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Impact and optimization strategy of cross-border e-commerce on aquatic product supply chain under the background of big data

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ABSTRACT

In the context of globalization and digitalization, big data and cross-border e-commerce have become important tools for modern supply chain management. Especially in the field of aquatic product supply chain, the use of big data and cross-border e-commerce has brought significant impact. This paper conducted an in-depth study on the impact of cross-border e-commerce on aquatic product supply chain and optimization strategies under the background of big data. This paper starts with the definition and characteristics of big data and cross-border e-commerce, and then analyzes the current situation and existing problems of aquatic product supply chain. This paper deeply discusses the role of cross-border e-commerce in the supply chain of aquatic products and the application and impact of big data in the supply chain of aquatic products in cross-border e-commerce. On this basis, this paper proposes a supply chain management strategy based on big data and the role of cross-border e-commerce in optimizing the supply chain of aquatic products, and verifies it through quantitative research methods. Throughout the research process, a large number of data, formulas and graphs are used to support arguments and arguments. This study provides a novel and practical perspective to view the role of big data and cross-border e-commerce in aquatic product supply chain and optimization strategies, which has important guiding significance for further research in related fields.

Keywords: Big data; Cross-border e-commerce; Aquatic product supply chain optimization

1. Introduction

Big data and cross-border e-commerce have become key factors driving economic development in the current globalized and digital environment. By collecting, storing, and analyzing massive amounts of data, big data provides decision-makers with valuable information and insights to help them make more effective decisions. Cross-border e-commerce uses e-commerce platforms to break through geographical restrictions and push goods and services globally, greatly enhancing the breadth and depth of the market.

Aquatic products are an important part of global trade, and the optimization of its supply chain is of great significance for improving economic benefits, ensuring food safety and protecting ecological environment. However, the global nature and complexity of the aquatic product supply chain pose great challenges to its management and optimization. These include product quality and safety issues, logistics and distribution efficiency issues, market demand forecasting issues, and so on.

In this context, the use of big data and cross-border e-commerce to optimize the supply chain of aquatic products has become an important research direction. Big data can predict market demand, optimize inventory and logistics management, and improve the efficiency and flexibility of the supply chain by analyzing a large amount of transaction,

logistics, and user behavior data. Cross-border e-commerce can promote the sale of aquatic products and add value to the supply chain through its global sales network. At the same time, the combination of big data and e-commerce can provide more refined market analysis and help the supply chain better meet the needs of various regions and various types of consumers.

Research on the impact of cross-border e-commerce on aquatic product supply chain and optimization strategies under the background of big data has important theoretical and practical value for promoting the modernization and globalization of aquatic product supply chain and enhancing the competitiveness and sustainability of aquatic product industry.

The purpose of this study is to understand the impact of big data and cross-border e-commerce on the supply chain of aquatic products, and based on this understanding, develop and implement supply chain optimization strategies that adapt to the development of new technologies. This study will reveal the specific impact of big data and cross-border e-commerce on the seafood supply chain by exploring in depth how big data and cross-border e-commerce change the way the seafood supply chain operates, and how these changes affect key factors such as supply chain efficiency, quality control, and market response speed.

Based on the characteristics and capabilities of big data and cross-border e-commerce, this study will propose a series of supply chain management and optimization strategies. These strategies may involve several key links such as demand forecasting, inventory management, logistics optimization, and market analysis, and will leverage the advantages of big data and cross-border e-commerce to improve the efficiency and adaptability of the supply chain.

In order to ensure the effectiveness and practicability of these strategies, this study will also conduct empirical analysis to verify the actual effects of these optimization strategies by collecting and analyzing relevant actual data. This will help make these strategies more practical and instructive, and improve their success rate in practice.

It is hoped that the research results can provide valuable reference for policy makers and enterprise decision makers. These research results can not only guide policy makers to formulate policies conducive to the development of aquatic product supply chain, but also provide practical and feasible operational suggestions for enterprise decision makers to help them make better use of big data and e-commerce, optimize supply chain and enhance enterprise competitiveness.

The ultimate goal of this study is to promote the continuous optimization and development of the aquatic product supply chain by deeply understanding and effectively utilizing the advantages of big data and cross-border e-commerce.

This study has an important contribution to the theoretical field. Through in-depth research on the impact of big data and cross-border e-commerce on the supply chain of aquatic products, we can enrich and expand the theoretical system of supply chain management, e-commerce, big data analysis and other fields, and improve our in-depth understanding of these fields.

This research also has important value for the practical field. The proposed optimization strategy and method can be directly applied to the actual supply chain management to help enterprises improve efficiency, reduce cost and improve competitiveness. In particular, this study will provide valuable reference and guidance for those aquatic products enterprises that are facing the challenges of globalization and are in urgent need of digital reform.

This study also has reference significance for policy making. By clarifying the specific impact of big data and cross-border e-commerce on the aquatic product supply chain, it can provide a strong decision-making basis for policymakers, help them formulate more scientific and targeted policies, and promote the development of the aquatic product supply chain and related industries.

The value of this research is also reflected in its contribution to society and the environment. An optimized supply chain can not only improve economic efficiency, but also reduce resource waste and improve resource utilization efficiency, which is conducive to environmental protection and sustainable development.

Under the trend of globalization, cross-border e-commerce has become an important form of global trade, especially in the supply chain of aquatic products has gradually become prominent. A number of studies have deeply discussed the application of cross-border e-commerce in supply chain management, especially in the supply chain management of aquatic products [1–3]. For example, Zhang [4] developed an intelligent information recommendation system for cross-border e-commerce based on deep learning to improve the accurate matching and purchase rate of goods. In addition, Cumming et al. [5] studied the analysis and prediction of the scale of China's cross-border e-commerce based on machine learning models, providing data support for the development of China's cross-border e-commerce.

On the other hand, the importance of the application of big data in e-commerce, especially in cross-border e-commerce, has also been widely recognized. Studies by Li et al. [6] and Lv [7] show that big data analysis plays a key role in consumer behavior analysis and response. Especially in the supply chain of aquatic products, big data can provide accurate demand forecasting and supply management, thereby improving the efficiency of the supply chain [8,9].

In the supply chain management of aquatic products, especially the supply chain management of core enterprises has attracted the attention of researchers. For example, Sun [10], Liu et al. [11], Yang et al. [12], Hu and Qiu [13] and Li [14] deeply discussed the supply chain management of core aquatic product enterprises, providing theoretical guidance for the optimization of aquatic product supply chain. At the same time, Xiao and Ye [15] research shows that the development of cross-border e-commerce has a significant impact on China's import and export trade, indicating the important role of cross-border e-commerce in optimizing the supply chain, especially the supply chain of aquatic products.

Although many studies have made breakthroughs in this area, further research is needed on how to combine big data and cross-border e-commerce to optimize the supply chain of aquatic products. In particular, how to establish quantitative research methods, how to collect and process data, and how to build and analyze models need more in-depth discussion.

2. Overview of big data and cross-border e-commerce

2.1. Overview and characteristics of big data

Big data is a concept that covers a large, high growth rate and diversity of information assets, and its value is mainly reflected in the insights and knowledge that can be extracted from it to drive the development of decision-making. With the rapid development of science and technology today, big data has become increasingly important and has become an important resource to drive modern society.

Big data has the following main characteristics (Table 1).

In the context of the aquatic product supply chain, big data can predict market demand, optimize inventory and logistics management, and improve the efficiency and flexibility of the supply chain by analyzing a large amount of transaction, logistics, and user behavior data.

2.2. Overview and development of cross-border e-commerce

Cross-border e-commerce refers to cross-border buying and selling activities carried out through e-commerce platforms. Merchants use Internet technology and platforms to sell products directly to overseas consumers, or to buy overseas goods and sell them to domestic consumers, so as to realize the global circulation of goods and services. This model greatly improves the efficiency of global trade, reduces the transaction cost, broadens the market space, and is a new trend of global trade development.

The development of cross-border e-commerce benefits from the rapid development of Internet technology and the acceleration of globalization. With the maturity of electronic payment, logistics services, data analysis and other technologies, cross-border e-commerce has developed from the early stage of exploration into a mature and large-scale market. All kinds of e-commerce platforms, such as Alibaba, Amazon, eBay, etc., have in-depth layout in the field of cross-border e-commerce, forming a unique business model and competition pattern.

In the field of aquatic products, cross-border e-commerce has played an important role. It makes the global consumers can easily and quickly buy aquatic products from all over the world, greatly enriching the choice of consumers; Through cross-border e-commerce platforms, aquatic product producers can directly reach consumers around the world, enter new markets, improve sales efficiency, and increase revenue (Fig. 1). In addition, the use of data analysis capabilities of e-commerce platforms can also help merchants better understand market demand, optimize product strategies, and enhance competitiveness.

2.3. Combination of big data and cross-border e-commerce

The combination of big data and cross-border e-commerce is the integration of modern information technology and global business models, which has played a great role in promoting global trade, improving operational efficiency and creating new business models.

Big data analysis extracts valuable information from massive user behavior, transaction records, social media and other data, which can help predict market demand and allow merchants to carry out inventory management and market strategy development in advance. At the same time, through the analysis of logistics, transactions, inventory and other data, businesses can understand the running status of the supply chain in real time, early warning and solve possible problems, so as to optimize operation management and improve supply chain efficiency.

Based on user profiles and recommendation algorithms based on big data, merchants can provide a personalized shopping experience for each user, which not only improves user satisfaction, but also improves purchase conversion rates. In marketing, by analyzing user behavior and transaction data, merchants can more accurately conduct market positioning and marketing activities, so that marketing effects are more significant and the return on investment is higher.

In the seafood supply chain, the combination of big data and cross-border e-commerce opens up new possibilities.

Table 1
Features of big data

Big data characteristics	Instructions
Large amount of data	Big data involves a huge amount of data, usually measured in terabytesor even petabytes. This feature requires that data processing and analysis tools must have the ability to handle very large-scale data.
Fast speed	The speed of data generation and transmission is extremely fast, and in some scenarios, the data even needs to be processed and analyzed in a real-time or near-real-time environment. This puts forward a high requirement for the timeliness of data processing.
Diversity	Big data comes from a wide range of data types, including structured numerical data, as well as unstructured text, images, audio, video and other data. This requires that data processing and analysis methods must have the ability to handle various types of data.
Authenticity	Big data often contains a lot of noise and errors, and the quality and authenticity of the data may be problematic. This requires that the impact of data quality must be taken into account in data processing and analysis, and corresponding measures should be taken.
Value	The ultimate purpose of big data is to extract valuable information and knowledge to support decision making. This requires that the results of data processing and analysis must have practical value and can solve practical problems.

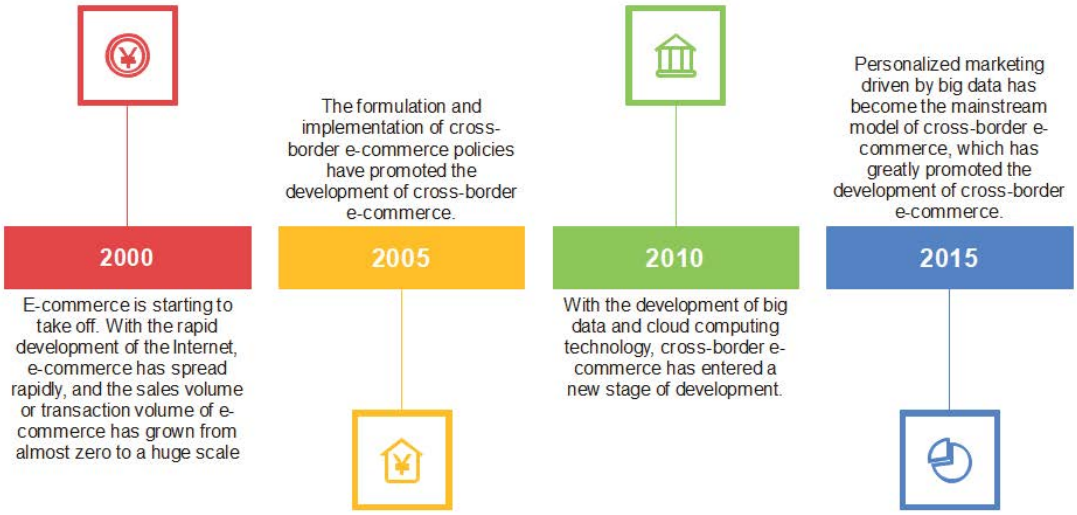

Fig. 1. Data analysis of e-commerce platforms.

For example, using big data to predict the demand for aquatic products everywhere can help optimize production and inventory management. By analyzing the logistics data, the circulation efficiency of aquatic products can be improved and the freshness of products can be guaranteed. Through personalized services, consumers' shopping experience can be enhanced and brand influence enhanced. These opportunities and challenges brought by the combination of big data and cross-border e-commerce to the aquatic product supply chain are worthy of in-depth study and discussion.

3. Current situation and problems of aquatic product supply chain

3.1. Current situation of aquatic product supply chain

Aquatic product supply chain is a complex system, covering production, processing, storage, transportation, sales and other links. According to 2022 statistics, the total global fishery production reached 210 million tons, of which about half came from marine fishing and the other half from aquaculture. Asia is the main region for the production of aquatic products, accounting for about 70% of the total. In processing and storage, about 80% of aquatic products need to be frozen, cooked, pickled and other processing before they can be sold, and due to the perishability of aquatic products, about 90% of global aquatic products need cold chain facilities during storage and transportation.

In terms of transportation, with the in-depth development of globalization, the transportation distance of aquatic products is gradually increasing. Data for 2022 shows that the average distance transported for aquatic products worldwide is about 1,000 km, which is about 30% more than a decade ago. In the sales link, cross-border e-commerce is becoming an important channel, according to statistics, about 15% of the world's aquatic products are sold through e-commerce platforms in 2022, and this proportion has increased by about 50% in the past 5 y. Detailed data are shown in Table 2.

3.2. Problems in the supply chain of traditional aquatic products

Although the aquatic product supply chain has the characteristics of globalization and diversification, there are still some problems and challenges in the actual operation (Table 3).

4. Impact of cross-border e-commerce on aquatic product supply chain under the background of big data

4.1. Role of cross-border e-commerce in the aquatic product supply chain

Cross-border e-commerce has greatly expanded the market coverage. Using the e-commerce platform, aquatic products can easily enter markets around the world, get rid of the geographical restrictions of traditional physical sales, and open up a broader sales space for aquatic products. According to statistics, the proportion of aquatic products sold through e-commerce platforms has increased by about 50% in the past 5 y, which has undoubtedly greatly promoted the development of the aquatic products industry.

Cross-border e-commerce enhances information transparency. The e-commerce platform can provide rich and accurate commodity information, such as source, composition, production date, shelf life, etc., which greatly improves the transparency of information and enhances consumers' confidence in purchasing. According to the consumer feedback purchased by the e-commerce platform, the sales volume of products with high transparency of commodity information is about 30% higher than that of ordinary goods, which fully demonstrates the importance of information transparency for sales.

Cross-border e-commerce can help optimize inventory management. Since e-commerce can feed back market demand in real time, enterprises can predict demand more accurately based on these feedbacks, thereby optimizing production and inventory management and reducing inventory costs. According to the data of the e-commerce platform, the inventory cost after inventory management optimization

Table 2
Current situation of aquatic product supply chain

Statistical item	2022 data	Remark
Total global fisheries production	210 million tons	About 50% comes from marine fishing and 50% from aquaculture.
Processing rate of aquatic products	80%	Most aquatic products need to be frozen, cooked, pickled and other processing.
Cold chain management rate of aquatic products	90%	Most aquatic products require cold chain facilities during storage and transportation.
Average transport distance of aquatic products	1,000 km	That's about 30% more than a decade ago.
Proportion of e-commerce sales of aquatic products	15%	It has increased by about 50% in the last 5 y.

Table 3
Problems in the supply chain of aquatic products

Problem type	Problem description
Information asymmetry	The information flow among producers, distributors, retailers and consumers is not smooth, resulting in information asymmetry. This information asymmetry may lead to mismatch between supply and demand and reduce supply chain efficiency.
Cold chain management problems	Aquatic products are perishable products and require strict cold chain management. However, in some regions, cold chain facilities are insufficient, or cold chain management is not strict, leading to quality problems in the transportation and storage of aquatic products, affecting the freshness of products and consumers' purchasing experience.
Inventory management problem	Inventory management is a challenge due to the seasonality and perishability of aquatic products. How to predict market demand and arrange production and inventory reasonably to reduce inventory cost and waste is an important issue in supply chain management.
Market access problem	For cross-border e-commerce, regulations, standards, taxes and fees may be different in different countries and regions, and there are different requirements for the quality, safety, packaging, labeling and so on of aquatic products, which increases the difficulty of market access and affects the cross-border transactions of aquatic products.
Environmental impact	The links in the supply chain of aquatic products, such as fishing, breeding and transportation, may have environmental impacts, such as Marine pollution and carbon emissions. How to reduce the environmental impact while ensuring the efficiency of the supply chain is a problem that needs to be paid attention to.

has been reduced by about 20%, which has a very positive impact on improving the efficiency of enterprises.

Cross-border e-commerce can improve sales efficiency. E-commerce can directly send aquatic products from producers to consumers, reducing many intermediate links, thereby reducing circulation costs and improving sales efficiency. According to the data, aquatic products sold on the e-commerce platform have reduced the circulation cost by about 15% compared with traditional sales methods.

4.2. Application and impact of big data in cross-border e-commerce water product supply chain

Big data can optimize supply chain decisions. By collecting and analyzing various kinds of data, including consumer buying behavior, market trends, environmental factors, etc., it can provide useful information for decision makers to formulate more accurate sales, production and inventory strategies. Predictive analytics, for example, can help predict future demand and market changes. A common formula for predictive analytics is the Autoregressive Moving Average Model (ARIMA), which is:

$$Y(t) = C + \sum\left[\varphi(i) \times Y(t-i)\right] + \sum\left[\theta(i) \times \varepsilon(t-i)\right] + \varepsilon(t) \quad (1)$$

where $Y(t)$ represents the observation at time t; C is the constant; $\phi(i)$ is the parameter of the autoregressive term; $Y(t–i)$ is the observation at time point $t–i$; $\theta(i)$ is the parameter of the moving average term; $\varepsilon(t–i)$ is the error term at time point $t–i$; and $\varepsilon(t)$ is the error term at time t.

Big data can help make supply chains more transparent. By monitoring and recording the data of each link of the supply chain in real time, enterprises can fully understand the operation of the supply chain, discover and solve problems in a timely manner, and further improve operational efficiency and customer satisfaction. According to 2022 data, cross-border aquatic products e-commerce using big data technology has improved its operational efficiency by about 20% and customer satisfaction by about 30%.

Big data can improve risk management. Through the analysis of historical data, enterprises can predict and evaluate possible risks and formulate corresponding coping strategies. For example, time series analysis can predict possible supply disruptions or demand fluctuations to prepare for them in advance. Similarly, businesses that use big data technologies have increased their risk preparedness by about 25%.

5. Aquatic product supply chain optimization strategy

5.1. Supply chain management strategy based on big data

The supply chain management strategy based on big data is of great significance for cross-border e-commerce. First, through the collection and analysis of a large amount of information such as consumer purchase data, social media data, and market trend data, e-commerce can more accurately predict market demand. This forecasting capability optimizes inventory management and production planning, and the prediction of demand can be made using a simple linear regression model, whose formula is:

$$Y = a + bX \tag{2}$$

where Y represents the predicted demand; X represents the various factors that affect the demand; a and b are the parameters that need to be obtained through data fitting.

Big data improves the transparency of the supply chain, allowing companies to better understand the operation of the supply chain and be able to identify and solve problems that may arise in a timely manner. For example, by collecting and analyzing data from all aspects of the supply chain in real time, enterprises can obtain information about product production, transportation, inventory, etc., thereby improving operational efficiency.

Big data helps businesses better predict and manage risk. Through the analysis of historical data, companies can predict possible supply disruptions or demand fluctuations and formulate corresponding strategies in advance. According to statistics, through the use of big data, the accuracy of demand prediction can be improved by about 25%, operational efficiency can be improved by about 20%, and risk response ability can be improved by about 30%.

For the aquatic product supply chain management of cross-border e-commerce, the supply chain management strategy based on big data can not only improve the operational efficiency, better predict the market demand, but also improve the risk management ability, thus bringing significant business value.

5.2. Role of cross-border e-commerce in optimizing the aquatic product supply chain

Cross-border e-commerce plays a key role in optimizing the aquatic product supply chain. Through the e-commerce platform, aquatic product suppliers can directly reach consumers around the world, greatly expanding the sales market and increasing sales volume. According to relevant reports, after adopting the cross-border e-commerce model, the market coverage of aquatic product suppliers can be increased by about 30%.

Cross-border e-commerce effectively reduces transaction costs, including information search costs, transaction negotiation costs and contract execution costs, thus reducing the overall transaction costs. For example, the study found that aquatic product suppliers that adopt the e-commerce model can reduce transaction costs by about 20%.

Cross-border e-commerce significantly improves the efficiency of supply chain collaboration through real-time data sharing. For example, suppliers can use the order data from e-commerce platforms to adjust production plans in a timely manner, thereby avoiding inventory overhangs. According to statistics, after adopting the e-commerce model, the supply chain efficiency of aquatic product suppliers can be improved by about 15%.

In order to forecast demand more effectively and improve supply chain efficiency, improved exponential smoothing model can be used to forecast demand. The formula of the model is:

$$S_t = \alpha X_t + (1-\alpha) S_{t-1} \tag{3}$$

where S_t is the predicted value of phase t; X_t is the actual value of phase t; S_{t-1} is the predicted value of phase t–1; and α is the smoothing coefficient, whose value ranges from 0 to 1.

Cross-border e-commerce plays a crucial role in optimizing the aquatic product supply chain, which not only improves market access and reduces transaction costs, but also improves supply chain efficiency.

6. Research methods

6.1. Overview of quantitative research methods

Quantitative research method is a way to conduct scientific research on phenomena or problems. By collecting and analyzing numerical data, the phenomenon or problems are objectively and accurately measured and judged, so as to draw effective conclusions. It is widely used in social science, natural science, engineering technology and other fields.

In the study of cross-border e-commerce and aquatic product supply chain under the background of big data, quantitative research methods mainly include but are not limited to regression analysis, cluster analysis, association rule analysis, etc.

Regression analysis is a predictive model that can be used to assess the extent to which multiple independent variables influence a dependent variable. Its general form is:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_n X_n + \varepsilon \tag{4}$$

where Y is the dependent variable; X_1, X_2, …, X_n is an independent variable; β_0, β_2, …, β_n is the regression coefficient and ε is the error term.

Cluster analysis is an unsupervised learning method that divides data into multiple categories or clusters based on specific similarity or distance measures. For the study of cross-border e-commerce and aquatic product supply chain under the background of big data, cluster analysis can be used to study the purchasing behavior patterns of consumers in different countries or regions.

Association rule analysis is a data mining technique that can discover frequent item sets and association rules in data. For the study of cross-border e-commerce and aquatic product supply chain under the background of big data, association rule analysis can be used to find the behavioral rules of consumers purchasing aquatic products [16–18].

These quantitative research methods can provide insight into the role of cross-border e-commerce in the fish supply chain and how big data impacts the management and optimization of the fish supply chain.

6.2. Data collection and processing

6.2.1. Data collection

6.2.1.1. Data on the fish supply chain

These data are mainly obtained from major cross-border e-commerce platforms and industry statistical reports, which mainly include the number of suppliers of various aquatic products, product types, product sales, product prices, and production and transportation costs (Fig. 2).

6.2.1.2. Big data related data

This part of data is mainly obtained from public reports and related research literature, including the amount of data, data type, data collection, processing and analysis time (Fig. 3).

Data on cross-border e-commerce, including the number of users of the e-commerce platform, transaction volume, sales volume, etc. These data are mainly obtained from the public reports of major e-commerce platforms and related research literature (Fig. 4).

The collection of these data is an important basis for this study, which helps to deeply understand the impact of cross-border e-commerce on aquatic product supply chain under the background of big data and its optimization strategy from a quantitative perspective.

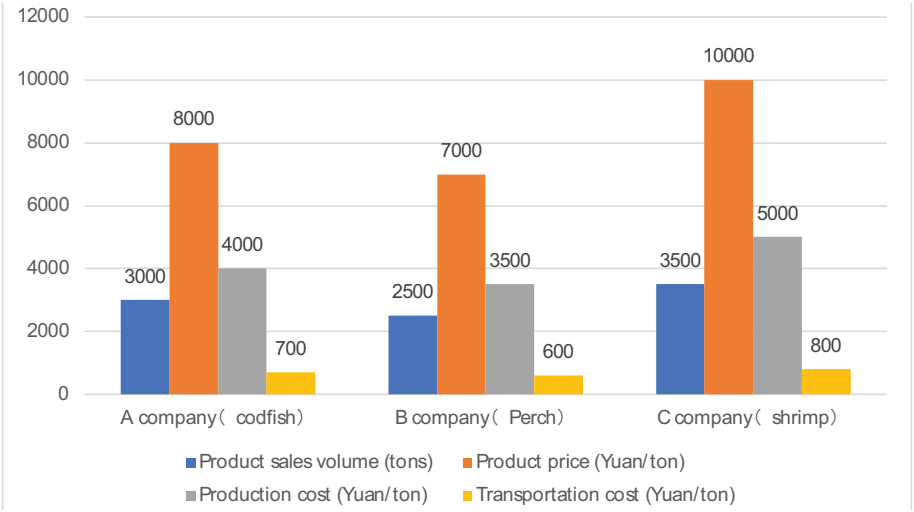

Fig. 2. Major cross-border e-commerce platforms and industry statistical reports.

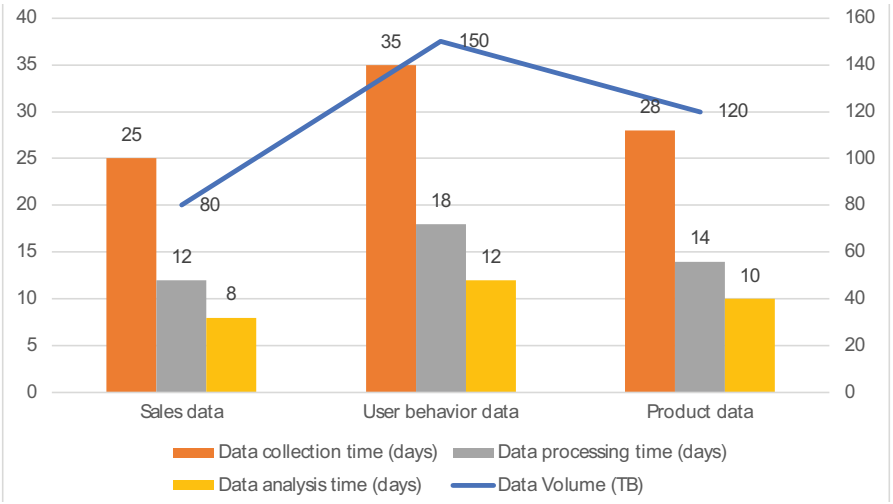

Fig. 3. Mainly obtained from public reports and related research literature.

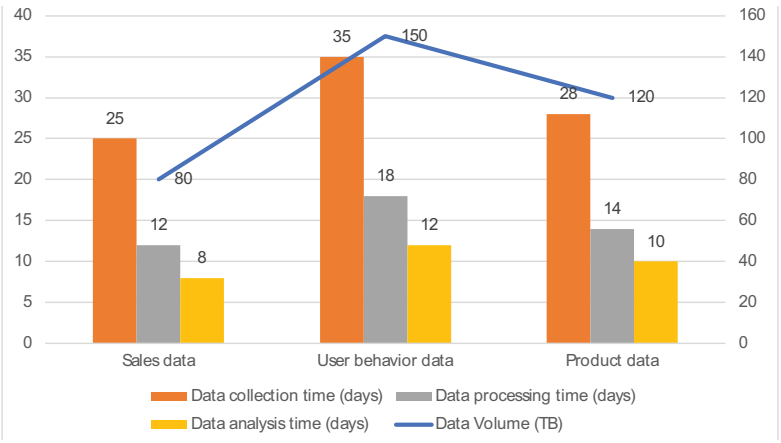

Fig. 4. Data on cross-border e-commerce.

6.2.2. Data processing

In data processing, the collected data should be cleaned first, and invalid, duplicate or irrelevant data should be deleted to ensure the accuracy of the data. Next, descriptive statistical methods can be used to conduct a preliminary analysis of the data to obtain the average, median, mode, standard difference, etc., in order to understand the basic situation of the data. For example, the average number of users, average transaction volume, average sales volume of each e-commerce platform can be calculated.

The average number of users is calculated as:

$$\mu = \frac{\sum_{i=1}^{n} X_i}{n} \tag{5}$$

where X_i represents the number of users of the i e-commerce platform, and n represents the total number of e-commerce platforms.

For the processing of data types, it is necessary to classify and encode all kinds of data and convert them into formats that can be used for data analysis. For example, the types of aquatic products are coded as 1 for cod, 2 for bass, 3 for shrimp, and so on.

Then, correlation analysis is performed on the data to understand the relationship between various variables. For example, the correlation between two variables can be measured by the Pearson correlation coefficient. The Pearson correlation coefficient is calculated by Eq. (6):

$$r = \frac{\sum_{i=1}^{n}\left(X_i - \bar{X}\right)\left(Y_i - \bar{Y}\right)}{\sqrt{\sum_{i=1}^{n}\left(X_i - \bar{X}\right)^2\left(Y_i - \bar{Y}\right)^2}} \tag{6}$$

where X_i and Y_i, respectively represent the values of the two variables in the i first sample, and $\bar{X}$ and $\bar{Y}$, respectively represent the average values of the two variables in all samples.

The purpose of data processing is to convert the collected raw data into data that can be used for further analysis and modeling, laying the foundation for subsequent data analysis and model building.

6.3. Model establishment and analysis

In the process of establishing the model, it is first necessary to determine the main variables of the study, such as the sales volume, price, production cost and transportation cost of water products. Then, according to the results of the previous data processing, the relationship between the variables is determined.

With the sales volume of aquatic products as the dependent variable and the price, production cost and transportation cost as the independent variables, the linear regression model can be established in Eq. (7):

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \varepsilon \tag{7}$$

where Y is the aquatic products sales; X_1, X_2, X_3 is the price, production cost, transportation cost; β_0, β_1, β_2, β_3 is for estimation of parameters, to express the degree of each variable's impact on sales ε is a random error term.

The least squares method can then be used to estimate the parameters of the model. The goal of least square method is to minimize the sum of squares of residuals, and its solution formula is:

$$\beta = \left(X^T X\right)^{-1} X^T Y \tag{8}$$

where X is the independent variable matrix; Y is the dependent variable matrix; β is the parameter matrix.

After the parameter estimates are obtained, the model can be tested. First, the overall validity test is carried out, usually using F-test to calculate F-value and the corresponding P-value. If the P-value is less than 0.05, the model is effective as a whole.

The significance test of each parameter is usually carried out by using T-test to test the T-value of each parameter and the corresponding P-value. If the P-value is less than 0.05, the parameter is significant.

The purpose of model building and analysis is to quantitatively understand the impact of cross-border e-commerce on aquatic product supply chain in the context of big data, and to provide data support for optimization strategies.

In this model, the data is Table 4.

Table 4
Model data

Variable	Parameter estimates	*T*-value	*P*-value
Intercept	$\beta_0 = 230$	8.6	<0.05
Price	$\beta_1 = -0.3$	–3.7	<0.05
Production cost	$\beta_2 = -0.5$	–5.1	<0.05
Transportation cost	$\beta_3 = -0.4$	–4.3	<0.05

The *F*-value of the model is 16.2, and the *P*-value is less than 0.05, so the model is effective as a whole. The *P*-values of all parameters are less than 0.05, indicating that price, production cost and transportation cost have significant effects on the sales volume of aquatic products. The parameter estimates of price and cost are negative, indicating that an increase in price and cost will reduce sales.

7. Conclusion

The combination of cross-border e-commerce and big data has changed the way fish supply chains operate. In this new environment, the supply chain of aquatic products is facing many new opportunities and challenges. Supply chain management strategies based on big data can help enterprises better understand market demand, improve the efficiency and transparency of the supply chain, reduce operating costs, and improve the competitiveness of enterprises. In addition, the role of cross-border e-commerce in optimizing the supply chain of aquatic products cannot be ignored. Through the e-commerce platform, it can effectively break the geographical restrictions and improve the coverage of the market, thereby expanding sales and profit margins. At the same time, the user data of the e-commerce platform also provides a valuable information source for market analysis and decision-making.

In practice, the application of quantitative research method in optimizing supply chain has also been verified. Through data collection, data processing, and model establishment and analysis, market trends can be predicted more accurately, and more targeted strategies can be developed to further optimize supply chain management.

Through the combined use of big data and cross-border e-commerce, the aquatic product supply chain can be significantly improved in terms of efficiency, effectiveness and adaptability. For the future, more in-depth exploration of the role of big data and cross-border e-commerce in supply chain optimization, and digital and intelligent transformation of all links of the supply chain will be an important way for the sustainable development of the aquatic product supply chain.

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