Research Article

Calculation Method of Logistics Energy Consumption in Agricultural Product Supply Chain Based on Structural Equation Model

Qingxiang Ma

Anhui Vocational College of City Management, Business Administration College, Hefei, Anhui 230011, China

Correspondence should be addressed to Qingxiang Ma; 2003008@cua.edu.cn

Received 12 February 2022; Accepted 7 March 2022; Published 11 April 2022

Academic Editor: Song Jiang

Copyright © 2022 Qingxiang Ma. 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.

The ecological value chain agricultural products in China are mainly produced by scattered farmers. Due to the lack of modern planting and breeding techniques for small-scale scattered farmers, it is difficult to obtain scale effects, and the benefit-cost ratio is generally low. Their own production, supply, and marketing integration organization can only enter the market separately, which is difficult to adapt to the needs of the market. In the circulation link, the agricultural product logistics management level in China is low and logistics losses are huge. This research attempts to conduct a theoretical analysis and discussion on the integration of the ecological agricultural product supply chain in China based on the enterprise theory. At the same time, we conduct an empirical analysis of the relationship between supply chain integration and performance from the perspective of logistics and build agricultural product supply chain integration with the company’s logistics capabilities as the center. We perform hypothesis model, collect data through survey methods, use quantitative analysis and path analysis methods to test the hypothesis model, explore the relationship between supply chain management and agricultural product logistics capabilities, and corporate competitiveness, to provide the empirical support for the introduction of supply chain management in the agriculture in China.

1. Introduction

With the accession to the WTO, China faces the impact of foreign high-quality agricultural products. The agricultural product market competition will become increasingly fierce. From the current situation of the agricultural product production and processing itself in China, it is clear that China has not yet prepared for these challenges [1]. The agricultural products are mainly produced by scattered farmers. Due to the lack of modern planting and breeding techniques for small-scale scattered farmers, it is difficult to obtain scale effects, and the benefit-to-cost ratio is generally low [2]. Most small-scale farmers do not have their own integrated production, supply, and marketing organization and can only enter the market separately, which is difficult to adapt to the needs of the market. In the circulation link, the ecological value chain agricultural product logistics management level in China is low, and logistics losses are huge [3].

The term "supply chain" was first introduced in the early 1980s and became more and more important in the late 1990s. A supply chain refers to a series of activities that integrate the processing and control products from raw materials, manufacturing to distribution to customers, and at the same time perform the integration activities in the most economical way [4, 5]. The supply chain includes every organization in the entire chain from the flow of raw materials to the delivery of products to the final consumer. All members of the organization, from raw material suppliers to consumers, including transporters, intermediaries, and information processing institutions, are related to supply chain operation [6]. The term “logistics” originated from Japan and was an abbreviation of “physical distribution.” The narrow definition of logistics refers to the physical
distribution part, that is, how to deliver products from the factory to consumers in the most efficient way. In a broad sense, logistics management is a similar concept to supply chain management, or supply chain management is an extension of traditional logistics management—that is, cross-organizational integrated logistics management [7, 8].

Generally speaking, the relationship between logistics management and supply chain management represents a series of evolutionary processes. The focus of supply chain management lies in the effective integration of related operations among supply chain enterprises [9]. To successfully achieve integration, companies must establish cooperative work teams to quickly exchange important business information and share the results fairly. From the perspective of enterprise boundaries, supply chain integration includes the integration of internal functions of the enterprise and external integration with upstream and downstream supply chain partners [10, 11]. In recent years, with the deepening of supply chain management research, capability analysis has become an important research orientation in the research topics of supply chain management. Among them, the ability of supply chain logistics integration is a strong barrier for companies to achieve good performance and prevent competitors from entering [12].

This research will be based on the theory of enterprises and discuss the integration of agricultural product supply chains from a microperspective. We construct a hypothetical model of integrated performance of agricultural product supply chain centered on enterprise logistics capabilities, collect data through survey methods, test the hypothetical model with quantitative analysis and path analysis methods, discuss supply chain management and agricultural product logistics capabilities, and corporate competitiveness, which provides empirical support for the introduction of supply chain management in the agriculture in China [13, 14].

2. Materials and Methods

2.1. Survey Design. The statistical data used in this study come from the question items in the questionnaire. Through reasonable question items, the internal integration, external integration, logistics capabilities, and corporate performance in the empirical model are reflected. In the form of question items, the Likert five-point system commonly used in psychology and management surveys is used (1 point means disagree at all and 5 points means agreement to a large extent). The questionnaire is divided into two parts. The first part is the understanding of the overall situation, and the purpose is to grasp the survey object’s supply chain logistics level overview. In this part, the surveyed company’s business scope, company scale (through capital amount), and financial performance (through capital return rate ROA) are investigated, and the basic logistics status of the company is investigated, including the company’s logistics in the past three years. In terms of cost changes, the areas where companies spend the most in purchasing batches and batches, logistics costs, and the logistics methods are used in procurement and sales [15, 16].

The second part is developed around the empirical model, and the survey items are designed according to five parts: internal integration, external integration, logistics capabilities, corporate performance, and supplier performance. Considering that processing companies, especially leading companies, are the main part of the agricultural product supply chain, investigations on the leading companies can more truly reflect the integration of the agricultural product supply chain and the operational status of logistics. The data for this study come from a survey of leading agricultural product-related companies in a certain city in Jiangsu Province. In this survey, 150 questionnaires are distributed and 140 are returned, with a recovery rate of 93.3%. A total of 135 valid questionnaires are obtained, with an effective questionnaire rate of 90.0%. Due to the high recovery rate, there is basically no need to consider the nonrecovery bias of the sample.

2.2. Data Analysis Method. The various concepts used in the hypothetical model proposed in this study are not directly surveyable but are reflected by multiple related question items in the questionnaire. This study chooses the structural equation model as the analysis tool. Structural equation modeling (SEM) is a research methodology based on statistical analysis technology, which is used to deal with the inquiry and analysis of complex multivariate research data [17, 18].

SEM can be expressed by the following matrix equation:

$$\eta = B\eta + \Gamma\xi + \zeta.$$  \hspace{1cm} (1)

ξ: potential exogenous variables (potential independent variables).
η: potential endogenous variable (potential response variable).
B: structural coefficient, which refers to the coefficient matrix of the effect of the potential dependent variable item on the potential strain item.
Γ: structure coefficient, which refers to the coefficient matrix of the effect of the latent independent variable on the latent strain term.

The measurement model is to define the relationship between each group of latent variables (η, ξ) (hypothetical concepts) and their respective connected display variables (y, x) (measurement variables) to detect and describe the relationship between the two characteristics and assumptions.

**Y measurement mode:**

$$Y = \lambda y\eta + \varepsilon.$$  \hspace{1cm} (2)

**X measurement mode:**

$$X = \lambda x\eta + \delta.$$  \hspace{1cm} (3)

X and Y are exogenous and endogenous indicators. λx is the relationship between the X index and the latent variable term of ξ, and λy is the relationship between the Y index and the latent variable term of η.
3. Results and Discussion

3.1. Basic Data Analysis

3.1.1. Changes in Logistics Costs. As shown in Figure 1, the logistics costs of most of the surveyed companies have increased in the past three years, and only a small number of companies have decreased or remained the same. From the survey results, the return on capital of most companies has increased, so it can be inferred that the increase in logistics costs is largely due to the increase in sales of companies in recent years. It can also be seen from another aspect that as leading companies become bigger and stronger, their logistics capabilities should also be paid more and more attention [19].

3.1.2. Changes in the Transportation Scale and Frequency of Purchases and Sales. Figures 2 and 3 reflect the changes in the procurement scale and frequency of the surveyed companies in the past three years. In recent years, most of the surveyed companies have expanded their procurement scale, which initially reflects that the surveyed companies’ production scale and processing capabilities have expanded, and the companies are in the process of expansion [20]. The company’s logistics costs for procurement and transportation also increase substantially with the expansion of transportation volume. At the same time, the procurement frequency of the surveyed companies has also greatly increased. The increase in procurement frequency and purchase batches directly leads to an increase in the company’s logistics costs, and logistics capabilities are becoming an important factor restricting the development of the surveyed companies.

3.1.3. Enterprise Logistics Method. As shown in Figure 4, in terms of procurement, the surveyed companies seldom use their own logistics, and only about 26% of the companies sometimes use their own logistics system to complete the procurement tasks, but mainly through the production base and the broker’s self-organized transportation. The fleet purchases raw materials. According to the survey results, the logistics system owned by the surveyed company is mainly used to meet the needs of downstream customers. Because the distance between the raw material production bases is relatively scattered, and the small- and medium-sized farmers are also very important raw material suppliers, the surveyed companies need to spend a lot of money to purchase through the own logistics. All in all, the surveyed companies will face high-cost and high-risk challenges when they use their own logistics system to complete their procurement tasks.

Figure 5 shows the logistics methods used by the surveyed companies for sales. Contrary to procurement, more than half of the surveyed companies use their own logistics to complete their sales tasks. At the same time, a considerable number of surveyed companies use third-party logistics, and relatively few companies use the partner’s logistics. The survey finds that the use of third-party logistics in the sales logistics of the surveyed companies has also reached a high level, which shows that the integration of the agricultural product supply chain in the surveyed areas has had a good start.

3.1.4. The Composition of Enterprise Logistics Costs. As shown in Figure 6, the logistics costs of the surveyed companies are mainly concentrated in the two main aspects of transportation and warehousing, of which transportation costs account for more than 60% of the total logistics costs and are the most important source of logistics costs. In other logistics costs, it also includes losses caused by the loss and expiration of agricultural products. It can be inferred from the use of logistics methods of the above enterprises that the storage costs of agricultural products by the surveyed enterprises mainly occur in raw materials, while the transportation costs mainly occur in finished products. This phenomenon can be explained by the difference between the company’s procurement and sales logistics methods—the company pays more attention to the logistics of the other party when purchasing raw materials, while the logistics of the other party is used when selling. The inventory and wastage are correspondingly more than that of processed finished products. In other logistics costs, it also includes handling costs and losses caused by damage and expiration of inventory.

3.2. Single Dimension Inspection. This study uses exploratory factor analysis (EFA) to detect whether the questionnaire items used have a single-dimensional quality. This research will adopt the method of analyzing each latent variable separately to obtain the factor loading between each survey item and the latent variable. The higher the factor loading, the more relevant the measurement item and the latent variable. This study will not be able to use exploratory factor analysis to clearly show whether the measurement items of different scales only converge to the corresponding latent variables. However, when all items in the same questionnaire have factor loadings higher than 0.5 for the latent variables, it means that the scale has a considerable degree of convergent validity. The result of factor analysis shows that when the explanatory variance of the latent variable to the same scale measurement item exceeds 50% (VE > 0.5), it can indicate that these measurement items are quite representative of the latent variable. Table 1 describes the factor loading and explanatory variation of each latent variable in the model.

3.3. Sample Reliability Test. After the previous validity analysis, some items that do not meet the validity requirements have been deleted. The following is a reliability test for the remaining samples. In this study, Cronbach’s reliability test is carried out while structural equation analysis is performed, the factor loading of each index related to the latent variable is evaluated, and the reliability analysis is carried out from two aspects, namely the factor loading of the indicators in the structural equation analysis. Cronbach’s test is performed on question items greater than
0.5. Generally speaking, the reliability coefficient of Cronbach’s greater than 0.7 is ideal. The results of reliability analysis show that the remaining question items after elimination have acceptable reliability values.

3.3.1. Cronbach’s Analysis. Therefore, this study uses SPSS software to perform Cronbach’s reliability analysis. The analysis results are shown in Table 2.

It can be seen that after removing some of the problem items, the indicators of each latent variable have reached a reliability coefficient above 0.7.

3.3.2. Structural Equation Analysis. This study uses AMOS 4.01 version to carry out structural equation analysis and analyzes the factors of internal integration (II), external integration (EI), logistics capability (LC), enterprise performance (FP), and supplier performance (SP), respectively, to obtain the factor load of each indicator variable. The index with factor load less than 0.5 will be deemed to fail to meet the reliability requirements.

(1) Internal Integration. There are 7 question items in this part, and there are 5 more after the question items are eliminated. We construct a structural model in AMOS software and calculate its factor load. The main goodness-of-fit indexes and explanations and the load of each index factor of latent variable II are shown in Table 3. The fitting results of the structural model show that all indicators of goodness of
fit are ideal (RMSEA is within the acceptable range), the t-value is above the threshold of 2.00, and the factor load of each indicator is above 0.5. In addition, it reaches more than 0.6, indicating that the sample has sufficient reliability.

(2) External Integration. There are 9 items in external integration, and there are 6 items after being eliminated. We construct its structural equation model in AMOS software. Due to space limitations, the model diagram is omitted. After statistical calculation, the main goodness-of-fit indicators and explanations and the load of each indicator factor of the latent variable EI are shown in Table 4. It can be seen from the table that the goodness of fit of the model is very ideal, the t-value is greater than 2.00, and the factor load of each indicator is greater than 0.5. The samples showing the logistics capacity have a high reliability value.

(3) Logistics Capability. There are altogether 11 items for logistics capability, and there are 7 items after being eliminated. We construct its structural equation model in AMOS software, and after statistical calculation, the main goodness-of-fit indexes and explanations are obtained (Table 5). It can be seen from the table that the goodness of fit of the model is very ideal, the t-value is greater than 2.00, and the factor load of each indicator is greater than 0.5. The samples showing the logistics capacity have a high reliability value.

(4) Corporate Performance. There are 9 items in corporate performance, and there are 8 items after being eliminated. Through structural equation analysis, the main goodness-of-fit index and explanation and the load of each index factor of the latent variable FP are shown in Table 6. It can be seen from the table that the goodness of fit of the model is very ideal, the t-value is greater than 2.00, and the factor load of each index is greater than 0.6.

(5) Supplier Performance. Supplier performance has a total of 4 items, all of which have passed the previous validity test. Through structural equation analysis, the main goodness-of-fit indexes and explanations and the load of each index factor of the latent variable FP are shown in Table 7. From the table,
### Table 3: Results of structural equation reliability test on internal integration latent variables.

| Goodness-of-fit index | Index result | Ideal value | Description     |
|-----------------------|--------------|-------------|-----------------|
| Discrepancy           | 8.520        | —           |                 |
| Degrees of freedom    | 5            | —           |                 |
| Discrepancy/df        | 1.78         | <2          | Ideal           |
| RMR                   | 0.028        | <0.05       | Ideal           |
| GFI                   | 0.963        | >0.879      |                 |
| AGFI                  | 0.864        | >0.879      | Not ideal       |
| IF1                   | 0.982        | >0.9        | Ideal           |
| TLI                   | 0.973        | >0.9        | Ideal           |
| CFI                   | 0.969        | >0.9        | Ideal           |
| RMSEA                 | 0.082        | <0.05–0.08  | Acceptable      |
| \(P\)                | 0.145        | >0.05       | Ideal           |

#### Nonstandard estimate

|                | Estimate | S.E | C.R. (t-value) |
|----------------|----------|-----|----------------|
| 117 \(<\) II  | 1.000*   |     |                |
| 112 \(<\) II  | 0.942    | 0.124 | 7.291**        |
| 113 \(<\) II  | 0.749    | 0.139 | 5.579**        |
| 114 \(<\) II  | 0.965    | 0.138 | 7.368**        |
| 115 \(<\) II  | 0.627    | 0.126 | 4.981          |

#### Factor load estimation

|                | Standardized estimate |
|----------------|-----------------------|
| 117 \(<\) II  | 0.885                 |
| 112 \(<\) II  | 0.763                 |
| 113 \(<\) II  | 0.642                 |
| 114 \(<\) II  | 0.773                 |
| 115 \(<\) II  | 0.584                 |

* B: fixed parameter value, ** \(P < 0.001\), * \(P < 0.05\).

### Table 4: Results of structural equation reliability test on externally integrated latent variables.

| Goodness-of-fit index | Index result | Ideal value | Description     |
|-----------------------|--------------|-------------|-----------------|
| Discrepancy           | 4.752        | —           |                 |
| Degrees of freedom    | 9            | —           |                 |
| Discrepancy/df        | 0.546        | <2          | Ideal           |
| RMR                   | 0.019        | <0.05       | Ideal           |
| GFI                   | 0.967        | >0.8–0.9    | Ideal           |
| AGFI                  | 0.953        | >0.8–0.9    | Ideal           |
| IF1                   | 1.027        | >0.9        | Ideal           |
| TLI                   | 1.058        | >0.9        | Ideal           |
| CFI                   | 1.004        | >0.9        | Ideal           |
| RMSEA                 | 0.000        | <0.05–0.08  | Ideal           |
| \(P\)                | 0.879        | >0.05       | Ideal           |

#### Nonstandard estimate

|                | Estimate | S.E | C.R. (t-value) |
|----------------|----------|-----|----------------|
| El1 \(<\) EI  | 1.000*   |     |                |
| El4 \(<\) EI  | 0.769    | 0.169 | 4.291**        |
| El5 \(<\) EI  | 0.657    | 0.164 | 3.923**        |
| El6 \(<\) EI  | 0.648    | 0.183 | 3.718*         |
| El7 \(<\) EI  | 0.732    | 0.171 | 4.522**        |
| El8 \(<\) EI  | 0.875    | 0.175 | 4.641**        |

#### Factor load estimation

|                | Standardized estimate |
|----------------|-----------------------|
| El1 \(<\) EI  | 0.711                 |
| El4 \(<\) EI  | 0.612                 |
| El5 \(<\) EI  | 0.563                 |
| El6 \(<\) EI  | 0.541                 |
| El7 \(<\) EI  | 0.669                 |
| El8 \(<\) EI  | 0.678                 |

* B: fixed parameter value, ** \(P < 0.001\), * \(P < 0.05\).
Table 5: Results of structural equation reliability test on latent variables of logistics capability.

| Goodness-of-fit index | Index result | Ideal value | Description |
|-----------------------|--------------|-------------|-------------|
| Discrepancy           | 11.5         | —           |             |
| Degrees of freedom    | 14           | —           |             |
| Discrepancy/df        | 0.80         | <2          | Ideal       |
| RMR                   | 0.029        | <0.05       | Ideal       |
| GFI                   | 0.963        | >0.8–0.9    | Ideal       |
| AGF1                  | 0.924        | >0.8–0.9    | Ideal       |
| IF1                   | 1.028        | >0.9        | Ideal       |
| TLI                   | 1.035        | >0.9        | Ideal       |
| CFI                   | 1.007        | >0.9        | Ideal       |
| RMSEA                 | 0            | <0.05–0.08  | Ideal       |
| P                     | 0.642        | >0.05       | Ideal       |

Nonstandard estimate

| Estimate | S.E | C.R. (t-value) |
|----------|-----|----------------|
| LC2<–LC  | 1.000B |               |
| LC3<–LC  | 1.069 | 0.264          | 4.159**     |
| LC4<–LC  | 0.958 | 0.26           | 4.626**     |
| LC7<–LC  | 0.836 | 0.257          | 3.931**     |
| LC8<–LC  | 0.987 | 0.234          | 4.498**     |
| LC9<–LC  | 1.095 | 0.245          | 4.747**     |
| LC11<–LC | 0.995 | 0.252          | 4.365**     |

Factor load estimation

| Standardized estimate |
|-----------------------|
| LC2<–LC               | 0.647 |
| LC3<–LC               | 0.586 |
| LC4<–LC               | 0.688 |
| LC7<–LC               | 0.564 |
| LC8<–LC               | 0.675 |
| LC9<–LC               | 0.723 |
| LC11<–LC              | 0.654 |

B: fixed parameter value, **P<0.001.

Table 6: Results of structural equation reliability test on latent variables of corporate performance.

| Goodness-of-fit index | Index result | Ideal value | Description |
|-----------------------|--------------|-------------|-------------|
| Discrepancy           | 26.156       | —           |             |
| Degrees of freedom    | 20           | —           |             |
| Discrepancy/df        | 1.325        | <2          | Ideal       |
| RMR                   | 0.04         | <0.05       | Ideal       |
| GFI                   | 0.951        | >0.8–0.9    | Ideal       |
| AGF1                  | 0.845        | >0.879      | Nonideal    |
| IF1                   | 0.957        | >0.9        | Ideal       |
| TLI                   | 0.948        | >0.9        | Ideal       |
| CFI                   | 0.962        | >0.9        | Ideal       |
| RMSEA                 | 0            | <0.05–0.08  | Ideal       |
| P                     | 0.169        | >0.05       | Ideal       |

Nonstandard estimate

| Estimate | S.E | C.R. (t-value) |
|----------|-----|----------------|
| FP1<–FP  | 1.000B |               |
| FP2<–FP  | 0.955 | 0.169          | 5.816**     |
| FP3<–FP  | 0.992 | 0.172          | 5.924**     |
| FP4<–FP  | 0.998 | 0.163          | 6.369**     |
| FP5<–FP  | 0.913 | 0.161          | 5.757**     |
| FP6<–FP  | 0.845 | 0.168          | 5.189**     |
| FP7<–FP  | 0.967 | 0.173          | 5.762**     |
| FP8<–FP  | 0.856 | 0.156          | 5.973**     |

Factor load estimation

| Standardized estimate |
|-----------------------|
| FP1<–FP               | 0.778 |
| FP2<–FP               | 0.698 |
| FP3<–FP               | 0.689 |
| FP4<–FP               | 0.723 |
| FP5<–FP               | 0.686 |
| FP6<–FP               | 0.634 |
| FP7<–FP               | 0.689 |
| FP8<–FP               | 0.679 |

B: fixed parameter value, **P<0.001.
the goodness of fit of the model is very ideal, the t-value is greater than 2.00, and the factor load of each index is greater than 0.6.

3.4. Structural Equation Model Test. After analyzing the reliability of each latent variable question item, it is reasonable to believe that the survey data meet the requirements of structural equation analysis. Based on the adjusted questionnaire, a structural equation model is set up, and the survey data are used for confirmatory analysis. We calculate the total impact by analyzing the direct impact and indirect impact separately for each latent variable. The path analysis results are shown in Table 8.

From the results of the path analysis, both internal integration and external integration have a significant positive impact on the company's performance, and the impact of internal integration is greater than that of external integration. It is worth noting that the impact of supply chain integration on logistics capabilities is greater than the impact of logistics capabilities on corporate performance. This shows that the surveyed companies have not well transformed their logistics capabilities into realistic competitiveness. The research on the transformation of competitiveness is of great significance, which leads to new areas for further research.

4. Conclusion

(1) After empirical analysis of data samples, it can be considered that supply chain integration, especially internal integration, significantly positively affects the company's logistics capabilities and performance. In addition, empirical evidence shows that supplier performance significantly positively affects corporate performance, which shows that suppliers' delivery reliability and quality performance will affect the production quality and delivery performance of processing enterprises. The improvement of supplier performance cannot promote the improvement of corporate logistics capabilities. The external integration has an indirect impact on
corporate performance through supplier performance, but its direct impact on corporate performance is not significant.

(2) Through supply chain integration, it can promote the improvement of enterprises' logistics capabilities, and the performance of enterprises and suppliers will increase. Through external integration activities, the mutual coordination of enterprises and suppliers and the improvement of supplier performance also promote the performance of processing enterprises. In the process of enterprise supply chain integration, external integration is always carried out after internal integration reaches a certain foundation. Internal integration and external integration are related.

(3) Supply chain integration, especially internal integration, has a significant positive impact on the logistics capabilities and performance of enterprises, which shows that enterprises can effectively improve their competitiveness through internal coordination and integration of logistics functions.

Data Availability

The figures and tables used to support the findings of this study are included in the article.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

This work was supported by the research project of Humanities and Social Sciences in Colleges and Universities of Anhui Province: Research on the Construction of Backbone Network of Cold Chain Logistics Infrastructure for Agricultural Products in Anhui Province (SK2020A0877); the Research Project of Humanities and Social Sciences in Colleges and Universities of Anhui Province: The Impact of Logistics Infrastructure Construction on the High-Quality Development of Anhui Economy under the New Development Pattern of Double Cycle and the Countermeasures (SK2020ZD58); and Anhui University Natural Science Research Project: Development of Logistics Vehicle Battery Management System Based on Internet of Things (KJ2019A1151).

References

[1] G. N. Stock, N. P. Greis, and J. D. Kasarda, “Enterprise logistics and supply chain structure: the role of fit,” Journal of Operations Management, vol. 18, no. 5, pp. 531–547, 2008.

[2] S. Gold and S. Seuring, “Supply chain and logistics issues of bio-energy production,” Journal of Cleaner Production, vol. 19, no. 1, pp. 32–42, 2011.

[3] J. J. Liu, Z. Wang, D.-Q. Yao, and X. Yue, “Transaction cost analysis of supply chain logistics services: firm-based versus port-focal,” Journal of the Operational Research Society, vol. 67, no. 2, pp. 176–186, 2016.

[4] H. Lee, T. Zhang, M. Boile, S. Theoanis, and S. Choo, “Designing an integrated logistics network in a supply chain system,” Ksce Journal of Civil Engineering, vol. 17, no. 4, pp. 806–814, 2013.

[5] K.-H. Lai, E. W. T. Ngai, and T. C. E. Cheng, “An empirical study of supply chain performance in transport logistics,” International Journal of Production Economics, vol. 87, no. 3, pp. 321–331, 2004.

[6] I. Tatsiopoulos and A. J. Tolis, “Economic aspects of the cotton-stalk biomass logistics and comparison of supply chain methods,” Biomass and Bioenergy, vol. 24, no. 3, pp. 199–214, 2003.

[7] L. C. Lin, “An integrated framework for the development of radio frequency identification technology in the logistics and supply chain management,” Computers & Industrial Engineering, vol. 57, no. 3, pp. 832–842, 2009.

[8] H. Kim, J.-C. Lu, P. H. Kvam, and Y.-C. Tsao, “Ordering quantity decisions considering uncertainty in supply-chain logistics operations,” International Journal of Production Economics, vol. 134, no. 1, pp. 16–27, 2011.

[9] X.-M. Yuan, J. M. W. Low, and L. Ching Tang, “Roles of the airport and logistics services on the economic outcomes of an air cargo supply chain,” International Journal of Production Economics, vol. 127, no. 2, pp. 215–225, 2010.

[10] I. A. Karim, “Unlock supply chain improvements through effective logistics,” Chemical Engineering Progress, vol. 98, no. 5, pp. 32–38, 2002.

[11] K. A. Kuznetsov, V. A. Gromov, and V. A. Skorohod, “Cluster-based supply chain logistics: a case study of a Ukrainian food distributor,” IMA Journal of Management Mathematics, vol. 28, no. 4, pp. 553–578, 2017.

[12] E. Jenkins, G. F. Ortmann, and C. N. Beuzidenhout, “Modelling commercial sugarcane quality in the context of climate and mill scale supply chain logistics,” International Sugar Journal, vol. 118, no. 1412, pp. 600–606, 2016.

[13] F. Ellerkmann, K. Hesse, J. Cirullies, and E. Fuss, “Exploring and modeling the impact of supply chain-related decisions in production and logistics on energy efficiency,” Nursing Research, vol. 56, no. 2, pp. 137–143, 2014.

[14] S. Nahmias, “Logistics and supply chain operations,” Operations Research, vol. 44, no. 2, p. 250, 1996.

[15] H. S. Hwang, “Design of supply-chain logistics system considering service level,” Computers & Industrial Engineering, vol. 43, no. 1, pp. 283–297, 2002.

[16] A. Gunasekaran and E. W. T. Ngai, “Decision support systems for logistics and supply chain management,” Decision Support Systems, vol. 52, no. 4, pp. 777–778, 2012.

[17] A. Bujak, “The development of the concept of supply chain management as an example of the evolution of logistics,” European Journal of Operational Research, vol. 242, no. 3, pp. 778–787, 2015.

[18] J. Yao, “Decision optimization analysis on supply chain resource integration in fourth party logistics,” Journal of Manufacturing Systems, vol. 29, no. 4, pp. 121–129, 2010.

[19] J. Jayaram and K.-C. Tan, “Supply chain integration with third-party logistics providers,” International Journal of Production Economics, vol. 125, no. 2, pp. 262–271, 2010.

[20] F. Bernstein, J. S. Song, and X. Zheng, “Free riding in a multi-channel supply chain,” Naval Research Logistics, vol. 56, no. 8, pp. 745–765, 2010.