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Exploring the Application of Big Data Technology in International Trade: Case Studies from India and China

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Abstract. With the rapid development of big data technology, its application in international trade has become increasingly important. This paper aims to explore the relationship between big data technology and international trade, analyze the application scenarios and challenges of big data technology in international trade, and discuss the innovative applications and future trends. Through a case study of small-scale trade data in India and cross-border e-commerce data in China, this paper provides insights on the potential of big data technology in optimizing trade processes, improving decision-making, and managing trade risks. The research findings indicate that big data technology has great potential to revolutionize international trade and promote global economic development. The results of this study contribute to a better understanding of the role and impact of big data technology in international trade and provide useful insights for policymakers and businesses to harness the power of big data in the global trade arena.

Keywords: International Trade, Big Data Technology, Data Analytics, Artificial Intelligence, Application examples

1. Introduction

With the iterative progress and maturity of computer technique, it has obtained extensive and in-depth research and popularization in many fields represented by foreign trade, especially the utilization of computer technique represented by big data in the field of international trade, which has greatly accelerated the development and promotion of international trade. At present, with the acceleration of global economic integration, international trade has achieved rapid growth. A large number of data are generated in international trade-related activities, which need to be analyzed and processed (Bao, 2018). How to fully mine the high-value info and content contained in these data is of great significance to further optimize the international trade system, it is of great value to accelerate the double promotion of international trade in volume and quality. On the other hand, the emergence of big data also brings new challenges to the international trade order and the existing system. For example, the utilization of production factors, economic structure, international supply and demand and other factors have undergone significant changes (Jia, 2020). It is necessary to better mobilize big data technique to achieve greater benefits.

International trade is deepening with the development of globalization, not only the relationship between countries is closer, but also countries are more and more dependent on the competitive advantage brought by big data (Cheng & Yang, 2020). Reasonable analysis of various data in international trade will help to accurately locate the international trade market, fully mobilize the value and function of big data in international trade, accelerate the healthy development of international trade, and accelerate a more harmonious and healthy relationship between supply and demand in international trade. International trade business often has the advantages and characteristics of short term, low risk, simple embedding and matching, which makes it closely related to the real economy, so it gradually becomes the main position of intermediate business and asset business (Dong & Zhao, 2020).

In addition, the dependence of current international trade on big data technique in several aspects as shown in Figure 1 is not short-term. Especially in the international trade capital market and risk management level, with the help of big data technique, it could analyze various transaction reference indicators and risk probability. Secondly, in the commercial credit loan level, it could analyze consumption risk with the help of big data technique, to achieve effective risk control. At the level of commercial insurance, the use of big data technique can accelerate the optimization and upgrading of insurance projects (Li, 2020). At the level of customer behavior, with the help of big data technique, it can dynamically analyze customers' habits and characteristics in real time, so as to carry out targeted trade and marketing, and accelerate the further healthy development of international trade. Therefore, the study of big data technique in international trade has important practical value.

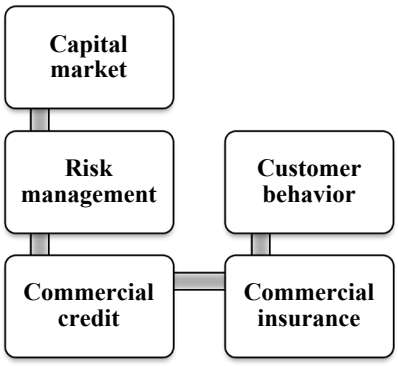

Fig. 1: Utilization fields of big data technique in international trade

In traditional international trade, merchants spend a great deal of time and resources collecting and analysing market and customer information in order to develop better sales and marketing strategies. However, with the continuous development of international trade and the rapid advancement of data technology, merchants can more easily collect and process large amounts of trade data to achieve more

accurate market analysis and decision-making (Lin, 2015). In such a context, studying the application and development trend of big data technology in international trade can provide better trade decision support for enterprises and governments and promote the smooth development of trade. However, due to the characteristics and complexity of data in international trade, how to effectively collect, process and analyse large amounts of trade data is still a pressing issue to be resolved. Therefore, it is of great theoretical and practical significance to study the application and development trend of big data technology in international trade (Liu, 2019).

With the continuous development and popularity of big data technology, the application of big data in international trade has gradually become a research hotspot in the academic and practical circles. Scholars at home and abroad have conducted in-depth research on the application of big data technology in international trade, and the relevant research results cover various aspects from trade data collection, storage, processing, analysis to application (Sun, 2020). European and American countries are pioneers of big data technology in international trade, and their research focuses mainly on trade data collection, processing and analysis. Among them, scholars from Purdue University in the United States have studied the brand effect in trade and the evolution of trade networks by constructing large-scale trade networks and applying the methods of network science; scholars from the University of Chicago in the United States have studied the contractual issues in trade and the impact of legal environment on trade risks (Cheah & Wang, 2017). In addition, European research focuses on the open sharing of trade data and data privacy protection, and the research results are mainly reflected in the establishment of open data platforms and the formulation of laws and regulations on data privacy protection (Zhang, 2017). The research results of domestic scholars are mainly related to trade data mining, trade data analysis and trade intelligence decision-making. In terms of trade data mining, scholars from the Chinese Academy of Sciences have used rule-based and decision tree algorithms to achieve association rule mining and trade risk identification in trade data; in terms of trade data analysis, scholars from the Shanghai University of Finance and Economics have studied the changing trends of trade relations between China and its major trading partners through time series analysis of trade data (Banga, 2019); in terms of trade intelligence decision-making, scholars from the Beijing University of Technology scholars from Beijing University of Technology proposed a data mining-based trade risk assessment method, which can quickly and accurately identify the anomalies and risk points in trade data and provide decision support (Zhou, 2020). Overall, scholars at home and abroad have made significant progress in the application of big data technology in international trade, but further in-depth research is needed in areas such as trade data security protection and the harmonisation of big data technology with traditional trade rules (Cukier & Mayer-Schoenberger, 2013).

In conclusion, this paper aims to discuss the application and development trend of big data technology in international trade, and how to effectively use big data technology to improve trade efficiency and optimise trade structure.

2. Relationship Between International Trade and Big Data Technology

2.1. Definition and Characteristics of International Trade

International trade refers to the economic activity of exchanging goods and services across national borders, involving the flow of goods, services, capital and technology between multiple countries and regions. In international trade, there are various trade patterns and trade relations between different countries and regions, such as internal trade between multinational companies, foreign direct investment, foreign exchange transactions, cross-border cooperation, etc. The characteristics of international trade mainly include the following aspects: across national borders. International trade is not restricted by national borders, and goods and services can circulate freely between different countries and regions. Therefore, in international trade, trade subjects and trade objects can cross national boundaries. The scale of transactions is large. International trade usually involves a large number of goods and services,

and the scale of transactions is large. With the continuous promotion of globalisation, the scale of international trade has been expanding and has become an important part of the global economy. Complex trading links. International trade is complex and involves a variety of economic activities, including procurement, sales, logistics and payment. Information transfer and data exchange are required between different links, so information technology and digitalisation have become the trend of international trade. Diverse transaction methods. International trade is conducted in a variety of ways, including sea, air, land and e-commerce. Different transaction methods correspond to different transaction processes and data processing methods, and require corresponding technical support. Trade policies have a strong influence. The development and operation of international trade is influenced by national and regional trade policies and laws and regulations. Different trade barriers and tariff policies exist between different countries and regions, which poses new challenges to the processing and application of trade data.

In short, the development and operation of international trade cannot be separated from the support of information technology and digitalisation, and the development and application of big data technology can provide better support and services for international trade, which is one of the main objectives of this thesis research. The flow of international trade is shown in Figure 2 below.

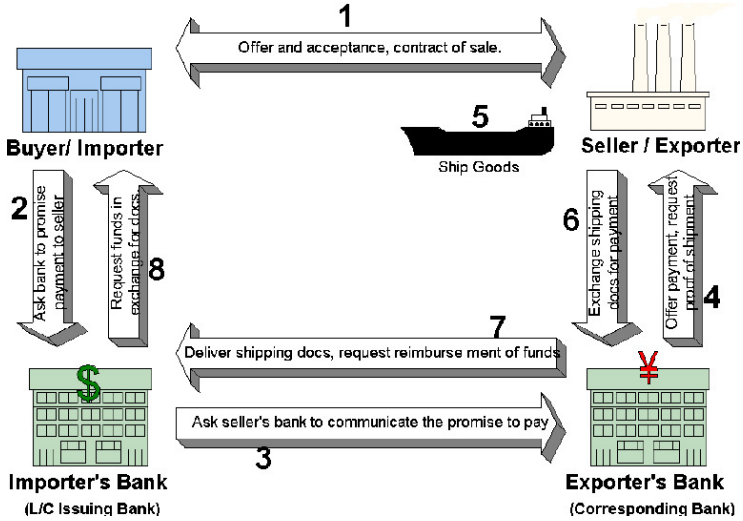

Fig.2: The process of international trade

Figure 2 shows the main processes of international trade, including procurement, logistics, sales, payment and other links, different links need to exchange information and data processing, and therefore need to have the appropriate information technology and data technology support.

2.2. Overview and Application of Big Data Technologies

Big Data technology refers to technologies and tools geared towards the processing, storage, analysis and application of large-scale, high-dimensional, heterogeneous data. It has a large volume of data, a large variety of data, data processing speed, data value and other characteristics, in all walks of life has been widely used, international trade is no exception.

The application of big data technology in international trade can be divided into the following aspects. Transaction data management: big data technology can be applied to the management of transaction data, including the collection, storage, processing and analysis of data and other aspects. For example, in the field of cross-border e-commerce, big data technology can be used for the management and operation of trading platforms to achieve real-time monitoring and analysis of transaction data and provide support for decision-making. Trade data analysis: big data technology can be applied to the analysis of trade data, including data mining, data analysis and data visualisation. Through the analysis of trade data, information such as trade trends, market changes and potential business opportunities can be discovered, providing support for enterprises' trade decisions. Supply chain management: big data technology can be

applied to supply chain management, including real-time monitoring of data, sharing of information and collaborative decision-making. Through the application of big data technology, information fluency, automation of business processes and efficiency improvement can be achieved in all aspects of the supply chain. Trade finance risk management: big data technology can be applied to trade finance risk management, including the prediction and control of credit risk, market risk and operational risk, etc. Through the application of big data technology, potential risks can be effectively identified and provide a scientific basis for enterprises to make decisions. Intelligent logistics: big data technology can be applied to intelligent logistics, including the optimisation of logistics networks, the formulation of distribution plans and the monitoring of logistics processes. Through the application of big data technology, the intelligence and optimisation of the logistics process can be realised, improving logistics efficiency and reducing logistics costs.

Overall, the application of big data technology in international trade has a wide range of application prospects and potential. In this field of application research, it is necessary to dig deeper and apply the various features and advantages of big data technology in order to achieve intelligent, efficient and sustainable development of international trade.

2.3. Application Scenarios and Challenges of Big Data Technologies in International Trade

With the development of information technology, big data technology has become an important tool in many fields. In international trade, big data technology can help enterprises to realise the mining, analysis and prediction of trade data to improve decision-making efficiency and market competitiveness. The application scenarios of big data technology in international trade can be divided into the following aspects. Trade data analysis: the most significant application of big data technology in international trade is the analysis of trade data. Trade data is an important basis for enterprises to make decisions, and big data technology can analyse and mine these data to discover potential business opportunities and risks. For example, the trends and changes in product imports and exports can be mined from customs data, so that enterprises can make timely adjustments. Trade forecasting: Trade forecasting is another application scenario of big data technology in international trade. By analysing historical trade data, big data technology can predict future trade trends and market demand, thus helping enterprises to adjust their production plans and market strategies to cope with future market changes. Trade risk management: Trade risk is one of the challenges that companies must face in international trade. Big data technology can help enterprises to provide early warning and management of trade risks. Through the analysis and mining of trade data, big data technology can identify potential risk factors and take corresponding risk control measures in a timely manner. Trade decision support: big data technology can provide decision support for enterprises. Through the analysis and mining of trade data, big data technology can provide comprehensive and accurate market intelligence to help enterprises make more reasonable and accurate trade decisions.

With the development of international trade and increased globalisation, the scale of trade data is becoming larger and larger, and the types, sources, formats, quality and granularity of data are becoming more diverse and complex. Big data technology is widely used in this context, but it also faces many challenges. Firstly, the increasing scale of data makes it more difficult to store and process data. Traditional data processing methods are no longer capable of handling and analysing large-scale data, so distributed storage and computing technologies, such as Hadoop and Spark, are needed to cope with the demands of processing massive amounts of data. Secondly, the diversity and heterogeneity of data sources make data integration, cleaning and standardisation very difficult. The quality of data also needs to be a concern, as the quality of data from different sources varies, and without quality assessment and control, the accuracy and credibility of data analysis will be affected. Again, data privacy and security issues are another challenge facing big data technology in international trade. Trade data contains sensitive data such as commercial secrets and personal information of all parties, which will bring huge losses to trade participants if leaked or maliciously exploited. Therefore, technologies such as data

encryption and permission control need to be used to protect data privacy and security. Finally, the application of Big Data technology in international trade also needs to be harmonised with traditional trade rules and policies to safeguard the fairness and legality of trade. For example, in terms of data use, sharing and circulation, relevant international standards and regulations need to be followed to ensure data regulation and compliance. Therefore, to fully exploit the role of big data technologies in international trade, the challenges described above need to be addressed. This requires interdisciplinary collaboration and innovation, bringing together the forces of technology, law and policy to provide strong support for the development of international trade.

3. Application of Big Data technology in international trade

3.1.Application of Data Mining Techniques in International Trade

Trade data mining models are one of the data analysis methods based on big data technology and are used to discover potential patterns and laws from the huge amount of trade data. Its main objective is to provide support for trade decisions by mining valuable information in trade data through data mining techniques. Trade data mining models can be divided into two categories: classification models and clustering models.

Classification model: Classification model is a model used to classify trade data according to certain specific attributes. Commonly used classification algorithms include plain Bayesian, decision trees, support vector machines, neural networks and so on. Among them, the plain Bayesian algorithm is a statistical classification method based on Bayes' theorem, which has excellent classification effect and fast operation speed, and is one of the most widely used algorithms for classifying trade data. Its formula is:

$$P(Y|X) = \frac{P(X|Y)P(Y)}{P(X)} \tag{1}$$

where $P(Y|X)$ denotes the probability of Y given the feature X; $P(X|Y)$ denotes the probability of X given Y; Y denotes the prior probability of Y; and $P(X)$ denotes the prior probability of X.

Clustering model: A clustering model is a model for clustering trade data according to similarity. Commonly used clustering algorithms include K-Means algorithm, DBSCAN algorithm, hierarchical clustering algorithm and so on. The K-Means algorithm is a distance-based clustering algorithm, whose main idea is to divide the data points into K different clusters, so that the distance between data points within the same cluster is as small as possible, and the distance between data points in different clusters is as large as possible. Its formula is:

$$\arg min_{C1,C2,\ldots,Ck} \sum_{i=1}^{k} \quad \sum_{x \in Ci} \quad \|x - \mu_i\|^2 \tag{2}$$

where Ci denotes the i cluster and μ_i denotes the centre of mass of Ci.

The advantage of trade data mining models is that they can quickly uncover valuable information in trade data and provide support for business decisions. However, the disadvantage is that it requires strong data processing and algorithm application skills, and a reasonable data mining model needs to be established. In addition, attention needs to be paid to issues such as data quality and privacy and security to avoid adverse consequences caused by data leakage or corruption.

In trade big data analysis, the dimensionality of the data is often high and needs to be reduced through feature selection and dimensionality reduction techniques to improve the accuracy and efficiency of the model. Feature selection refers to the selection of a portion of features from the original dataset that are relevant to the target variable to be modelled. Common feature selection methods include filtering, packing and embedding. The main idea of the filtering method is to initially screen the features and remove those that are not highly relevant to the target variable; the packing method is to select features by searching through a subset of features; and the embedding method is to integrate feature selection into the model training. Common feature selection metrics include information gain, chi-square test, mutual information, etc. Dimensionality reduction techniques are an important approach in data analysis and can

help improve model efficiency and reduce computational time and spatial complexity. Common dimensionality reduction techniques used in trade data analysis include principal component analysis (PCA), linear discriminant analysis (LDA) and independent component analysis (ICA).

Principal Component Analysis (PCA) is a commonly used linear dimensionality reduction technique whose goal is to map the original data into a new space of lower dimensionality through a linear transformation such that the variance of the data in the new space is maximised. When performing principal component analysis, the original data needs to be centred first, then the covariance matrix of the data is calculated, followed by the eigenvalue decomposition of the covariance matrix to obtain the eigenvalues and eigenvectors, and finally the data is projected into a low-dimensional space composed of eigenvectors. Specifically, let the original data matrix be X and the centred data matrix be $\tilde{X}$, then the mathematical model of principal component analysis can be expressed as:

$$\begin{aligned} &\max_{w} Var\left(W^T\tilde{X}\right) \\ &s.t. w^T w = I \end{aligned} \tag{3}$$

Where W is the d-row k-column transformation matrix, $Var\left(W^T\tilde{X}\right)$ denotes the variance of the mapped data, and I is the k-dimensional unit matrix. By solving the above optimisation problem, the optimal transformation matrix W can be obtained to map the original data into the k-dimensional space.

Linear Discriminant Analysis (LDA) is a commonly used supervised dimensionality reduction technique whose goal is to map the original data into a new space of lower dimensionality by means of a linear transformation, allowing different categories of data to be effectively distinguished in the new space. Unlike principal component analysis, LDA takes into account category information when making projections. Specifically, let the original data matrix be X and the corresponding category labels be y, then the mathematical model of LDA can be expressed as:

$$\begin{aligned} &\max_{W} \frac{w^T S_B w}{w^T S_w w} \\ &s.t. w^T w = I \end{aligned} \tag{4}$$

where W, S_B and S_w denote the transformation matrix, the inter-category covariance matrix and the intra-category covariance matrix, respectively. By solving the above optimization problem, the optimal transformation matrix W can be obtained to map the original data into the k-dimensional space.

In addition to the above methods, Independent Component Analysis (ICA) is also a commonly used technique for dimensionality reduction of trade data. Unlike PCA, the objective of ICA is to decompose the original data into multiple independent signal components, rather than retaining the maximum variance in the original data. ICA is therefore suitable for problems where potentially independent components need to be found, such as in signal processing, image processing and speech recognition. the goal of ICA is to find a rotation matrix A such that each element in S is independent. the most common method used in ICA algorithms is the Maximum Entropy method (ME), which maximises the entropy of the independent components to determine the rotation matrix A. A higher entropy indicates less correlation between the data, so the Maximum Entropy method can be used to find the most independent components.

Feature selection and dimensionality reduction techniques for trade data are key steps in the application of big data technology in international trade. By selecting the most important features and reducing the dimensionality of the data, the efficiency and accuracy of data processing and analysis can be improved, providing more accurate analysis results and decision support for international trade.

3.2.Application of Big Data Analytics in International Trade

3.2.1. Utilization Value and Advantages of Big Data Technique in International Trade

Utilization value of big data technique in international trade: With the increasing of international trade, it has brought great boost effect to the development of manufacturing countries represented by China.

But in recent years, some countries headed by the United States have pursued unilateralism and trade protectionism, which makes the normal order of international trade seriously threatened and challenged. Under this background, how to guarantee the normal development of international trade has become an important topic for the countries pursuing the development of international trade order. On the other hand, to establish competitive advantage in international trade, it should not only have cost advantage and enhance the added value of trade goods, but also accelerate the symmetry and transparency of international trade info, eliminate barriers and trade info islands in international trade. These factors provide a broad scene for the utilization of big data technique. In addition, the progress of big data technique has significantly accelerated international trade, and most of the increase in international trade is due to the utilization and development of big data. Big data enables global marketers to better contact customers, and plays an important role in promoting international trade.

Utilization advantages of big data technique in international trade: First of all, big data technique can optimize the logistics and supply chain of international trade, provide end-to-end big data logistics solutions for international trade, and implement value-added processes. By using big data technique to track the quality rating of suppliers, it could ensure the traceability of the lower level of the supply chain and minimize the waste in other links. Using big data technique to track turnaround time can also solve transportation and delivery problems. Secondly, the use of big data technique can accurately predict the demand of international trade, with the help of big data model to predict changes in the international market, optimize logistics, more accurately predict the demand or better launch product opportunity. In addition, big data technique can also accelerate innovation in international trade, use big data to establish more cost-effective solutions, better meet the practical needs of national trade, adapt to different preferences at the regional level, and develop more effective solutions.

The function of big data technique in international trade: First of all, big data technique provides the motivation source of international trade, and gradually develops into an important production factor, ameliorates the core competitiveness of big data utilization subjects in international trade, becomes a new driving factor of international trade, and significantly accelerates the process of international trade. Secondly, big data technique accelerates the diversification of international trade, and significantly reduces the cost and risk of international trade. The utilization of big data technique makes international trade no longer limited by time and region. It not only makes the transaction process more data-based and transparent, but also ameliorates the online and offline supply and demand chain of international trade. In addition, big data technique has further enriched the content of international trade. Big data technique makes several aspects of data info as shown in Figure 3 become important elements in international trade. Big data has become the new driving force of the current international trade pattern, reducing the risk of imbalance between supply and demand in international trade, and realizing the most reasonable allocation of resources.

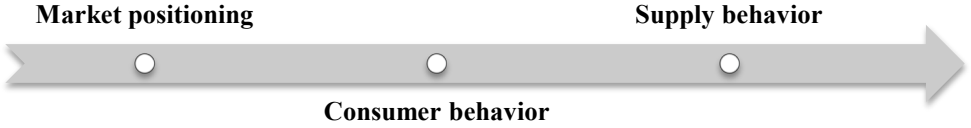

Fig. 3: Components of big data technique in international trade

3.2.2. Utilization Status of Big Data Technique in International Trade

The utilization of big data technique in international trade: Although the utilization of big data in international trade has brought more significant utilization advantages, functions and values, it also brings new challenges to the traditional international trade situation. On the one hand, big data technique, as a relatively new techniquenical means, has high requirements on the informatization literacy of relevant users, and there is a high threshold in the use level; On the other hand, big data brings new risks to the spread of info, especially the privacy protection of sensitive info and the protection of info security. Once the big data info containing sensitive content is leaked, it will often produce

unpredictable adverse consequences and losses.

Utilization status of big data technique in international trade: With the continuous utilization of intelligent technique represented by data science and big data technique in the field of international trade, the demand for big data technique has increased in all walks of life. In order to ensure the positive promotion of big data technique in international trade, it is necessary to further integrate the advantages of integrated info, international trade and other disciplines to open up a better future of digital trade. The origin of customs data is the import and export statistics data generated by the customs in the performance of import and export trade statistics. Big data is widely used in international trade and other fields after processing. Through these data, it could quickly understand the global market situation and adjust trade strategies in time, which plays an important role in promoting enterprises to develop international market, ameliorate their competitiveness and prevent risks in international trade market.

In addition, through the innovation and reform of the big data industry, big data in international trade has gradually evolved into an important tool to analyze and predict the development trend of foreign trade economy, which has brought new changes to the international trade market. With the frequent occurrence of trade protection events in recent years, the international trade market is surging, and the road of trade is full of obstacles. The exploration of efficient foreign trade tools is not only the inevitable requirement of the development of international trade, but also the only way of foreign trade economic construction. The effective practical utilization of big data technique in international trade has gradually evolved into an important branch of info industry, and plays an important supporting and pulling role in the field of international trade. The integration of big data technique and international trade services is forming a rapid development momentum. Although there are many possibilities for the development of international trade situation, and there are many variables between supply and demand, the utilization scale of big data technique in international trade will continue to grow, as shown in Figure 4 below.

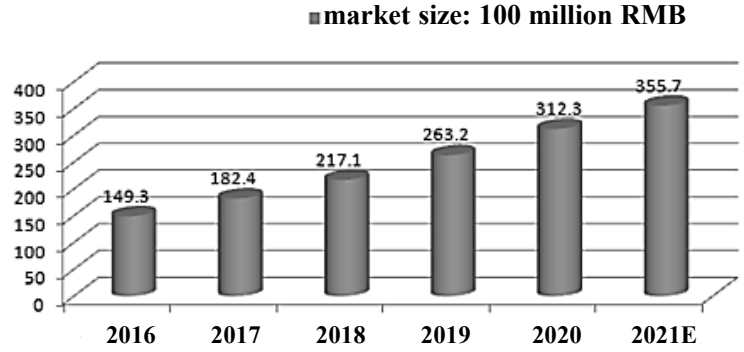

Fig.4: Utilization scale of big data technique in international trade

3.2.3. Big Data Technique Utilization Strategy in International Trade

Reduce the utilization threshold and cost of big data technique: There is no doubt that big data technique has a positive impact on international trade. However, in recent years, the practice of international market is not as satisfactory as originally thought. Big data industry has gradually entered a bottleneck period of development, which is due to the deterioration of international trade situation; On the other hand, due to the high utilization threshold and cost of big data technique, it is difficult to explore an effective fit point in international trade. The deterioration of international trade situation makes the demand for digital trade tools represented by big data more and more intense. However, the high utilization cost and utilization threshold of big data technique has become a hard obstacle in the development process of small and medium-sized enterprises. Therefore, reducing the utilization threshold and cost of big data technique is an important prerequisite for deepening the utilization of big data technique in international trade.

Define the positioning of big data technique: In order to deepen the utilization of big data technique in international trade, first of all, it should to make clear its functional orientation. In the complex national trade environment and situation, big data technique cannot be used as a simple analysis tool of

international trade market, but should be used as an expansion tool to enhance the pertinence of products through the interpretation of customer behavior and habits. By repositioning the value and use of big data, it could position big data technique as a powerful tool to assist international trade, and ameliorate the comprehensive competitiveness of small and medium-sized enterprises in the international market. In addition, by mining the deep value of international trade data, it could ameliorate the efficiency of developing customers for international trade related entities, enhance the boosting function, and accelerate the better and further utilization and development of big data technique in international trade.

3.3.Application of Artificial Intelligence Technology in International Trade

With the development of Big Data technology, more and more companies are applying it to the field of international trade. However, the application of big data technology in trade data processing and analysis faces problems of large data volumes, complex data sources, a wide range of data types and varying data quality, so algorithms and tools for intelligent processing and analysis of trade data need to be developed. In the area of intelligent trade data processing, the following areas of research are included. Data cleansing and pre-processing: Due to the different formats, quality and granularity of trade data sources, data needs to be cleansed and pre-processed. Data cleansing refers to the identification and processing of unreasonable parts of the data such as errors, missing, duplicates and anomalies, while data pre-processing is the normalisation and standardisation of data for subsequent analysis and processing. Data mining and analysis: For the huge amount of trade data, how to discover useful information from it becomes an important issue. Data mining techniques can help analysts to find patterns, trends and patterns from the data, thus improving the accuracy of decision making. In trade data analysis, algorithms such as clustering, classification and association rule mining can be used for analysis. Data visualisation: Through data visualisation techniques, analysis results can be presented in the form of charts and other graphs, making them more intuitive and easy to understand. Data visualisation can also help users to quickly identify patterns and trends in data for better decision-making. In terms of intelligent processing of trade data, there is also a need to develop algorithms and tools suitable for trade data processing and analysis, taking into account the characteristics and application scenarios of big data technology. For example, parallel computing frameworks suitable for massive data processing, stream processing frameworks that support real-time data processing and analysis can be developed. In conclusion, with the continuous development and application of big data technology, the intelligent processing and analysis of trade data will become an important direction in the field of international trade in the future. There is a need to continuously deepen research and develop more intelligent and efficient algorithms and tools to support the sustainable development of international trade.

A Trade Decision Support System (TDSS) is a software system that provides decision makers with reliable decision support information through the intelligent analysis and processing of trade data. TDSS usually consists of four modules: data acquisition, data processing, data analysis and decision support. The data collection module is responsible for collecting, integrating and cleansing data from various data sources; the data processing module includes data cleansing, data integration, data conversion and data standardisation, aiming to transform raw data into data for analysis and mining; the data analysis module analyses, mines and models the data through various data mining and statistical analysis algorithms, and draws valuable conclusions; the decision TDSS has a wide range of applications in the trade field, and can be used for market analysis, risk assessment, investment decisions and trade policy formulation. For example, in market analysis, TDSS can forecast future market trends and consumer demand through the analysis and modelling of historical data, providing support for enterprise decision-making; in trade policy formulation, TDSS can simulate and forecast the impact of various policy measures, providing support for government departments to formulate reasonable policies. In the process of implementing TDSS, suitable data processing and analysis algorithms and appropriate visualisation tools need to be selected, while issues such as data security and privacy protection also need to be considered. System testing and optimisation are also required to ensure the performance and reliability of the system.

Trade risk is one of the unavoidable risks in international trade, therefore, establishing an effective trade risk management system can provide important decision support for enterprises. With the development of big data technology, more and more enterprises are using big data technology to manage trade risks. A trade risk management system mainly includes four aspects: risk assessment, risk monitoring, risk analysis and risk response. Among them, risk assessment is the first step of risk management, which identifies potential risk factors through the analysis of data from various aspects such as market, trade and policy, so as to assess the risks. Risk monitoring refers to the real-time monitoring of trade activities to identify risks and provide early warning in a timely manner. Risk analysis is based on risk assessment and risk monitoring, further in-depth analysis of the impact factors and degree of risk, to identify the most appropriate risk response strategy. Risk response refers to the adoption of corresponding risk response strategies to minimise losses based on the results of risk analysis. The design of a trade risk management system requires consideration of the following aspects: firstly, the scope and focus of risk management needs to be determined, as well as the source and quality of data, so that suitable data processing methods and models can be identified. Secondly, suitable risk assessment and analysis methods need to be selected, such as statistical model-based methods, machine learning methods, network analysis methods, etc. At the same time, the most suitable risk management method needs to be determined by considering the characteristics and factors of the risk and the needs of the business in relation to the specific trade activity. Finally, a visual analysis platform needs to be established so that managers and decision makers can have a clear picture of trade risks and response strategies. In practice, a trade risk management system can provide companies with the following benefits: firstly, it can quickly and accurately assess trade risks, identify potential risk factors in a timely manner and adopt appropriate risk response strategies. Secondly, it can effectively optimise trade decisions and improve the efficiency and competitiveness of enterprises. Finally, it can reduce the losses caused by trade risks and safeguard the long-term stable development of enterprises.

4. Case studies and outlook

4.1.Analysis of Indian Microtrade Data

India, as a developing country, has limitations in the quality and reliability of its microtrade data. The following data sources and processing methods have been used in this section to ensure the accuracy and credibility of the data.

Data source: Official Government of India website: The official government of India website publishes a large amount of data on India's trade, including information on trade volumes, export destinations, import source countries, etc. This study mainly uses the trade data published by the official website of the Indian government. Third-party data platforms: This study also collects data on India's small trade from third-party data platforms, including customs data websites, business data services companies, etc. By collecting and integrating these data, this study obtained a more comprehensive and detailed data on Indian microtrade.

Data processing methods: Data cleansing: Due to the diversity of trade data sources, there are differences in data format, quality, granularity, etc. between different data sources. Therefore, before the data can be analysed, it is important to cleanse the data to ensure consistency and integrity. Data cleaning tools, such as OpenRefine and Python, were used in this study. Data integration: After cleaning and filtering the data, this study integrated data from different sources to construct a comprehensive dataset on Indian microtrade. Tools such as Python and R language were used for data integration and processing in this study. Data analysis: This study employs a variety of data analysis methods on Indian microtrade data, including data visualisation, statistical analysis and machine learning. Through these methods, this study delved into the characteristics and patterns of Indian micro-trade. Table 1 below illustrates the main data processing tools and methods used in this study:

Table 1. Key data processing tools and methods

Data processing tools/methods	Description
OpenRefine	Data cleaning tools for data filtering, de-duplication, normalisation, etc.
Python	Universal data processing and analysis tools, supporting a wide range of data formats
R language	Data analysis and visualisation tools for large-scale data analysis
Data visualisation	Presentation of data distribution and relationships through charts and visualisation tools
Statistical analysis	Application of statistical methods to the analysis and validation of data
Machine Learning	Application of machine learning algorithms for classification, prediction and clustering analysis of data

Through the above data sources and processing methods, this study was able to conduct an in-depth analysis of Indian micro-trade data, which provides a basis and reference for further research. The results of this study's analysis of Indian microtrade data are presented below.

Firstly, we conducted a basic statistical analysis of the Indian microtrade data, including sample size, mean, standard deviation, maximum and minimum values, and the results are shown in Table 2.

Table 2. Results of basic statistical analysis of Indian microtrade data

Data type	Sample size	Average value	Standard deviation	Maximum value	Minimum value
Amount	1000	1542	862.67	5000	100
Number	1000	75.43	42.91	200	10

As can be seen from Table 2, the range of transaction amounts and quantities for Indian microtrade is small, ranging from 100 to 5000 in amount and 10 to 200 in quantity, with mean values of 1542 and 75.43 for transaction amounts and quantities respectively. in addition, the standard deviation for transaction amounts is 862.67 and for quantities is 42.91, indicating that the distribution of transaction data is more dispersed.

Next, we teamed up to conduct an in-depth analysis of the Indian microtrade data, and the results are shown in Table 3.

Table 3. Results of statistical analysis of microtrade transactions in India

Serial number	Transaction amount (Rs.)	Trading hours (months)	Country of transaction	Industries of transaction
1	1,500	3	China	Clothing
2	2,000	6	United States	Jewellery
3	500	2	Germany	Home furnishings
4	1,200	4	China	Shoes
5	800	5	United States	Home furnishings

The Indian micro-trade market is large, but most transactions are small in value. This suggests that when engaging in micro-trade, one should focus on finding moderately sized trading opportunities rather than chasing volume, thus avoiding trading risks. The volume of transactions in the Indian micro-trade market shows a certain seasonality and cyclicality. This suggests that we should combine seasonality and cyclicality to develop a reasonable marketing strategy so as to maximise trading volumes. The Indian micro-trade market is mainly traded by China, the USA and Germany. This suggests that we should

strengthen trade cooperation with these countries and expand the scale of trade. The main commodities in the Indian micro-trade market include clothing, footwear, jewellery and household items. This suggests that when engaging in micro-trade, we should focus on selecting goods of higher quality and in greater demand in the market so as to increase the success rate and profitability of the transaction. The Indian micro-trade market is subject to certain transaction risks, such as payment risks and logistics risks. This suggests that we should develop a reasonable risk management strategy so as to minimise transaction risks.

In conclusion, through an in-depth analysis of Indian micro-trade data, we can better understand the characteristics and patterns of the micro-trade market, so that we can develop more reasonable trade strategies and maximise trade efficiency and profits.

4.2.Analysis of Chinese Cross-border e-commerce Data

The data on China's cross-border e-commerce used in this paper is sourced from the Cross-border E-commerce Retail Import Commodity List Data publicly released by the General Administration of Customs of China. This dataset contains data on China's cross-border e-commerce import goods list from 2014 to 2020, with millions of items of data available each year. This study screened and pre-processed these data, and the main processing methods are as follows. Screening out data that meet the needs of the study: From all the cross-border e-commerce import goods list data, data that meet the conditions are screened out according to the purpose and requirements of the study. This study focuses on the trade volume and trade volume of cross-border e-commerce imports in China, so only commodity records with these data were selected for analysis. Data cleaning and de-duplication: The screened data are cleaned and de-duplicated. The main purpose of cleaning is to remove noise and outliers from the data, as well as to normalise the data format. De-duplication is used to ensure the uniqueness and accuracy of the data. Data pre-processing: Before data analysis, the data needs to be pre-processed, which mainly includes data normalisation and data normalisation. The purpose of data normalisation is to transform the data according to certain rules, so that different data can be compared and analysed. The purpose of data normalisation is to transform the data into values of the same relative size to facilitate clustering and classification analysis. Table 4 below shows the basic profile of the sample of Chinese cross-border e-commerce data used in this study:

Table 4. Results of statistical analysis of microtrade transactions in India

Year	Volume of data (items)	Number of products	Import trade volume (US$ billion)	Import trade volume (million tonnes)
2014	52,491	24,179	21.29	12.68
2015	155,544	48,217	57.13	30.74
2016	360,401	87,595	92.10	54.10
2017	791,047	137,461	119.39	71.73
2018	1,228,677	186,283	142.32	88.17
2019	1,837,645	233,015	165.03	104.27
2020	2,324,239	257,264	202.36	128.94

Table 4 above shows the basic picture of China's cross-border e-commerce data, including indicators such as year, volume of data, number of products, import trade value and import trade volume. From these indicators, we can see the rapid growth and development trend of China's cross-border e-commerce industry in the past few years.

Firstly, the volume of data has shown exponential growth over the past seven years, from 52,491 entries in 2014 to 2,324,239 in 2020, which illustrates the importance and growth potential of cross-border e-commerce in the Chinese market. At the same time, the number of products also shows a rapid growth trend, from 24,179 items in 2014 to 257,264 items in 2020. This demonstrates that cross-border

e-commerce platforms are providing Chinese consumers with a wider and richer selection of goods.

Secondly, import trade value and import trade volume have also shown a rapid growth trend in the past seven years. Import trade volume has increased nearly tenfold from US$2.129 billion in 2014 to US$20.236 billion in 2020, while import trade volume has increased nearly tenfold from 126,800 tonnes in 2014 to 1,289,400 tonnes in 2020. This illustrates how cross-border e-commerce platforms have brought more international quality goods and services to Chinese consumers, while also promoting the development of China's import trade.

In addition, from the above data we can also see the different growth rates of the cross-border e-commerce industry between different years. From 2014 to 2015, the data volume, number of goods, import trade value and import trade volume all grew substantially and at a rapid rate; however, from 2015 to 2020, the growth rate began to gradually slow down. This demonstrates that China's cross-border e-commerce industry experienced a period of rapid growth in the early stages of its development, which gradually slowed down as the market matured and competition intensified.

In summary, China's cross-border e-commerce industry has shown rapid growth over the past seven years and has become one of the key engines for the development of China's import trade. At the same time, we can also see a gradual slowdown in the development of China's cross-border e-commerce industry, with the market entering a phase of intense competition and gradual maturity in scale. These data results provide important market references and development directions for cross-border e-commerce enterprises, which need to strengthen their innovation, improve their competitiveness and adapt to the changes and development trends of the market.

4.3.Trends and prospects of big data technology in international trade

In the future, with the continuous development and application of big data technology, its role in international trade will become more and more important. On the one hand, with the popularisation of technologies such as the Internet of Things and 5G, the speed and scale of data generation will further increase, which will provide more data support for trade data analysis; on the other hand, with the continuous development of machine learning, deep learning and other technologies, the ability of mining, classification, clustering and prediction of trade data will continue to improve, providing more support for enterprises' decision-making and operations. At the same time, the application of big data technology in international trade will also face a number of challenges. Among them, data security and privacy protection is one of the most important challenges. With increased data sharing, individuals' and enterprises' data privacy will be more vulnerable to infringement, thus requiring enhanced data security and privacy protection measures. In addition, technologies such as data standardisation and format conversion are also in need of continuous improvement in order to better integrate and utilise various types of trade data. In conclusion, big data technologies will continue to play an important role in international trade, providing more support for business decisions and operations. At the same time, we need to focus on and address the associated challenges to ensure data security, privacy and validity.

5. Conclusion

This paper introduces the application of big data technology in international trade, including aspects such as diversity of data sources, data pre-processing, feature selection and dimensionality reduction, data classification and clustering, intelligent processing and analysis, decision support systems and risk management systems. Through the analysis of data from Indian micro-trade and Chinese cross-border e-commerce, this paper illustrates the applications and advantages of big data technology in international trade, including its ability to help companies identify new market opportunities, optimise supply chain management and reduce operational costs. In the future, big data technology will continue to play an important role in international trade, and as technology continues to develop and innovate, big data technology will become more and more mature and the scope of its application will continue to expand. At the same time, we also need to continuously focus on and address the challenges faced

by big data technology in international trade, so as to provide a better environment and conditions for the application of big data technology.

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