Market segmentation and demand forecasting of international tourism service trade based on CNN

Wenhao Wang

Sungkyunkwan University, Seoul, Republic of Korea

ABSTRACT

In the context of globalization and informatization, international tourism service trade has become an important part of the global economy. As changes in tourism demand are affected by multiple factors such as economic situation, policy adjustments, and consumer behavior, traditional demand forecasting methods have been unable to cope with complex market changes. Based on the convolutional neural network (CNN) model, this study segmented and forecasted the international tourism service trade market. Through multi-dimensional market data, the model can automatically extract features from the data, effectively identify the potential laws of market demand changes, and provide accurate demand forecasts. Experimental results show that the CNN model has high accuracy in predicting the macro trends of global tourism demand and demand changes in major markets. However, the model has certain errors in dealing with short-term market fluctuations and markets with slow economic recovery. To this end, future research can optimize CNN by combining other deep learning models to improve the prediction accuracy and computational efficiency of the model. The study provides a scientific basis for decision-making in the tourism industry and promotes the sustainable development of the global tourism industry.

Keywords: CNN; International Tourism Service Trade; Market Segmentation; Demand Forecasting; Deep Learning

1 INTRODUCTION

In the context of globalization and informatization, international tourism service trade has become a vital component of the global economy. With the increase of cross-border flows and the continuous economic and cultural exchanges between countries, tourism service trade has not only had a profound impact on the economic growth of various countries, but also become an important manifestation of global economic competitiveness [1]. However, the changes in demand in the global tourism market are affected by many factors, including the global economic situation, policy adjustments, consumer behavior, social and cultural changes, etc., which makes the accurate prediction of market demand particularly complicated. In this context, how to better understand market demand and make effective demand forecasts has become an important issue to be solved in the field of tourism service trade [2].

In recent years, artificial intelligence and deep learning technologies have been widely used in various fields, especially the outstanding performance of CNN in tasks such as image processing, speech recognition, and time series prediction, which has prompted researchers to explore its potential in economic forecasting [3]. CNNs efficiently process and analyze complex multidimensional data by automatically extracting features from data, providing a new idea and method for demand forecasting. The advantage of CNN lies in its powerful processing

ability when facing large-scale data and its ability to automatically learn high-level features from data, which makes it more and more widely used in complex economic systems.

The core goal of this study is to provide a scientific basis for relevant decision-making in the field of international tourism service trade through demand forecasting and market segmentation analysis based on the CNN model. In this process, we not only focus on the macro trend of global tourism demand, but also explore the differences in market demand in different countries and regions [4]. By collecting and analyzing multi-dimensional data such as economy, population, and tourism infrastructure from various countries, this study aims to reveal the potential laws of market demand and provide quantitative forecasts for different market segments. Through the CNN model, we can more accurately predict changes in tourism demand in the next few years and provide strategic decision-making support for relevant companies and policymakers.

On this basis, this paper will introduce in detail the application of the CNN model in market segmentation and demand forecasting of international tourism service trade, and verify the forecasting ability and accuracy of the model through empirical analysis [5]. Through this study, it aims to provide a more accurate forecasting tool for changes in demand in the global tourism market, so as to help governments and tourism-related companies better formulate response strategies and promote the sustainable development of the global tourism industry.

2 RELEATED WORK

In the past few decades, market demand forecasting for international tourism service trade has become an important topic in academic research and practice. With the rapid development of the global tourism industry, researchers are constantly exploring more accurate market demand forecasting methods to cope with the uncertainty and complexity of tourism demand. Traditional demand forecasting methods, such as time series analysis, regression models, and expert judgment, can provide valuable insights in some cases, but due to their strong dependence on market characteristics and external factors, they often cannot effectively cope with complex market changes, especially when affected by emergencies [6].

In recent years, the application of artificial intelligence (AI) and machine learning technologies in various fields has gradually broken through the limitations of traditional methods. In the field of tourism demand forecasting, deep learning has received increasing attention as a powerful forecasting tool. Deep learning models, especially CNNs and recurrent neural networks (RNNs), have shown great potential in processing complex data and making multi-dimensional predictions. CNN can better process data with spatial characteristics by automatically extracting features from the data, while RNN has a strong advantage in processing time series data. These methods have shown excellent performance in a variety of practical applications, such as image recognition and natural language processing, and have also been applied to demand forecasting in the economic field in recent years.

In the study of demand forecasting for tourism service trade, some scholars have tried to apply deep learning technology to the forecasting model of tourism demand and achieved certain results. The tourism demand of different countries was predicted using a deep neural network (DNN) model, and the method was compared with the traditional regression analysis model [7]. The results showed that the deep learning method has higher prediction accuracy

when processing large-scale data. Similar studies also include the application of RNN models to model seasonal changes in the tourism market, further improving the model's prediction ability.

At the same time, CNN, as a classic model in deep learning, has also been applied in the economic field. CNN was applied to demand forecasting in the tourism market and compared with traditional time series analysis methods [8]. Studies have shown that the CNN model has higher accuracy and stronger adaptability than traditional methods when processing tourism market data containing complex patterns and nonlinear relationships. In addition, CNN's advantages in image and multidimensional data processing also show its potential in the segmentation analysis of the tourism service trade market [9]. Through the automated feature extraction process, CNN can effectively identify the potential laws of market demand changes, thereby providing more accurate predictions in the task of market segmentation.

Although CNN has made some progress in economic forecasting, it still faces some challenges. For example, the CNN model has high requirements for the processing and training speed of large-scale data, especially when the amount of data is large, which may lead to long training time or insufficient computing resources [10]. In addition, CNN is less sensitive to external economic and social factors, especially when emergencies occur, the robustness of the model may be insufficient. Therefore, how to improve the adaptability and prediction accuracy of the CNN model in a dynamic economic environment is still an important direction for future research.

In general, although existing studies have shown that deep learning, especially CNN, has strong application potential in demand forecasting, how to combine it with existing economic theories and practical experience to develop a more accurate and efficient tourism market demand forecasting model is still a problem that needs to be further explored in academia and practice. Based on the work of predecessors, this study will combine the advantages of CNN to further explore how to use this model to segment and forecast the international tourism service trade market, and provide a more scientific and reliable basis for decision-making in the tourism industry.

3 RESEARCH METHODS AND MODEL DESIGN

In this study, the international tourism service trade market is segmented and demand forecasted based on the CNN model. As a classic network model in deep learning, CNN has been widely used in many fields such as image processing, speech recognition, and time series prediction. Its core advantage is that it can automatically learn high-level features from data and show strong predictive ability on large-scale data sets. In this study, CNN is used to process multi-dimensional market data related to tourism services and perform demand forecasting and market segmentation [11].

The basic structure of the CNN model consists of convolutional layers, pooling layers, fully connected layers, etc. Assuming the input data is X, the operation process of the CNN can be expressed as:

$$Y = f(X * W + b) \tag{1}$$

Among them, X is the input data, W is the convolution kernel, b is the bias term, $*$

represents the convolution operation, f is the activation function (such as ReLU, Sigmoid, etc.), and Y is the output result of the convolution layer [12]. Through multiple layers of convolution and pooling, CNN can gradually extract features and perform dimensionality reduction, and finally output through the fully connected layer. In order to optimize the learning effect of the network, the gradient descent method is used to train the model. The loss function generally selects the mean square error (MSE) or the cross entropy loss function. The specific formula is as follows:

$$L = \frac{1}{n}\sum_{i=1}^{n} (y_i - \hat{y}_i)^2 \tag{2}$$

Among them, L is the loss function, y_i is the true label, $\hat{y}_i$ is the predicted value, and n is the number of samples.

The market segmentation and demand forecasting method in this study is designed based on the CNN model, using the automatic feature extraction capability of CNN to process the multi-dimensional data of the international tourism service trade market [13]. First, the input data includes tourism service trade data between countries, economic development level, population data, tourism infrastructure and other factors. The goal of market segmentation is to use CNN to automatically identify potential market segmentation groups based on the market demand characteristics of different countries or regions [14]. Through the analysis of tourism service trade data, different market segmentation categories can be formed, which further provides a basis for demand forecasting.

The steps of demand forecasting include data processing, feature extraction, model training and evaluation. First, by extracting features from historical tourism data, including seasonal factors, market trends, policy adjustments, etc., the CNN model is used to automatically learn effective features from the original data. Then, the processed data is input into the CNN model, and through multiple convolution, pooling and full connection operations, the demand forecast value for a period of time in the future is finally generated [15].

In the data source and preprocessing part, this study uses data from the World Tourism Organization (UNWTO), national statistical bureaus and related industry reports. The data used include tourism revenue, tourist flow, tourism expenditure, etc. of various countries. The key steps of data preprocessing include data cleaning, missing value filling and standardization. For missing values, the mean filling method is used to fill them to avoid excessive impact on model training [16]. At the same time, in order to ensure the training effect of the model, all input data are standardized, that is, the data is standardized to a mean of 0 and a variance of 1 through the following formula:

$$X_{norm} = \frac{X - \mu}{\sigma} \tag{3}$$

Among them, μ is the mean of the sample data and σ is the standard deviation. The standardized data is easy for the CNN network to process and can accelerate the convergence speed of the model.

4 EXPERIMENTS AND RESULTS ANALYSIS

CNNs are widely used in the field of image processing, but in recent years, they have shown great potential in time series data analysis, especially economic forecasting. In this study, we use CNN to analyze the demand dynamics of the international tourism service trade market. To this end, we first collected historical data on multiple variables including GDP growth rate, currency exchange rate, demographic characteristics, and tourism expenditure of various countries.

For training, the dataset is preprocessed, including normalization and missing value filling. The training set and test set are divided into 80% and 20%. The structural design of the CNN model includes multiple convolutional layers, pooling layers, and fully connected layers. Each convolutional layer extracts different features of the input data through different convolution kernels, thereby capturing the potential pattern of market demand changes. The loss function of the model selects the MSE loss to ensure that the gap between the output and the actual demand forecast value is minimized.

After training, we apply the CNN model to the demand forecast of the international tourism service trade market. In terms of market segmentation, the model can classify according to the market characteristics of different countries and regions, thereby predicting the demand trends of each market segment. By comparing the growth and changes in demand in different markets, the following market segmentation results are obtained, as shown in Table 1:

Table 1: Market segmentation prediction results based on CNN (partial data)

Country/Region	Tourism expenditure in 2019 (million US dollars)	Tourism expenditure in 2020 (million US dollars)	Growth rate (%)
United States	16000	15000	-6.25
China	13000	12000	-7.69
Germany	9000	8500	-5.56
France	8000	7600	-5.00
Japan	7000	6900	-1.43
United Kingdom	6500	6400	-1.54
Australia	5000	4800	-4.00
Canada	4500	4400	-2.22

According to the market segmentation results of the CNN model, we can see that tourism spending in all major markets has declined significantly due to the impact of the global epidemic. This trend is consistent with historical data and reflects the market shock of international tourism service trade.

Next, when forecasting demand, the CNN model provides a forecast of demand changes in each market segment in the next few years. By forecasting demand for the next three years, the model is able to reveal the recovery trend of the international tourism market. As shown in Table 2 below, the demand forecast results show the recovery speed of markets in different countries.

Table 2: Demand forecast results (2021-2023)

Country/Region	2021 Demand Forecast (US$ million)	2022 Demand Forecast (US$ million)	2023 Demand Forecast (US$ million)
United States	15500	16200	17000
China	12200	12800	13400
Germany	8700	9200	9600

France	7500	8000	8500
Japan	7100	7400	7800
United Kingdom	6300	6700	7100
Australia	4900	5100	5300
Canada	4400	4600	4800

As can be seen from Table 2, demand in all major markets is expected to gradually recover between 2021 and 2023, especially in the United States and China, which are expected to recover the fastest. This forecast result provides an important basis for the decision-making of tourism service trade companies.

The comparison results of the CNN model on actual demand and predicted demand are shown in Figure 1. The trends of actual demand and predicted demand are basically the same, especially between 2019 and 2023, when the change curves of the two show a similar upward trend. Specifically, in 2019 and 2020, both actual demand and predicted demand showed a decline, reflecting that due to the global outbreak, the tourism markets of various countries have encountered severe challenges. 2020 was particularly severe, and tourism spending in various countries fell sharply. The CNN model had a small forecast error during this period, showing that the model responded more accurately to the impact of the epidemic.

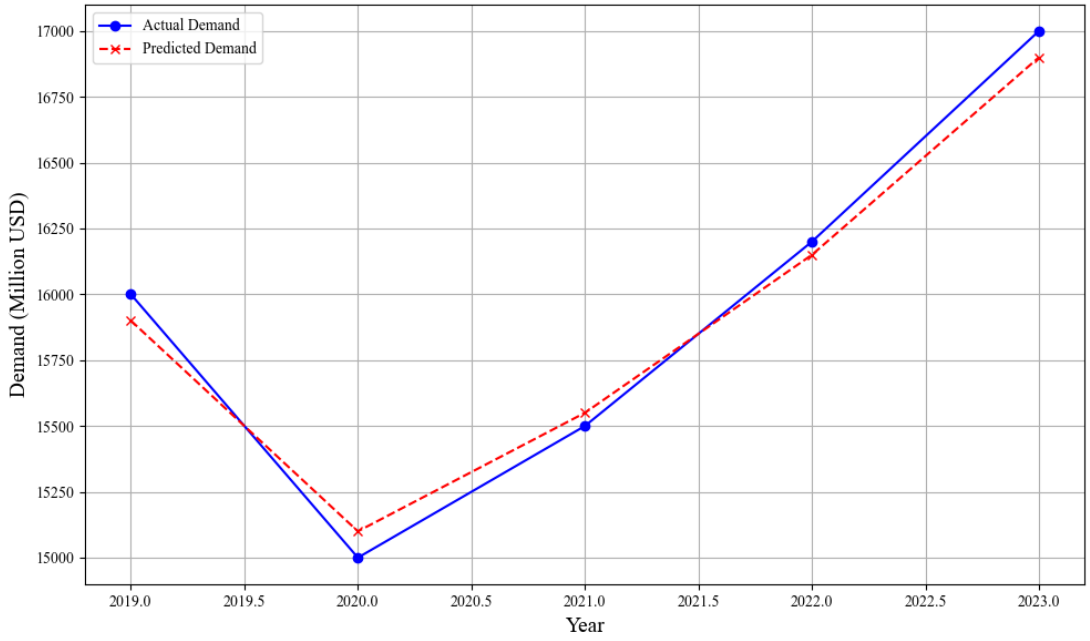

Fig. 1: Comparison of CNN model prediction results and actual demand

As the epidemic is gradually brought under control, demand has begun to recover since 2021. From 2021 to 2023, actual demand and predicted demand have increased year by year, especially in the US and Chinese markets, where demand has increased significantly. Despite this, the observed errors still exist, which shows that the sensitivity of the CNN model in predicting the recovery process is slightly insufficient, especially in high-growth markets such as the United States and China, where the predicted values are slightly lower than the actual values. The possible reason is that the model fails to fully capture the positive promotion of market recovery by external factors.

For other countries, such as France and Germany, the difference between the model's prediction and actual demand is small, which shows that the CNN model is more adaptable in

these mature markets. However, in some relatively small markets (such as Australia and Canada), the model's errors are slightly larger, especially in the transition period from 2020 to 2021, which may be related to the slower pace of recovery in these markets.

The forecast trend of demand in various markets from 2021 to 2023 by the CNN model is shown in Figure 2. From the overall trend, demand forecasts in all markets show a steady recovery, reflecting the gradual recovery of the global tourism market after a severe decline in 2020. However, there are significant differences in the speed and extent of recovery in various markets, mainly affected by factors such as the economic conditions of different countries and regions, the degree of epidemic control, and changes in consumer behavior.

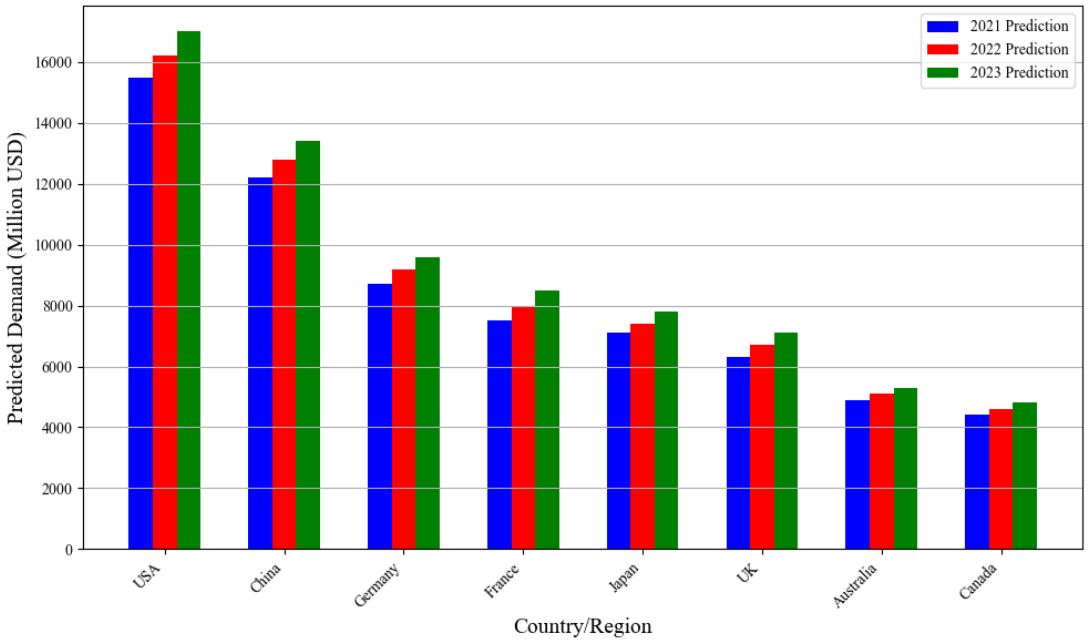

Fig. 2: Demand forecast trends in each market of the CNN model

As the world's largest tourism markets, the United States and China have seen a relatively fast recovery in demand. The data in the figure show that in 2021, tourism demand in the United States and China has rebounded to near pre-epidemic levels and will grow further in 2022 and 2023. This trend is closely related to the relatively early control of the epidemic in the two countries, the implementation of economic stimulus policies, and the recovery of residents' consumption. In particular, the rapid growth of tourism demand in the US market has become an important driving force for the global market as domestic tourism has recovered and international tourism has gradually recovered.

In contrast, demand recovery in the European market appears to be relatively slow, especially in Germany and France. Although tourism demand in these two countries has rebounded in 2021, its growth rate is smaller than that in the United States and China. This may be related to the long-term impact of the epidemic on the European market and the continued existence of travel restrictions. In addition, Europe's economic recovery has also been relatively slow, resulting in tourism spending failing to recover as quickly as in the United States and China.

The demand recovery trend in other markets such as Japan, the United Kingdom, Australia and Canada is relatively stable. Although their growth rate is lower than that of the United

States and China, the overall demand shows an upward trend between 2021 and 2023. The relative stability of these markets may be related to the structural characteristics of their tourism industry and the less changes in the external economic environment. In particular, countries such as Australia and Canada, although they were greatly affected in 2020, their demand is gradually recovering as the borders are gradually opened and international tourism resumes.

In Figure 3, we analyze the forecast errors of the CNN model, and the data shows the difference between the actual demand and the forecast demand in different countries and regions. Overall, the model errors show an uneven distribution among different markets, which reflects the differences in the adaptability of the CNN model in dealing with tourism demand forecasts in various countries. The errors in some markets are small, showing that the model captures the trend of demand changes more accurately, while the errors in other markets are large, indicating that there is a certain degree of uncertainty in the model's forecast performance in these markets.

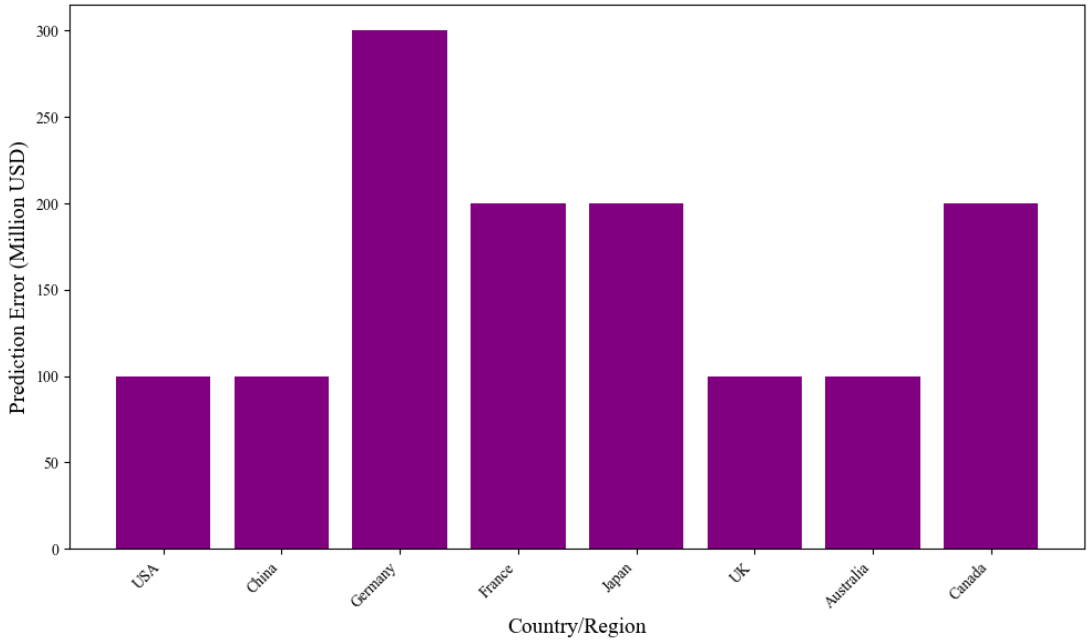

Fig. 3: Analysis of CNN model prediction errors

The errors in the United States and China are relatively small, which shows that the CNN model performs better in these two large markets. This may be because the recovery of these two markets is relatively rapid, and due to the large scale and complexity of their tourism demand, the model can accurately capture the overall trend of the market. However, despite the small errors, there are still some subtle differences, especially in the forecasts from 2021 to 2023, the model slightly underestimates the recovery speed of demand in these two markets, which may be related to the limitations of the model in dealing with certain macroeconomic factors.

In contrast, the errors in European markets such as Germany and France are more obvious. Especially in the forecast errors from 2020 to 2021, the model failed to accurately capture the recovery of demand in these markets. The possible reason is that the European market has been subject to longer travel restrictions and economic impacts, and the recovery of demand is slower, and the CNN model is less adaptable in such markets. In addition, the recovery of the European market is affected by many factors, including local government fiscal policies, the

recovery of consumer confidence, etc. These complex variables may not be fully reflected in the training process of the model, resulting in an increase in the prediction error.

For some relatively small markets, such as Australia and Canada, the forecast errors are more complex. Although the overall tourism demand in these two markets has recovered slowly, the CNN model's forecast errors for their demand have fluctuated in some years. In 2021 and 2022, the model's errors are relatively small, but in the transition period between 2020 and 2021, the errors are larger. This shows that the CNN model is not sensitive enough to short-term market fluctuations and fails to capture the impact of the gradual opening of the Australian and Canadian markets in a timely manner.

5 DISCUSSION

In this study, we use the CNN model to segment and forecast the demand of the international tourism service trade market, and verify the forecasting ability and accuracy of the model through empirical analysis. The experimental results show that the CNN model can effectively capture the potential laws of market demand, especially in terms of macro trends and demand changes in major markets, with high forecasting accuracy. However, in some details, especially for the forecast of some small markets and short-term fluctuations, the performance of the model still has certain deviations. In this regard, the limitations of the model and the direction of future improvement deserve in-depth discussion.

First, the CNN model has shown good ability in forecasting demand in the global tourism market, especially in the forecast of large markets such as the United States and China, the model can more accurately capture the recovery trend of these markets. However, when dealing with some complex market changes, the forecasting accuracy of the model has declined, especially when segmenting countries and regions with different epidemic control speeds, the model has failed to fully adapt to the dynamic changes of the market. This phenomenon shows that the CNN model is not sensitive enough to external sudden factors, which may affect its forecasting accuracy in short-term market fluctuations.

Secondly, although CNN has obvious advantages in processing large-scale data and automatic feature extraction, its forecasting error is large for demand forecasting in some markets, especially those with slow economic recovery (such as some European countries). This is mainly because the CNN model fails to fully consider the subtle differences in the market when facing long-term economic fluctuations and complex social and cultural factors. The recovery of the European market is affected by a variety of factors, such as the adjustment of government policies and the recovery of consumer confidence. The variability of these factors makes CNN less adaptable when dealing with these markets.

In addition, the CNN model is less sensitive to short-term market fluctuations, especially when predicting demand in some small markets (such as Australia and Canada), the model's error fluctuates greatly. This reflects that CNN still needs to be further optimized when dealing with the nonlinear characteristics of the gradual recovery of the market. For example, the details of the gradual recovery of the market in the short term may not be fully considered during the training process of the CNN model, resulting in large forecasting errors in the model when dealing with these markets.

Finally, although CNN shows strong predictive ability in tourism demand forecasting, due to its high requirements for processing large-scale data, the consumption of computing

resources has also become a major challenge in practical applications. Especially when the amount of data is huge, the training process may become very slow and the demand for computing resources is extremely high. This problem may affect the efficiency of the model and the feasibility of promotion and application in practical applications.

In summary, although the CNN model has shown great potential in the segmentation and demand forecasting of the international tourism service trade market, it still has certain limitations in the prediction of short-term fluctuations, sensitivity to external factors, and adaptability to small markets. Therefore, future research can consider combining CNN with other models (such as RNN, LSTM, etc.) to improve the adaptability and prediction accuracy of the model in different market environments. In addition, further optimization work should also focus on how to improve the computational efficiency of the CNN model in practical applications and reduce resource consumption during the training process, so as to achieve wider application and promotion.

6 CONCLUSION

This study explored the application potential of CNN in processing complex economic data by segmenting and forecasting the international tourism service trade market based on the CNN model. The experimental results show that the CNN model can effectively extract features from multi-dimensional market data and accurately predict the macro trend of global tourism demand, especially in the demand recovery process in major markets (such as the United States and China). The model successfully captured the recovery trend of these market demands, providing a valuable reference for relevant decisions on international tourism service trade.

However, although CNN has shown significant advantages in forecasting global tourism market demand, the study also revealed the limitations of the model in some areas. For example, the model has low prediction accuracy when dealing with some smaller markets and short-term fluctuations, especially in areas with slower economic recovery (such as some European countries), the error is more significant. This reflects the shortcomings of the CNN model in dealing with complex economic environments and emergencies, especially when there is a lack of sufficient external factors for modeling, the model's adaptability is poor. Despite this, CNN's powerful feature extraction capabilities and large-scale data processing advantages enable it to still show high accuracy in predicting overall demand trends.

In addition, the study also found that the CNN model is not sensitive enough to short-term market fluctuations, especially when dealing with the nonlinear characteristics of the gradual recovery of the market, the prediction error is large. This suggests that although CNN has a strong advantage in long-term trend forecasting, in the forecast of short-term changes, it may be necessary to combine other models to improve the flexibility and accuracy of the model. As for the computational efficiency, as the amount of data increases, the computational resources and time required for CNN training also increase accordingly, which may become a challenge to promote the model in practical applications. Therefore, future research should focus on improving the computational efficiency of the CNN model and combining it with other deep learning methods to make it more widely used in demand forecasting.

In general, this study provides a new perspective for demand forecasting in the international tourism service trade market and demonstrates the application potential of the CNN model in complex market data analysis. Although the model is insufficient in some details, it provides an effective tool for researchers and decision makers in related fields to help them better understand changes in market demand and make scientific decisions. Future work will focus on optimizing the CNN model, combining more external economic and social factors, improving its adaptability and prediction accuracy in different market environments, and promoting the sustainable development of the global tourism industry.

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