charge/yuan	985	601
Economic punishment/ yuan	40	80

Table 7 shows that the transportation routes reduced, but the loading rate of vehicles on the route fully improved, which is because that less vehicles are dispatched. Moreover the total freight also reduced. There is an economic punishment compared to hard time window.

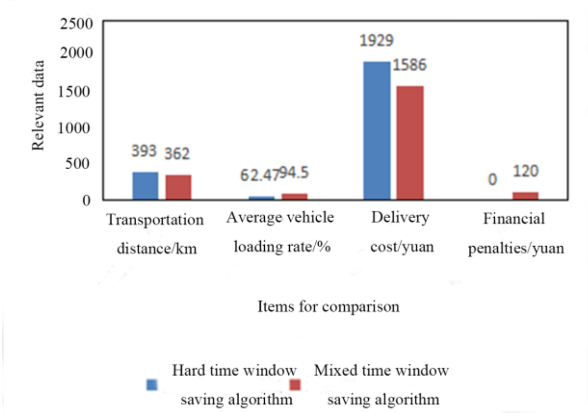

Figure 8: Data comparison between hard time window based saving algorithm and mixed time window based saving algorithm

Figure 8 demonstrates that mixed time window saving algorithm could greatly reduce logistics cost and improve operation efficiency and economic benefits. The transportation distance is optimized by 7.89%, the average loading rate is optimized by 51.27%, and the transportation cost is optimized by 17.78%. But there will be extra economic punishment if schedulers make mistakes. As shown in Table 7, there is an punishment of 120 yuan. The profit cannot be guaranteed because of the punishment; hence mixed time window should be used with caution.

6. Conclusion

With the development of e-commerce, the mode of market trade has gradually transformed from the traditional C2C e-commerce mode to the B2C e-business mode. Multiple links involving in the traditional distribution logistics of agricultural products short refreshing time of agricultural products will result in the deterioration of agricultural products in the process of transportation and cause economic loss to merchants. Then the transport cost and loss will eventually be reflected in the purchase price of consumers. To solve the problems existing in the traditional logistics distribution of agricultural products, distribution routes were optimized in B2C mode. Moreover saving algorithms based on two time windows were compared and analyzed, taking a real case as an example. It was found that optimizing distribution routes with hard time window based saving algorithm led to low average loading rate, long transportation distance and high freight charge; optimizing distribution routes with mixed time window based saving algorithm improved the average loading rate and reduced vehicle number, distance and transportation cost, but there is an economic punishment. The comparison of the optimization effect of the two saving algorithms suggested that mixed time window based saving algorithm is better as it can reduce logistics cost and improve economic benefits. But mixed time window should be carefully used because there will be a loss if schedulers make mistakes.

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