Analysis on the Construction of Sustainable Operation Mechanism of Agricultural Product Supply Chain under the Background of Wireless Communication and Internet of Things

Qianyi Wang and Yuqiu Cai

School of Economics and Management, Northeast Agricultural University, Harbin, Heilongjiang 150000, China

Correspondence should be addressed to Yuqiu Cai; cai_yuqiu@sina.com

Received 5 January 2022; Revised 25 January 2022; Accepted 27 January 2022; Published 14 March 2022

Academic Editor: Kalidoss Rajakani

Copyright © 2022 Qianyi Wang and Yuqiu Cai. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Historical experience shows that the people’s happiness index is highly correlated with the development of agriculture. The prosperity of agriculture and industrial production has also brought most people into a well-off life. Since the innovation of agricultural production equipment and concepts, the efficiency of agricultural production in my country has also been greatly improved compared to before the reform and opening up. In the era when robots will gradually become mainstream work machinery tools, the production efficiency and supply of agricultural products will become the focus of attention of the people of all countries. In such a general environment, the competition between agricultural products markets is no longer solely based on the competitiveness of agricultural products but also depends on the advantages of the agricultural supply chain to win. This article analyzes the construction of the sustainable operation mechanism of the agricultural supply chain in the context of wireless communication and the Internet of Things. First, the method of literature research is used to explain the characteristics of the agricultural supply chain and the problems existing in the development of the current agricultural supply chain model in the context of wireless communication and the Internet of Things. Next, study the current situation of the sustainability mechanism of the agricultural supply chain, and finally optimize the construction of the sustainability mechanism of the agricultural supply chain products based on the research results. According to the survey results, the main problem with the current mechanism of the agricultural product supply chain at this stage is that the logistics information technology is difficult to update in time, accounting for about 44%, followed by the lack of effective monitoring methods, accounting for about 34%.

1. Introduction

The application of big data technology to the production and supply of agricultural products can gradually optimize the entire supply process of agricultural products in the forecast of product production input and transportation scheduling and reduce resource waste [1, 2]; the agricultural informatization supply chain that combines big data and the Internet of Things has also completely reformed the traditional agricultural supply chain, making all links in the supply more convenient [3, 4].

In the research boom of supply chain optimization, some scholars believe that the agricultural supply chain should reduce the intensity of market development and further increase the investment in the whole process control and process optimization of the supply chain [5, 6]. For example, focus on studying the limitations and implementation issues of vertical integration. In addition, the two researchers also believe that operating costs, marketing processes, and product quality are the three key links in the entire supply chain that must be strictly controlled, and the supply chain must be integrated and used to improve the efficiency of fast logistics operations to ensure a short time. Other scholars emphasized that the degree of information disclosure in the food supply process should be increased, and the entire process from production to consumption should be
transient, so that consumers can purchase agricultural products with confidence, thereby increasing agricultural product sales [7, 8]. However, this process will harm some businesses. Benefits increase the investment and expenditure of merchants on supply process monitoring equipment, so this scheme has not been adopted on a large scale in actual production [9]. Some scholars pointed out that the main body of production in the supply chain is farmers who are not strictly organized and cannot provide stable support for the supply of agricultural products. Although there are organized companies as the main body, they are all small in scale and cannot meet the huge consumer demand of the market in the future. The optimization of the main body of agricultural product supply should be further strengthened [10].

The goal of this paper is to establish an efficient and sustainable agricultural supply chain mechanism. This article analyzes the construction of sustainable operation mechanism of agricultural product supply chain under the background of wireless communication and Internet of Things and analyzes the development barriers and solutions of agricultural product supply chain in the current information age based on the latest research results of scholars from various countries and the corresponding literature. The method then analyzes the status quo of the supply chain through questionnaire survey methods, and finally, through the analysis of the survey results, puts forward an effective and sustainable operation mechanism establishment method.

In summary, current scholars want to improve the stability of the agricultural product supply chain from all angles, including the optimization of the transportation process and supply side of agricultural products. This paper is mainly to build a sustainable agricultural supply chain, which is consistent with the research direction of many scholars [11].

2. Research on the Construction of Sustainable Operation Mechanism of Agricultural Product Supply Chain

2.1. Characteristics of Agricultural Product Supply Chain

2.1.1. Combination of Nature and Social Production. First of all, agricultural producers must carry out agricultural production activities in the natural environment. After the natural growth activities are completed, agricultural products will continue to be processed, transported, and stored and enter the community for production. Agricultural products will not be considered until the distribution network is delivered to the end user. It is the entire life cycle of agricultural products [12].

2.1.2. Higher Logistics Requirements. Since different types of agricultural products have different characteristics, such as vegetables, fruits, and aquatic products, they are easy to rot. The production of agricultural products is restricted by the seasonal climate, place of production, and other conditions, so the requirements in the circulation process are very high [13]. For example, for agricultural products that need to be kept fresh (such as vegetables, fruits, and aquatic products), due to their dispersibility, they must be equipped with cold-fresh equipment for storage and transportation; for corn, wheat, and other economic crops, they must be equipped with equipment production areas, large-scale logistics warehousing, and transportation facilities to facilitate transaction difficulties in different regions and different time periods.

2.1.3. High Asset Specificity. Agricultural products need to be processed and transported in different ways and methods in different scenarios, so as to achieve the supply for consumer demand. After entering the transportation link, transportation and processing operators must provide targeted improvements based on the different characteristics of agricultural products and the equipment and facilities and make targeted adjustments to storage and transportation equipment and facilities [14]. Usually dedicated equipment should have high performance and high restriction characteristics, and this kind of equipment can only be used for specific agricultural products [15].

2.1.4. The Market Is Uncertain. First, the production activities of agricultural products are greatly affected by factors such as planting area and seasonal climate and are extremely uncontrollable [16]. For example, in the event of drought and floods, agricultural production will be greatly reduced in a short period of time, and it is difficult to adjust, which can easily lead to fluctuations in agricultural product prices; secondly, our country’s agricultural production mainly relies on household production. This market is fragmented, and the market position is low [17]. They cannot obtain timely supply and marketing information and are unable to deal with market risks. Therefore, the market uncertainty of the ASC is relatively high.

2.1.5. The Complexity of Participants. From a macroeconomic perspective, the complexity, multiple levels, and intersecting characteristics of the SC determine the complexity of the main participants in the SC. From a very small point of view, the main sectors of agricultural production in our country are small and scattered, and the development of agricultural distribution networks is not yet very mature. Therefore, in the entire ASC, each link will have many participants, and in some cases, the main link contains secondary links, so the participants are very complicated.

2.2. Problems in the Development of the Current Model of Agricultural Product Supply Chain under the Background of Wireless Communication and the Internet of Things

2.2.1. The Actual Logistics Does Not Match the Demand. The vehicles used for transportation are all large freight trucks, and there are very few customized vehicle developments for the ventilation and preservation requirements of agricultural products, and there is a lack of special agricultural product transportation tools; in addition, the preservation measures at the transportation destination are not in place, which often causes large-scale rot and smelly incidents of
agricultural products. The other is the source packaging of agricultural products. In order to save costs, some merchants use nonstandard agricultural product bags to start product transportation, which violates the hygiene requirements of agricultural products themselves and also violates the demand for refined packaging required for transportation in the logistics industry. It can be seen that governance at the source of the supply chain is the key direction. In addition, some logistics companies involved in the supply of agricultural products still use traditional transportation methods to consign agricultural products and have not realized the visualization of the transportation process. Some logistics companies only use computers to manage some links, while most companies are still in the manual inspection process. This kind of transportation method that does not integrate the technology of the times will affect the confidence of consumers in the safety of agricultural products.

2.2.2. The Development of Agricultural Product e-Commerce Is Lagging Behind. First of all, agricultural product e-commerce itself has not kept up with the development of e-commerce of the times. Second, the rural network infrastructure is relatively backward. As the country’s overall strategy is inclined to urban construction, the construction of network facilities is also given priority to cities, and the network infrastructure in some rural areas is still in poor conditions. However, due to the limitation of cultural level and the traditional thinking of farmers, their understanding of e-commerce is very limited, and they have no sense of security for online transactions and virtual products. In addition, the lagging development of the rural economy and insufficient government support for e-commerce have delayed the construction of rural infrastructure and network facilities. The establishment of agricultural brands is not yet mature. The quality of most agricultural products is different, and there is no unified production model, let alone the introduction of brands, which seriously hinders the development of agricultural e-commerce. Therefore, the e-commerce of agricultural products should start from deepening farmers, organize various forms of dispersed farmers, standardize large-scale production, use online platforms for marketing and publicity, establish brands, establish reputation, and increase forecasts.

2.2.3. The Income of the Agricultural Product Supply Chain Is Not Evenly Distributed. At present, most of the supply sources in the agricultural product supply chain are farmers. Wholesalers, as the second subcontracting node, obtain key profits, while subsequent retailers squeeze some profits from the wholesalers, leaving less than 15% of the remaining profits. For farmers, according to statistics from professional organizations, wholesalers’ profits are 6 times that of farmers when it comes to transactions of bulk agricultural products, while retailers’ profits are 4 times that of farmers. While profits are being squeezed, farmers also bear more risks, such as product technology, changes in supply and demand, and natural disasters. This uneven distribution of profits has greatly disrupted the balance of returns in the supply chain and affected farmers’ enthusiasm for participating in the supply of agricultural products. From another perspective, if the source of production cannot produce products consistently and stably, the supply chain will no longer exist. In the long run, it is extremely detrimental to the sustainable development of the agricultural product supply chain.

3. Investigation on the Status Quo of Sustainable Operation Mechanism of Agricultural Product Supply Chain

3.1. Purpose of the Investigation. Through the investigation of the current situation of the sustainable operation mechanism of the agricultural product supply chain, analyze and sort out the rules and other problems existing in the current supply process of agricultural products, combine the causes of the problems to analyze targeted solutions, and give future optimization plans. The ultimate goal is to achieve a stable and long-lasting operation of the agricultural supply chain.

3.2. Questionnaire Survey

3.2.1. Survey Object. This article is mainly to investigate the status quo of the sustainable operation mechanism of the agricultural product SC. Therefore, the subject of this investigation is the major agricultural product logistics personnel. Random surveys of 3 agricultural product logistics companies of different reputations and levels in this city conducted a questionnaire survey. The logistics companies are marked as a, b, and c companies. Due to the limitations of this research condition, the questionnaire is only a survey of graduate students from 3 logistics companies. The research results still have certain technical limitations and cannot fundamentally represent our agricultural product SCs from other provinces, cities, and regions across the country.

3.2.2. Issuance of Questionnaires

(1) The Minimum Distribution of Questionnaires. The minimum sample size formula is an important measurement formula in statistics. The initial confidence of the questionnaire in this article is set to 80%, and an error of no more than 8% is allowed. Calculate the minimum sample size as

\[ \theta_0 = \left( \frac{k_n}{2\Delta f} \right)^2 \]

(1)

(2) This Questionnaire Survey Is Completed in Two Stages. The first stage is the distribution of questionnaires. According to the minimum sample size, the number of questionnaires distributed this time is 180. The second stage is the questionnaire recovery stage, which will be recovered after 6 days. It was 167, and the response rate of this questionnaire was 95%.

(3) In Order to Test the Reliability and Stability of This Survey. Firstly, the variance of the questionnaire results was calculated, and then, the reliability of the returned questionnaire was tested by the method of “half reliability” test. Using formula (2) to calculate the reliability coefficient, the
The correlation coefficient of this questionnaire is calculated as $r = 0.883$. According to the research of the mathematical theory of probability theory, if the correlation coefficient is higher than 0.8, the experiment can be regarded as a credible experiment. The test results confirm that the questionnaire is reliable.

\[ x = 1 - \frac{F^2_2}{F^2_n}. \]  

### 3.3. Data Processing

1. Enter the relevant questionnaire content through the office software Excel, use the Grubbs method to strip the data that deviate from the straightforward content in the questionnaire content, and then sort out the content table for the current situation of the agricultural product supply chain.

2. Use the SPSS analysis software to process the table data in the Excel office software, and write the analysis code to analyze the content of the table data.

3. Use the SPSS analysis tool that comes with the Questionnaire Star platform to analyze the questionnaire data, quickly determine the reliability and validity of the questionnaire, and finally ensure the feasibility of the questionnaire.

### 4. Analysis of Survey Results and Construction of Sustainable Operation Mechanism of Agricultural Product Supply Chain

#### 4.1. The Main Problems of the Current Mechanism of the Agricultural Product Supply Chain

The main problems of the current mechanism of the agricultural product SC were investigated through questionnaires. The results of the survey are shown in Table 1.

It can be seen from Figure 1 that the main problem with the current mechanism of the agricultural product SC at this stage is that the logistics information technology is difficult to update in time, accounting for about 44%, followed by the lack of effective monitoring methods, accounting for about 34%.

#### 4.2. Implement the Sustainable Operation Plan of the Agricultural Product Supply Chain

##### 4.2.1. Ideas for Constructing Sustainable Operation Mechanism of Agricultural Product SC

1. First, agricultural producers are small and scattered and are in a relatively weak bargaining position. Second, retailers or wholesalers target their personal interests, and it is difficult to defend the rights and entitlements of agricultural producers. When the...
interests of agricultural producers are divided, it is difficult to guarantee the supply of high-quality agricultural products. In order to improve the quality of the source of supply, a manageable and clearly regulated organization should be established for the farmers who are the main agricultural product producers, and the negotiation of the farmers can be increased through the organization, which can defend the rights and interests of farmers, and ultimately realize the optimization of the source of supply. Therefore, it is necessary to establish agricultural mutual cooperatives to disperse agricultural producers together and take their rights as the starting point to effectively increase their income [18].

(2) At present, the main participants in the middle of the ASC are mainly distributors and wholesalers in the place of origin. Despite their bargaining power, they are small in scale, inadequately organized, and basically lack agricultural processing links. Agricultural product wholesale markets can classify, process, package, and store agricultural products, while leading agricultural product processing companies can collect and distribute, centrally process and sell agricultural products, and generate added value. Specialized wholesale markets and leading processing companies have obvious advantages in terms of transaction, processing, distribution, and information sensitivity. They can also reduce their own transportation costs through economies of scale, and they can also play a role in lowering the prices of agricultural products.

(3) Agricultural sales terminals mainly include retail stores, farmers’ markets, and supermarket chains. Agricultural products are usually distributed to users through these sales entities. These sales entities have multiple levels, and each level of agricultural products will track a certain profit. Therefore, the more intermediate links there are for sales operators, the higher the price of agricultural products. This article believes that although the prices of agricultural products on the farmers’ market are relatively low, its internal environment, equipment, facilities, sanitary conditions, and product quality are still difficult to determine. Supermarkets have obvious advantages in terms of environment, quality, freshness, and health. At present, the epidemic is still raging in many cities, and the agricultural product supermarket program has gradually developed into an online agricultural product shopping mall. This program may become the mainstream agricultural product sales method in the future. It can not only solve the epidemic isolation problem but also improve the consumer’s buying experience.

4.3. According to the Survey Results, the Sustainable Operation Mechanism of the Agricultural Product SC Is Constructed

(1) Aiming at the problem that logistics information technology is difficult to update in time, this paper constructs a perception layer (Figure 2). In the traceability environment of the SC system, various perception control technologies can be applied, such as sensor network systems, mobile communication systems, RFID systems, QR code recognition systems, and GPS positioning systems. In addition, the detection layer equipment mainly preprocesses the collected information, including filtering, classifying, and classifying multichannel information.

(2) For the situation where there is no monitoring in the supply process, radio frequency tags can be used as the key monitoring unit to establish a whole-process management platform for agricultural information to ensure the sanitation of agricultural products in the transportation process and to achieve the effect of tracking the production process after the consumption is completed, so as to solve the problem of consumption insufficient confidence in the health and safety hazards of agricultural products.

5. Conclusions

Under the form of future internationalization, the optimization of the agricultural product supply chain will gradually
become the focus of competition among countries. In the face of fierce competition, existing problems still exist, such as low-level industrialization, low-level information, post-management methods, low-level value chains, and decentralized institutions. Innovative technologies and concepts in the future are an important route for the development of my country’s agricultural product supply. Based on the current status of the sustainable operation mechanism of the agricultural supply chain, this article optimizes the construction of the sustainable operation mechanism of the agricultural supply chain and proposes the establishment of an agricultural product quality and safety traceability information system.

Data Availability
The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Conflicts of Interest
The authors declare that they have no conflicts of interest.

References
[1] J. Xue and W. Xue, “Research on construction and analysis of supply chain model of agricultural special products in Yunnan area,” Revista de la Facultad de Ingenieria, vol. 32, no. 12, pp. 547–554, 2017.
[2] Y. S. Vélez, H. P. Varela, J. C. Londoño, and J. W. Escobar, “Redesign of supply chains for agricultural companies considering multiple scenarios by the methodology of sample average approximation,” International Journal of Business Performance and Supply Chain Modelling, vol. 12, no. 1, pp. 44–68, 2021.
[3] K. H. Widodo, H. Nagasawa, K. Morizawa, and M. Ota, “A periodical flowering-harvesting model for delivering fresh agricultural products to multiple markets,” Journal of Japan Industrial Management Association, vol. 56, no. 3, pp. 164–173, 2017.
[4] A. Hu, “Construction of supply chain accounting information system based on knowledge base and online analysis technology,” Revista de la Facultad de Ingenieria, vol. 32, no. 4, pp. 812–820, 2017.
[5] J. Chen, Y. Huang, P. Xia, Y. Zhang, and Y. Zhong, “Design and implementation of real-time traceability monitoring system for agricultural products supply chain under Internet of Things architecture,” Concurrency and Computation: Practice and Experience, vol. 31, no. 10, p. e4766, 2019.
[6] Y. Bo, X. H. Wu, Y. Bing, and Y. W. Zhang, “Three-level supply chain coordination of fresh agricultural products in the Internet of Things,” Industrial Management & Data Systems, vol. 117, no. 9, pp. 1842–1865, 2017.
[7] Y. Sun, X. Yuan, and K. Shi, “Research on decision of supply chain of fresh agricultural product based on altruism preference,” Systems Engineering-Theory & Practice, vol. 37, no. 5, pp. 1243–1253, 2017.
[8] B. Yan, J. Fan, C. Cai, and J. Fang, “Supply chain coordination of fresh agri-products based on value loss,” Operations Management Research, vol. 13, pp. 185–196, 2020.
[9] Z. Sazvar, M. Rahmani, and K. Govindan, “A sustainable supply chain for organic, conventional agro-food products: the role of demand substitution, climate change and public health,” Journal of Cleaner Production, vol. 194, pp. 564–583, 2018.
[10] A. Nagurney, D. Besik, and D. Li, “Strict quotas or tariffs? Implications for product quality and consumer welfare in differentiated product supply chains,” Transportation Research, vol. 129, pp. 136–161, 2019.
[11] L. Zhang, “Research on deepening path of agri-product supply chain with blockchain application,” in Proceedings of 5th International Conference on Economics and Management, Education, Humanities and Social Sciences (EMEHSS 2021), pp. 67–72, Guilin, 2021.
[12] H. Song, A. Vajdi, Y. Wang, and J. Zhou, “Blockchain for consortium: a practical paradigm in agricultural supply chain system,” Expert Systems With Applications, vol. 184, article 115425, 2021.
[13] X. Sun and S. Kunliang, “Application research of perception data fusion system of agricultural product supply chain based on Internet of Things,” EURASIP Journal on Wireless Communications and Networking, vol. 2021, no. 1, 2021.
[14] W. Yingli, X. Li, Q. Liu, and G. Tong, “The analysis of credit risks in agricultural supply chain finance assessment model based on genetic algorithm and backpropagation neural network,” Computational Economics, vol. 23, pp. 1–24, 2021.
[15] H. Mishra and P. Maheshwari, “Blockchain in Indian public distribution system: a conceptual framework to prevent leakage of the supplies and its enablers and disableds,” Journal of Global Operations and Strategic Sourcing, vol. 14, no. 2, pp. 312–335, 2021.
[16] W. Xu, Z. Zhong, D. Proverbs, S. Xiong, and Y. Zhang, “Enhancing the resilience of the management of water resources in the agricultural supply chain,” Water, vol. 13, no. 12, p. 1619, 2021.
[17] Y. Feng, Y. Hu, and L. He, “Research on coordination of fresh agricultural product supply chain considering fresh-keeping effort level under retailer risk avoidance,” Discrete Dynamics in Nature and Society, vol. 2021, Article ID 5527215, 15 pages, 2021.
[18] D. Doriane, S. David, and P. Freddy, “Sustainability assessment and agricultural supply chains evidence-based multidimensional analyses as tools for strategic decision-making the case of the pineapple supply chain in Benin,” Sustainability, vol. 13, no. 4, p. 2060, 2020.