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High Quality Development Strategy of Tourism Industry Supply Chain Driven by the "Dual Carbon" Goal—A Case Study of Guangdong Province

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Abstract: *This study explores high-quality development strategies for the tourism industry supply chain in Guangdong Province, driven by the "dual carbon" goal. Through literature review and field research, the key issues facing the current tourism supply chain in green development have been identified. Using supply chain management theory and sustainable development theory, countermeasures and suggestions based on collaborative innovation, green technology application, and supply chain collaborative governance have been proposed. Through the evaluation experiment of carbon emission reduction effect, it was found that the experimental group introducing green technology reduced carbon emissions from 100 tons to 75 tons within 6 months. The experimental results of improving resource utilization efficiency showed that the experimental group reduced water consumption by 10 cubic meters within 3 months. In addition, the experiment on improving supply chain collaboration efficiency showed that the order completion time of the experimental group was shortened from 15 days to 10 days, and the inventory turnover rate was increased from 2.5 times to 3.5 times, while the change in the control group was not significant. These experimental results indicate that green technology and collaborative management platforms significantly improve the carbon efficiency, resource utilization efficiency, and overall operational efficiency of the tourism industry supply chain.*

Keywords: *Green Supply Chain Management, Tourism Industry, The 'Dual Carbon' Goal, Carbon Emissions Reduction, Tourism Industry Supply Chain*

1. Introduction

With the increasing global attention to climate change, China has proposed the "dual carbon" goal, providing new directions for the green and low-carbon transformation of various industries. As an important economic pillar of Guangdong Province, the tourism industry faces enormous challenges in achieving carbon reduction and efficient resource utilization in its supply chain. The significance of this study is to explore the application of green technology and supply chain management optimization measures in the tourism industry, aiming to improve the overall efficiency of the supply chain and promote the sustainable development of the industry.

This article systematically evaluates the impact of green technology and supply chain management on carbon emissions, resource utilization efficiency, and supply chain synergy efficiency through three experiments. The research results indicate that the introduction of green technologies and collaborative management platforms can significantly improve various efficiency indicators of the supply chain, providing theoretical support and empirical evidence for the tourism industry to achieve high-quality development under the "dual carbon" goal.

The organizational structure of the article is as follows: Firstly, the background and importance of the research are introduced. Subsequently, the design, data collection, and analysis methods of the three experiments are described in detail. Finally, the significance of the experimental results is discussed, and relevant suggestions are proposed to provide guidance for the green transformation of Guangdong's tourism industry.

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2. Related Works

In recent years, there has been an increasing number of studies on supply chain and green development in the tourism industry. For example, Amjad A et al. studied the competitiveness and return on investment of companies in green supply chain management practices. They explored how organizational behavior is influenced by external resources based on resource dependence theory [1]. Globally, green consumer behavior is fundamentally changing the life cycle and branding of green products to mitigate the environmental impacts of tourism. Khan M I et al.'s study aimed to explore the willingness to consume green in the hospitality and tourism industry as an outcome of green supply chain management and strategic green marketing [2]. Galeazzo A et al. examined how green shopping affects businesses' bottom lines and how visitors' green buying habits play a part in. Previous studies have paid little attention to green purchasing behavior of tourists as a key factor influencing the effectiveness of environmental practices [3]. Karim R A et al. investigated how green supply chain management practices affect customer behavioral intentions and the mediating role of customer satisfaction in the hospitality industry (involving five and four star hotels) in Bangladesh. Through convenience sampling, they collected opinions from 404 customers [4]. In order to better understand the relationship between green motivation and sustainability, Yousaf Z et al. conducted a research in which they sought to determine the direct effects of green business strategies and green motivation on sustainability in the hospitality sector [5]. Long Q et al. established an evolutionary game model consisting of green sensitive governments, businesses, and consumers, taking into account policy factors, and solved the evolutionary stability strategy of the model [6]. In order to better understand how cultural tourism may operate better in northeastern Thailand, Kerdpitak C looked into creative management strategies such supply chain management, digital marketing, cooperative networks, and high-quality service. He concluded that performance improvement in cultural tourism relies on the effective implementation of these innovative management strategies [7]. The sustainable development of enterprises largely depends on sustained performance and environmental sustainability. Rupa R A's research found that green supply chain management practices have a significant impact on business performance and environmental sustainability in developing countries such as Bangladesh [8]. However, most of these studies remain at the level of theoretical discussion and lack specific practical strategy guidance. Meanwhile, the existing studies generally lack in-depth analysis of specific regional or industry characteristics, making it difficult to provide precise countermeasure suggestions for the green development of regional tourism industry. Therefore, there are still limitations in the research on the high-quality development of the tourism industry supply chain under the goal of "dual-carbon".

To address the shortcomings in the above studies, several academics have started attempting to investigate the tourist supply chain's green growth route using quantitative research and case study techniques. For example, Shafiee S et al. designed a system dynamics model to simulate the development of smart tourism destinations using intelligent technology. The results of the study provided policy makers with decision support for developing strategies to reduce carbon emissions by predicting the behavior of different subsystem variables [9]. Ma S et al. found that tourists' low-carbon preference enhanced the decarbonization level of tourism products, but the fierce competition among LSS (Low-Carbon Service System) led to a decrease in the decarbonization level instead [10]. However, these methods still have the problems of high model complexity and difficult operation in practical application, and fail to completely solve the challenges in practice. Therefore, this paper intends to adopt countermeasure suggestions based on collaborative innovation, green technology application, and collaborative supply chain governance, with a view to better solving the above problems and promoting the high-quality green development of the tourism industry supply chain.

3. Methods

3.1. Constructing a Carbon Emission Accounting Model for the Tourism Supply Chain

3.1.1. Background and Purpose of Modeling

Driven by the “dual-carbon” goal, carbon emission control in the tourism industry has become a key link in realizing sustainable development. However, the lack of a systematic carbon accounting mechanism in the traditional tourism supply chain management model makes it impossible to effectively monitor and reduce the carbon footprint. In order to deal with this problem, this paper constructs a carbon emission accounting model for tourism supply chain to provide a scientific tool for tourism enterprises and supply chain managers in Guangdong Province to accurately assess and reduce

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carbon emissions in each link [11].

3.1.2. Cross Device Collaboration

The construction of the carbon emission accounting model is divided into the following steps:

The tourism supply chain involves a number of links, including transportation, accommodation, catering, scenic spot operation, and so on. In order to accurately calculate the carbon emissions of each link, it is first necessary to collect detailed data on these links. This mainly includes energy consumption, the use of transportation, passenger flow, and the operating hours of various types of equipment.

This paper makes reference to internationally recognized greenhouse gas accounting standards, such as the *Guidelines for Accounting and Reporting Greenhouse Gas Emissions* (GHG Protocol), and combines them with China's industry standards to develop carbon emission factors applicable to the tourism industry in Guangdong Province. Where the carbon emission factor for each energy type or activity is calculated by the following equation (1):

$$\mathrm{E_{activity}} = \mathrm{A} \times \mathrm{EF} \tag{1}$$

Where in equation (1), $E_{activity}$ denotes the carbon emissions of an activity, A denotes the activity data (e.g., energy consumption) for that activity, and EF denotes the emission factor for that activity.

3.1.3. Data processing and Accounting

In the process of data processing, this paper adopts the method of itemized accounting, i.e., the tourism supply chain is divided into four main links: transportation, accommodation, catering and scenic spot operation, and the carbon emissions of each link are calculated separately. After synthesizing the carbon emissions of all links, the total carbon emissions of the supply chain can be obtained, as shown in equation (2):

$$\mathrm{E_{total}} = \sum_{\mathrm{j=1}}^{\mathrm{m}} \mathrm{E_j} \tag{2}$$

Where in equation (2), E_j denotes the carbon emissions of the j link, and m denotes the total number of links in the supply chain. For this purpose, we constructed the following data table (Table 1):

Table 1: Calculation of carbon emissions from the tourism supply chain

Segment	Activity Data Type	Activity Data Amount	Emission Factor (kg CO_2e/unit)	Carbon Emissions (tons CO_2e)
Transport	Car Fuel Consumption	50,000 L	2.31	115.5
	Aircraft Fuel Consumption	10,000 L	3.15	31.5
Accommodation	Electricity Consumption	100,000 kWh	0.6	60
	Gas Consumption	20,000 m³	2.34	46.8
Catering	Gas Consumption	15,000 m³	2.34	35.1
Scenic Area Operation	Electricity Consumption	50,000 kWh	0.6	30

Based on the above accounting model, tourism enterprises can regularly assess the carbon emissions of each segment, identify the main sources of carbon emissions, and formulate corresponding emission reduction measures.

3.2. Introduction of Green Supply Chain Management Mechanisms

3.2.1. The Need to Introduce Research Mechanisms

In the context of the “dual carbon” goal, the traditional supply chain management model can no longer meet the sustainable development needs of the tourism industry. Guangdong Province, as an important tourism province in China, is facing tremendous pressure on environmental protection. Currently, the problems of high energy consumption, resource waste, and carbon emissions in the tourism supply chain are particularly prominent. Therefore, the introduction of green supply chain management mechanism is not only a necessary action to respond to the national policy, but also a key

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to enhance the competitiveness and brand image of tourism enterprises [12].

By implementing eco-friendly technologies and management practices at every stage of the supply chain, green supply chain management maximizes resource utilization efficiency and minimizes environmental impact, ultimately creating a win-win scenario for both the environment and the economy. In order to support the tourist industry's high-quality growth, this study addresses how to particularly implement and improve the green supply chain management mechanism in Guangdong Province's tourism sector.

3.2.2. Implementation Steps for a Green Supply Chain Management Mechanism

Green procurement initiates green supply chain management by choosing suppliers with low carbon footprints and environmentally sustainable practices. Enterprises should create green procurement standards and a supplier evaluation system to ensure suppliers adhere to environmental qualifications in energy usage and waste management.

Efficient resource use and waste disposal are central to green supply chain management. Implementing water and energy conservation technologies, waste sorting and recycling, and energy management systems helps enterprises reduce resource consumption and waste generation significantly.

In order to quantify the effect of resource conservation and waste management, this paper provides a comparative analysis of resource utilization before and after the introduction of green management mechanisms (Table 2).

Table 2: Resource consumption and waste reduction after implementation of green management

Management Segment	Resource Consumption/Waste (Before Implementation)	Resource Consumption/Waste (After Implementation)	Reduction (%)
Water Consumption	500,000 L	450,000 L	0.1
Energy Consumption	200,000 kWh	170,000 kWh	0.15
Solid Waste Disposal	10,000 kg	7,500 kg	0.25
Wastewater Discharge	300,000 L	270,000 L	0.1

In the tourism industry, transportation is one of the main sources of carbon emissions. By optimizing transportation routes, adopting low-carbon transportation means, and implementing joint distribution and other measures, energy consumption and carbon emissions in the transportation process can be effectively reduced. Optimization of the logistics link is equally critical. It is recommended that inventory and logistics be monitored in real time through an information-based management platform to reduce unnecessary transportation and storage links.

3.2.3. Effectiveness and Challenges of Implementing Green Supply Chain Management

Through the implementation of green supply chain management, some tourism enterprises in Guangdong Province have achieved significant improvements in terms of operating costs, brand value and market competitiveness. However, there are some challenges, such as the high initial investment in green technology and the difficulty of synergizing various links in the supply chain. These problems need to be gradually solved in practice through policy support, technological innovation and close cooperation among supply chain parties. Among them, the economic benefits of green technology (B) can be calculated by the following equation (3):

$$B = C_{before} - C_{after} - I \tag{3}$$

Where in equation (3), C_{before} and C_{after} denote the total operating costs before and after the implementation of green technology and Idenote the initial investment cost of green technology, respectively. If $B > 0$, then the green technology is economically favorable.

3.3. Optimizing Supply Chain Collaboration Mechanisms

3.3.1. The Need to Optimize Supply Chain Collaboration Mechanisms

In the tourism industry, supply chain management involves a number of complex links, including

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the design of tourism products, supplier management, service delivery and customer experience. The traditional supply chain management model often suffers from information silos, slow response time, and inefficient resource utilization, making it difficult for all parts of the supply chain to operate in an efficient and coordinated manner. In the context of the "dual-carbon" goal, these problems further magnify the risk of carbon emissions and resource waste. Therefore, optimizing the supply chain coordination mechanism and improving the collaboration efficiency of each link in the supply chain are the keys to achieving green supply chain management and high-quality development [13].

3.3.2. Core Elements of Supply Chain Synergy Mechanisms

Optimizing the supply chain collaboration mechanism requires systematic improvement around the following core elements:

Information sharing is the foundation of supply chain collaboration. Tourism enterprises should build a comprehensive information sharing platform covering the upstream and downstream of the supply chain, integrating functions such as inventory management, order processing, logistics scheduling and customer feedback. Through real-time data exchange, links can respond more quickly to changes in market demand, thereby reducing delay and waste.

Each node enterprise in the supply chain, especially suppliers, manufacturers and retailers, should work together to develop supply chain operation strategies through the mechanism of collaborative planning and joint decision-making. Through this collaborative mechanism, all parties can reach a consensus on procurement, production, inventory and logistics to optimize resource allocation and reduce operating costs.

In the tourism market, demand fluctuations and market changes are the norm. The optimization of the supply chain synergy mechanism needs to introduce the ability of dynamic response and flexible adjustment to cope with various uncertainties. By building a flexible supply chain, enterprises are able to quickly adjust production plans, logistics arrangements and inventory management according to real-time market information, reducing overproduction and resource waste in the supply chain.

3.3.3. Practical Cases of Optimizing Supply Chain Collaboration Mechanisms

Taking a large tourism enterprise in Guangdong Province as an example, the enterprise realized a high degree of collaboration among suppliers, manufacturers and retailers by introducing a supply chain collaboration management platform. After the platform went live, the enterprise's supply chain response speed during the peak tourism season increased by 30%, inventory turnover increased by 40%, and, at the same time, supply chain carbon emissions due to insufficient collaboration were reduced by 20%. These findings demonstrate that enhancing supply chain cooperation mechanisms significantly raises the network's overall sustainability and efficiency [14].

4. Results and Discussion

4.1. Carbon Emission Reduction Effectiveness Assessment Experiment

The purpose of the Carbon Emission Reduction Effectiveness Assessment Experiment is to evaluate how green technology affects carbon emissions in the travel and tourist sector. The experiment compares the changes in carbon emissions between the experimental group and the control group over a six-month period. The experimental group introduced green technologies and management mechanisms, while the control group maintained traditional supply chain management. The carbon emission data of the two groups were recorded every month, and the specific data can be seen in Figure 1.

In Figure 1, the carbon emissions of the experimental group decreased from 100 tons in the first month to 75 tons in the sixth month month month by month, while the carbon emissions of the control group only decreased slightly from 100 tons to 98 tons in the same time. This difference shows that the experimental group reduced carbon emissions by a total of 25 tons in 6 months, which is a more significant reduction compared to the control group, verifying that green technology has a significant emission reduction effect in the tourism industry.

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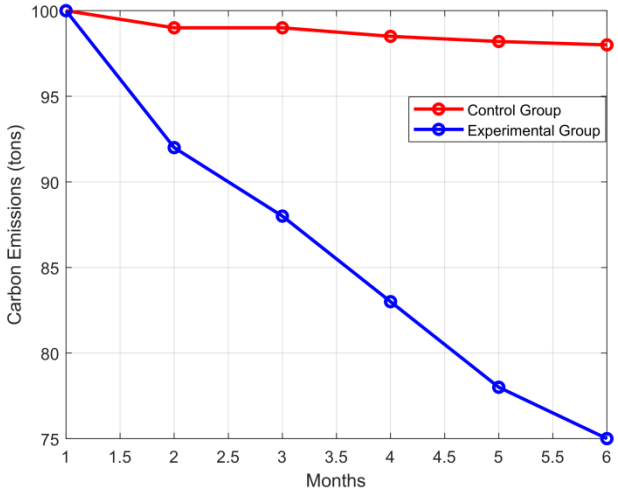

Figure 1: Assessment of Carbon Emission Reduction Effectiveness

4.2. Resource Efficiency Improvement Experiment

This experiment aims to assess the effect of green technology on the improvement of resource utilization efficiency in the supply chain of tourism industry. The experimental group optimized the management of water and energy consumption through the introduction of energy-saving equipment and intelligent management systems, while the control group maintained the traditional way of resource use. The 3-month experiment recorded the resource consumption data of the two groups under the same conditions, aiming to compare the actual impact of green technology on resource utilization efficiency. The specific data situation can be seen in Figure 2:

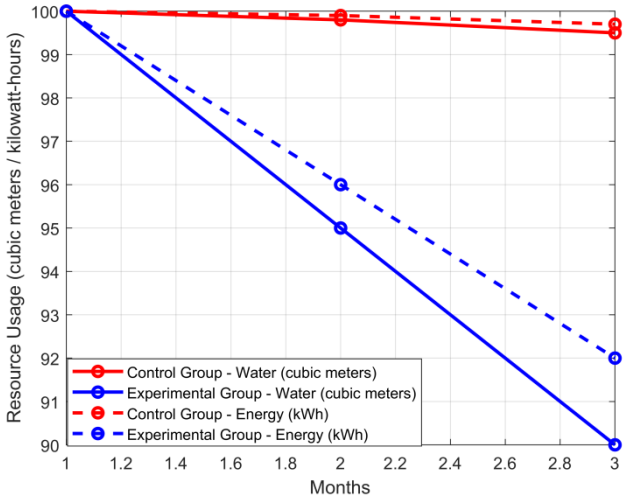

Figure 2: Assessment of resource efficiency gains

In Figure 2, the average water consumption of the experimental group decreased by 10 m^3 from 100 m^3 to 90 m^3 per month. In addition, the energy consumption of the experimental group decreased by 8 kWh from 100 kWh to 92 kWh per month. In contrast, the control group's water consumption decreased only slightly to 99.5 m^3 and energy consumption decreased slightly to 99.7 kWh, which is a very small change. This demonstrates that green technologies significantly optimize resource efficiency in the short term.

4.3. Supply Chain Collaboration Efficiency Improvement Experiment

The purpose of this experiment is to evaluate how a collaborative supply chain management platform affects supply chain effectiveness in the travel and tourist sector. The experimental group achieves real-time information sharing and optimal resource allocation in the upstream and downstream

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of the supply chain through the introduction of a collaborative management platform, while the control group continues to use traditional management methods. The experiment lasted for 3 months, and the order fulfillment time and inventory turnover data of the two groups were recorded to compare the effect of the collaborative platform in enhancing the overall operational efficiency of the supply chain. The specific data situation can be seen in Figure 3:

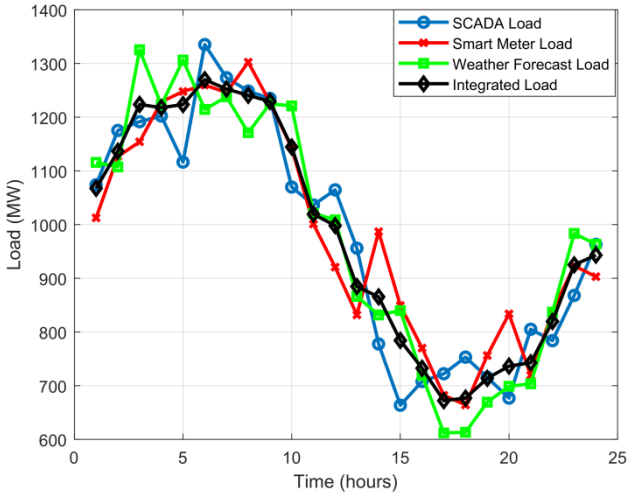

Figure 3: Supply Chain Collaboration Efficiency Improvement Assessment

In Figure 3, the order fulfillment time for the experimental group was reduced by 33% from 15 days to 10 days. At the same time, inventory turnover increased from 2.5 to 3.5 times, a 40% increase. In contrast, the control group's order fulfillment time was only slightly reduced from 15 days to 14.7 days during the same period, and the inventory turnover rate was basically maintained at around 2.6 times. This indicates that the collaborative supply chain management platform significantly improved the operational efficiency of the supply chain.

5. Conclusion

In this study, based on three experiments of carbon emission reduction, resource utilization efficiency improvement, and supply chain collaborative management, the significant effects of green technology and supply chain management optimization measures on the high-quality development of supply chain of tourism industry in Guangdong Province are verified. The experimental results show that the introduction of green technology significantly reduces carbon emissions and enhances resource utilization efficiency, while the supply chain collaborative management platform significantly improves the operational efficiency of the supply chain. However, there are still some shortcomings in the experimental design of this paper, such as the relatively short experimental period, which has not yet covered the changes of the off-peak season of tourism, and the insufficient depth of research on the synergistic effect among different industries. Future research can further explore the applicability of supply chain optimization in different regions and industries by extending the experimental period, expanding the scope of the study, and incorporating more actual cases, so as to promote broader green transformation and high-quality development.

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