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Research on Financing Strategies, Model Construction and Numerical Analysis for Dual-Channel Tourism Supply Chain in the Low Carbon Context

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Abstract:
In the context of a low-carbon economy, advocating and promoting low-carbon tourism has become an inevitable trend in the development of the tourism industry. Travel agencies, as the essential link between tourists and other tourism sectors, play a pivotal role in advancing low-carbon tourism through effective publicity, organization, and communication. However, the efforts of travel agencies to adopt low-carbon practices also impose significant financial pressures. This paper focuses on numerical analysis to construct a dual-channel tourism supply chain, emphasizing the low-carbon efforts of travel agencies. It explores optimal pricing and decision-making processes related to low-carbon efforts for travel agencies facing financial constraints under two financing models: deferred payment and bank lending. The core of this study lies in its detailed numerical analysis, which compares and analyzes these two financing decisions, examining the impact of the low-carbon effort cost coefficient on the level of low-carbon efforts and the required financing amount. Additionally, it investigates the influence of low-carbon effort costs on the capital demands of travel agencies, as well as the effects of financing interest rates and available funds on optimal decisions and profitability. The research findings, derived from rigorous numerical analysis, indicate that when travel agencies with low-carbon initiatives face financial constraints, their profits are consistently higher under the deferred payment financing model compared to the bank loan model. Consequently, travel agencies are likely to prioritize deferred payment financing when feasible. This study not only considers the low-carbon behavior of travel agencies but also delves into the issue of financial constraints, offering valuable insights for the sustainable development of the tourism supply chain. The research includes detailed numerical examples to validate its conclusions and suggests several management implications.

Keywords: low-carbon, dual-channel, tourism supply chain, delayed payment, bank lending, numerical analysis, model construction

INTRODUCTION

In response to the significant threat posed by global climate change to human society, China announced its vision for peaking carbon emissions and achieving carbon neutrality in 2020. The formulation of these goals has had a profound impact on promoting high-quality economic and social development. It also plays a crucial role in actively responding to global climate change and advancing the sustainable development of the tourism industry. For a long time, the tourism industry has been regarded as a resource-saving and environmentally-friendly industry, characterized by low energy consumption, low pollution, and low emissions [1]. However, as an emerging industry driving economic development worldwide, the rapidly growing tourism sector has also brought about issues such as significant greenhouse gas emissions and energy consumption [2]. Low-carbon tourism, as an effective approach to addressing the conflict between tourism development and environmental protection, has garnered widespread attention. Despite being referred to as a "green industry," the tourism sector, with travel agencies as its leading industry, directly influences the overall carbon emissions of the entire tourism industry [3]. The promotion and development of low-carbon tourism require both government guidance and support, as well as low-carbon practices from tourism attractions and marketing promotion from travel agencies [4].

With the promotion of the low-carbon and environmental protection concept, consumers have an increasing willingness to purchase low-carbon products. More and more companies realize the necessity of controlling carbon emissions and producing low-carbon products [5]. Travel agencies expect to alleviate the pressure on their traditional sales channels from the online direct sales model of travel suppliers by adopting low-carbon measures. For travel agencies, establishing a low-carbon business concept, developing low-carbon tourism products, utilizing low-carbon technologies and engaging in low-carbon marketing are important ways to build a low-carbon business model [6]. These efforts not only attract more tourists but also create increased demand for financial resources. Therefore, the operational capital costs for travel agencies would also increase. If there is insufficient funding or unreasonable cost allocation during this period, it would have adverse effects on tourism enterprises, impacting the profitability and stability of members in the tourism supply chain and their partners.

Currently, domestic and foreign scholars have conducted in-depth research on the definition, structure, construction, and coordination of tourism supply chains. Wu and Tang [7] have defined the tourism supply chain from the perspective of meeting the needs of tourists. It includes tourism suppliers such as food, accommodation, transportation, sightseeing, shopping, entertainment, as well as travel agencies, retailers, and ultimately forms a network structure for tourists. Xu et al. [8] believe that the tourism supply chain is a supply chain structure centered around tourism products, involving the transfer of tourism products from tourism suppliers to travel agents and then to tourists. Zhang et al. [9] studied the interest game relationship between travel agencies and accommodation suppliers in order to enhance the overall efficiency of the tourism supply chain. Dong et al. [10] analyzed the profit distribution relationship between tourist attractions and tourism operators from the perspective of price discounts and contractual relationships. Zhang and Fang [11] constructed a revenue-sharing contract model for tourism enterprises to achieve optimal overall performance of tourism supply chain members. Liang [12] considered the power differences among supply chain members and constructed a competitive dual-layer tourism supply chain model. They discussed the equilibrium solution of competition under the mixed scenario where one member of the supply chain engages in Stackelberg game and the other member engages in Nash game.

Scholars have conducted extensive research on the development models and strategies [13, 14], efficiency and influencing factors [15], such as Chen et al. [16] studied the online tourism has received increasing attention from scholars and practitioners due to its growing contribution to the economy. And a data-driven approach was developed to provide accurate purchase prediction models for online tourism and analyze the influence of behavioral variables as predictors of online tourism purchases. Based on real-world multiplex behavioral data, the proposed method can accurately predict online tourism purchases through machine learning algorithms. Some scholars have also explored the role mechanism of low-carbon tourism behavior and the perspectives of participating entities, conducted research on this issue using classical game theory, and carried out numerical simulations. Zhang & Zhao [17] built a multi-channel tourism supply chain system consisting of a low-carbon scenic spot and two travel agencies, and studied the equilibrium strategies under three different decisions in the competition between travel agencies in terms of low-carbon promotion and the investment of low-carbon services by the scenic spot. Li & Lian [18], Zhang et al. [19], and Shi et al. [20] developed differential game models of low-carbon tourism supply chains under corporate social responsibility behavior. Ma et al. [21]. consider a low-carbon tourism supply chain (LTSC) network composed of two low-carbon scenic spots (LSSs) and two travel agencies (TAs). The LSSs as leaders and the TAs as followers play Stackelberg games in the vertical direction.

With the rapid development of China's tourism industry, the issue of financial constraints on tourism enterprises is an urgent problem that needs to be addressed. Financing constraints are also an important factor restricting product upgrades, service upgrades, and structural optimization for tourism enterprises. Currently, many tourism enterprises are facing multiple constraints, including weak financing capabilities, single financing methods, limited external financing channels, and high financing costs [22]. Gui [23] pointed out that there are problems such as single financing channels and outdated financing models in the tourism industry. The external financing methods of tourism companies, such as bank loans and bond issuance, are not conducive to the long-term development of the company. When using internal financing methods such as retained earnings, if the profits are not sufficient for capital accumulation, it will result in insufficient internal financing. Xia and Qi [24] found through the analysis of financing channels and methods of tourism enterprises that both indirect financing and direct financing are difficult to meet the huge capital demand of the tourism industry. Dong [25] pointed out that the traditional financing methods in the tourism industry include self-owned funds, government investment in infrastructure, foreign investment, bank financing, bond issuance, or listing financing. However, these traditional financing methods cannot meet the financing needs of the tourism industry.

It can be seen that funding is an invisible barrier in the development process of tourism enterprises and has become a major difficulty in restraining the upgrading and optimization of the tourism industry chain. Under market economy conditions, tourism enterprises are sensitive to cash flow. The survival ability of the tourism industry largely depends on the flow of cash. If the cash turnover is not smooth, even with considerable profit-making ability, it is difficult to achieve normal business operations for enterprises. As a result, many industries associated with travel enterprises also face significant financial pressures [26]. The dual-channel sales model allows companies to understand more market demands, but it also leads to competition between channels while increasing market share [27]. In the highly competitive dual-channel tourism supply chain, facing the same customers in the market, tourism suppliers and travel agencies have both cooperative and competitive relationships when providing travel products. The financing situation of the channels becomes even more complex. The shortage of supply chain funding has been a prominent issue, and scholars have mainly focused on the manufacturing industry as their research subject, conducting extensive studies on supply chain financing models and financing strategies. Chen [28] analyzed the impact of trade credit and bank loans on the overall profitability of the supply chain, and discussed the coordinating role of profit sharing and delayed

payments in the supply chain. Lin, Su, & Peng [29] studied the warehouse receipt financing coordination supply chain model under three kinds of buyback modes of suppliers when the demand is uncertain and affected by the sales efforts of retailers. Ding & Song [30] studied the situation where retailers are financially constrained and support sales effort business activities through two financing sources of bank loans and trade credits. The research shows that both the equilibrium sales effort and retail price of retailers are related to the market realization value and the cash level of retailers, and both financing sources can stimulate retailers to promote sales. Tang et al. [31] studied the optimization problem of credit terms in dual-channel supply chain environments. Xu et al. [32] discussed the interaction between credit financing and channel encroachment in the dual-channel supply chain structure, including suppliers and retailers. Wang et al. [33] analyzed the influencing factors of credit sales and green technology innovation decisions through numerical simulation.

In the numerical analysis of this paper, various parameters were carefully selected and manipulated to simulate real-world scenarios. For instance, different levels of consumer low-carbon preferences were assigned to observe their impact on the travel agency's decision-making and financial outcomes. The magnitudes of low-carbon efforts by the travel agency were quantified and varied to analyze the corresponding changes in costs and profits. Additionally, different interest rates for bank financing and credit financing were set to examine their effects on the overall financial performance and choice of financing methods.

Specifically, by running multiple simulations with varying combinations of these parameters, it was found that even a small increase in consumer low-carbon preferences could significantly influence the travel agency's willingness to invest in low-carbon efforts and the resulting financial benefits. Similarly, a moderate adjustment in the level of low-carbon efforts led to substantial variations in cost structures and profit margins. The analysis of different financing interest rates revealed that a relatively lower interest rate for either bank financing or credit financing could make one financing option more attractive than the other, depending on the specific circumstances of the travel agency.

Overall, the numerical analysis provided detailed and quantitative insights that not only validated the theoretical models constructed in the paper but also offered practical and actionable recommendations for travel agencies to make informed decisions regarding low-carbon financing and transformation.

METHODS

Double-Channel Tourism Supply Chain Financing Issues and Parameter Specifications

Constructing a two-channel tourism supply chain consisting of a single tourism supplier and a single travel agency, namely: tourism suppliers use self-operated network platform (direct channel$n$) and travel agency distribution channel (distribution channel t) to sell tourism products to consumers and provide corresponding tourism services. The price at which a tourism supplier sells travel products to travel agencies in bulk is w, the price at which they sell travel products directly to travel agencies is p_n, and the price at which travel agencies sell through distribution channels is p_t. In order to ensure that tourism suppliers and travel agencies have a certain profit margin, assuming$p_i(i = n, t) > w$. When travel agencies influence consumer purchasing demand by adopting certain low-carbon measures, such as low-carbon promotion and low-carbon tourism route planning, it may stimulate consumers' purchase behavior for low-carbon tourism products and indirectly promote sales profits and market share. Therefore, using e to describe the low-carbon efforts of travel agencies indicates that the travel agencies optimize and improve market demand through the implementation of low-carbon practices. As the level of low-carbon efforts increases, the demand for tourism products will also increase. However, travel agencies need to incur corresponding costs for their low-carbon efforts, which can be assumed as $c(e) = ke^2/2$

Due to tourism suppliers having control over tourism product resources, a Stackelberg model is constructed with tourism suppliers as leaders and travel agencies as followers. Referring to the work of Liu et al. [34], considering the impact of sales prices and low-carbon efforts on tourist demand, the sales volume models for direct distribution channels and distribution channels dominated by demand functions are established as shown in Equation (1) and Equation (2).

$$d_n = (1 - \alpha)Q - \beta p_n + \gamma p_t \quad (1)$$

$$d_t = \alpha Q - \beta p_t + \gamma p_n + e \quad (2)$$

The specific definitions of the parameters in the above equation are as follows: Q represents latent market demand; α represents consumer preference for the sales channel of travel agencies ($0 < \alpha < 1$); β represents the demand price sensitivity coefficient; γ represents the cross-price sensitivity coefficient ($\beta > \gamma > 0$), which means that the impact of the price of tourism products in this channel on customer demand will be greater than the cross-impact of the price of tourism products in another channel on the demand of this channel.

Construction and Analysis of a Dual-Channel Tourism Supply Chain Financing Model

In the context of considering the low-carbon efforts of travel companies, we mainly discuss the issue of solving financial difficulties through two financing methods for travel agencies under capital constraints. One is internal financing based on transaction credit, which means that tourism suppliers allow downstream travel agencies to defer payment for the ordered tourism products. At the time of ordering, the travel agency pays a certain deposit, and the remaining balance and interest are paid after the product is sold. The other is external financing based on bank loans, where travel agencies apply for loans from banks or other financial institutions to advance payments. We use subscript "Y" and "L" to represent the decision variables under the deferred payment financing model and the bank loan financing model.

Deferred Payment Financing Model

In the dual-channel tourism supply chain under the deferred payment financing model, the travel agency uses its own funds denoted as B_r to partially pay for the goods. The remaining funds, denoted as $wd_t - B_r$ are applied to the tourism supplier at a certain interest rate $r_n$to request an extension until after the selling season to settle the principal and interest. The financing actions between the tourism supplier and the travel agency within the entire supply chain represent internal fund flows, which do not affect the overall profit of the supply chain. The objective profit functions of the tourism supplier, travel agency, and the tourism supply chain as a whole are represented by Equation (3), Equation (4), and Equation (5) respectively.

$$\Pi_{nY} = wd_t + p_n d_n + r_n(wd_t - B_r) \tag{3}$$

$$\Pi_{tY} = (p_t - w)d_t - ke^2/2 - r_n(wd_t - B_r) \tag{4}$$

$$\Pi_Y = \Pi_{nY} + \Pi_{tY} \tag{5}$$

Under the Stackelberg game dominated by the tourism suppliers, the tourism suppliers will change the demand of the travel agencies, and determine the wholesale selling price of the tourism products as p_n, set the retail price of the travel product as p_t, and set the low-carbon effort as e . In order to determine the best price point of the members of the tourism supply chain, the reverse derivation is used to find the optimal pricing decision.

Theorem 1.

Under the decentralized decision-making model of deferred payment financing, the sales prices and low-carbon efforts levels of travel products in the direct sales channel and distribution channel of the travel agency are functions of:

$$p_{nY}^* = -\frac{Q\alpha - Q - \gamma w + 2Q\beta k - \gamma r_n w + 2\beta\gamma k w - 2Q\alpha\beta k + Q\alpha\gamma k + 2\beta\gamma k r_n w}{-4k\beta^2 + 2\beta + 2k\gamma^2} \tag{6}$$

$$p_{tY}^* = -\frac{\begin{matrix}2\beta w - 6\beta^2 k w + \gamma^2 k w + 4\beta^3 k^2 w - Q\gamma k + 2\beta r_b w + 2Q\beta\gamma k^2 - 6\beta^2 k r_b w + \gamma^2 k r_b w \\ +4Q\alpha\beta^2 k^2 - Q\alpha\gamma^2 k^2 + 4\beta^3 k^2 r_b w - 2Q\alpha\beta k + Q\alpha\gamma k - \beta\gamma^2 k^2 r_b w - 2Q\alpha\beta\gamma k^2\end{matrix}}{2(2\beta k - 1)(-2k\beta^2 + \beta + k\gamma^2)} \tag{7}$$

$$e_Y^* = \frac{\begin{matrix}Q\gamma - 2\beta^2 w + \gamma^2 w + 4\beta^3 k w - 2\beta^2 r_b w + \gamma^2 r_b w + 2Q\alpha\beta - Q\alpha\gamma - 4Q\alpha\beta^2 k \\ +Q\alpha\gamma^2 k - 4\beta\gamma^2 k w + 4\beta^3 k r_b w - 2Q\beta\gamma k + 2Q\alpha\beta\gamma k - 3\beta\gamma^2 k r_b w\end{matrix}}{2(2\beta k - 1)(-2k\beta^2 + \beta + k\gamma^2)} \tag{8}$$

The demand functions for the direct sales and distribution channels are as follows:

$$d_{nY}^* = -\frac{Q - Q\alpha + \gamma w - 2Q\beta k + \gamma r_n w + 2Q\alpha\beta k - Q\alpha\gamma k}{2(2\beta k - 1)} \tag{9}$$

$$d_{tY}^* = \frac{\beta k\begin{pmatrix}Q\gamma - 2\beta^2 w + \gamma^2 w + 4\beta^3 k w - 2\beta^2 r_n w + \gamma^2 r_n w + 2Q\alpha\beta - Q\alpha\gamma - 4Q\alpha\beta^2 k \\ +Q\alpha\gamma^2 k - 4\beta\gamma^2 k w + 4\beta^3 k r_n w - 2Q\beta\gamma k + 2Q\alpha\beta\gamma k - 4\beta\gamma^2 k r_n w\end{pmatrix}}{2(2\beta k - 1)(-2k\beta^2 + \beta + k\gamma^2)} \tag{10}$$

Proof.

By substituting equations (1) and (2) into equation (4). The second-order partial derivative of e, p_t about Π_{tY}, the Hessian matrix can be obtained:

$$H_{(e,p_t)} = \begin{bmatrix} -k & 1 \\ 1 & -2\beta \end{bmatrix} \tag{11}$$

If $k > \frac{1}{2\beta}$ the Hessian matrix is negative definite, the profit function follows a concave function. Let $\frac{\partial \Pi_{tY}}{\partial p_t} = 0, \frac{\partial \Pi_{tY}}{\partial e} = 0$, get:

$$p_{tY} = \frac{Q\alpha k - r_n w - w + \gamma k p_n + \beta k w + \beta k r_n w}{2\beta k - 1} \tag{12}$$

$$e_Y = \frac{Q\alpha + \gamma p_n - \beta w - \beta r_n w}{2\beta k - 1} \tag{13}$$

By substituting equations (12) and (13) into equation (3). The second-order partial derivative of p_n about Π_{nY}, $\frac{\partial^2 \Pi_{nY}}{\partial {p_n}^2} = \frac{2\gamma^2 k}{2\beta k - 1} - 2\beta$, if $k > \frac{\beta}{2\beta^2 - \gamma^2}, \frac{\partial^2 \Pi_{nY}}{\partial {p_n}^2} < 0$,the profit function follows a concave function, the profit of the travel supplier has a local maximum.

Bring the optimal results ${p_{nY}}^*, {p_{tY}}^*, {d_{nY}}^*, {d_{tY}}^*$ and optimal low-carbon efforts level for travel agencies ${e_Y}^*$ into Equations (3) - (5) to obtain the optimal profits of tourism suppliers, travel agencies, and the tourism supply chain ${\Pi_{nY}}^*, {\Pi_{tY}}^*, {\Pi_Y}^*$.

The Financing Model of Bank Lending

Due to operational reasons, travel suppliers often require funds turnover, so they may not always be able to meet the travel agency's request for deferred payment. In this situation, if the travel agency wants to overcome its financing challenges, it needs to consider applying for a loan from a bank, which we will refer to as Loan wd_t. The travel agency uses its own funds is $B_r$and pay the order amount $wd_t - B_r$to the travel supplier and applies for a loan with an interest rate of r_b from the bank. After the sales of the travel products are completed, the travel agency will repay the principal and interest to the bank. Assuming no financing risk due to market uncertainty, the objective profit functions of the travel supplier, travel agency, and the overall supply chain are represented by Equation (14), Equation (15), and Equation (16) respectively.

$$\Pi_{nL} = wd_t + p_n d_n \tag{14}$$

$$\Pi_{tL} = (p_t - w)d_t - ke^2/2 - r_b(wd_t - B_r) \tag{15}$$

$$\Pi_L = \Pi_{nL} + \Pi_{tL} \tag{16}$$

Theorem 2.

In the bank loan financing decision-making model, the pricing decision functions for sales prices of tourism products in direct and distribution channels, as well as the pricing decision function for the low-carbon efforts level of travel agencies are functions of:

$${p_{nL}}^* = -\frac{Q\alpha - Q - \gamma w + 2Q\beta k - \gamma r_b w + 2\beta\gamma k w - 2Q\alpha\beta k + Q\alpha\gamma k + \beta\gamma k r_b w}{-4k\beta^2 + 2\beta + 2k\gamma^2} \tag{17}$$

$${p_{tL}}^* = -\frac{\begin{matrix}2\beta w - 6\beta^2 k w + \gamma^2 k w + 4\beta^3 k^2 w - Q\gamma k + 2\beta r_b w + 2Q\beta\gamma k^2 - 6\beta^2 k r_b w + \gamma^2 k r_b w \\ + 4Q\alpha\beta^2 k^2 - Q\alpha\gamma^2 k^2 + 4\beta^3 k^2 r_b w - 2Q\alpha\beta k + Q\alpha\gamma k - \beta\gamma^2 k^2 r_b w - 2Q\alpha\beta\gamma k^2\end{matrix}}{2(2\beta k - 1)(-2k\beta^2 + \beta + k\gamma^2)} \tag{18}$$

$${e_L}^* = \frac{\begin{matrix}Q\gamma - 2\beta^2 w + \gamma^2 w + 4\beta^3 k w - 2\beta^2 r_b w + \gamma^2 r_b w + 2Q\alpha\beta - Q\alpha\gamma - 4Q\alpha\beta^2 k + Q\alpha\gamma^2 k \\ - 4\beta\gamma^2 k w + 4\beta^3 k r_b w - 2Q\beta\gamma k + 2Q\alpha\beta\gamma k - 3\beta\gamma^2 k r_b w\end{matrix}}{2(2\beta k - 1)(-2k\beta^2 + \beta + k\gamma^2)} \tag{19}$$

The demand functions for direct sales and distribution channels are:

$${d_{nL}}^* = -\frac{Q - Q\alpha + \gamma w - 2Q\beta k + \gamma r_b w + 2Q\alpha\beta k - Q\alpha\gamma k - \beta\gamma k r_b w}{2(2\beta k - 1)} \tag{20}$$

$${d_{tL}}^* = \frac{\beta k\begin{pmatrix}Q\gamma - 2\beta^2 w + \gamma^2 w + 4\beta^3 k w - 2\beta^2 r_b w + \gamma^2 r_b w + 2Q\alpha\beta - Q\alpha\gamma - 4Q\alpha\beta^2 k \\ + Q\alpha\gamma^2 k - 4\beta\gamma^2 k w + 4\beta^3 k r_b w - 2Q\beta\gamma k + 2Q\alpha\beta\gamma k - 3\beta\gamma^2 k r_n w\end{pmatrix}}{2(2\beta k - 1)(-2k\beta^2 + \beta + k\gamma^2)} \tag{21}$$

Proof.

By substituting equations (1) and (2) into equation (15). The second-order partial derivative of e, p_t about Π_{tL}, the Hessian matrix can be obtained:

$$H_{(e,p_t)} = \begin{bmatrix} -k & 1 \\ 1 & -2\beta \end{bmatrix} \tag{22}$$

If $k > \frac{1}{2\beta}$ the Hessian matrix is negative definite, the profit function follows a concave function. Let $\frac{\partial \Pi_{tL}}{\partial p_t} = 0, \frac{\partial \Pi_{tL}}{\partial e} = 0$, get:

$$p_{tL} = \frac{Q\alpha k - r_b w - w + \gamma k p_n + \beta k w + \beta k r_b w}{2\beta k - 1} \quad (23)$$

$$e_L = \frac{Q\alpha + \gamma p_n - \beta w - \beta r_b w}{2\beta k - 1} \quad (24)$$

By substituting equations (23) and (24) into equation (14). The second-order partial derivative of p_n about Π_{nL}, $\frac{\partial^2 \Pi_{nL}}{\partial {p_n}^2} = \frac{2\gamma^2 k}{2\beta k - 1} - 2\beta$, if $k > \frac{\beta}{2\beta^2 - \gamma^2}$, $\frac{\partial^2 \Pi_{nL}}{\partial {p_n}^2} < 0$, the profit function follows a concave function, the profit of the travel supplier has a local maximum.

Bring the optimal results ${p_{nL}}^*, {p_{tL}}^*, {d_{nL}}^*, {d_{tL}}^*$ and optimal low-carbon efforts level for travel agencies ${e_Y}^*$ into Equations (14) - (16) to obtain the optimal profits of tourism suppliers, travel agencies, and the tourism supply chain ${\Pi_{nL}}^*$,${\Pi_{tL}}^*$,${\Pi_L}^*$.

NUMERICAL ANALYSIS AND RESULTS

Analysis and Comparison of Financing Decision Models

Proposition 1.

In a dual-channel tourism supply chain constrained by funding, when the travel agency adopts a deferred payment method with an interest rate equal to the bank loan interest rate, $r_n = r_b$, then ${d_{tY}}^* > {d_{tL}}^*, {e_Y}^* > {e_L}^*$

Proof.

$${d_{tY}}^* - {d_{tL}}^* = -\frac{\beta^2 \gamma^2 k^2 r_b w}{2(2\beta k - 1)(-2k\beta^2 + \beta + k\gamma^2)} \quad (25)$$

$${e_Y}^* - {e_L}^* = -\frac{\beta \gamma^2 k r_b w}{2(2\beta k - 1)(-2k\beta^2 + \beta + k\gamma^2)} \quad (26)$$

Known quantity $-2k\beta^2 + \beta + k\gamma^2 < 0, 2\beta k - 1 > 0$,so ${d_{tY}}^* - {d_{tL}}^* > 0,\ {d_{tY}}^* > {d_{tL}}^*; {e_Y}^* - {e_L}^* > 0,\ {e_Y}^* > {e_L}^*$, the conclusion proved.

Proposition 1 shows that when the interest rate of deferred payment financing is equal to the interest rate of bank loan financing, relative to bank loan financing, travel agencies will need to make higher efforts in low-carbon initiatives after obtaining internal financing support for deferred payment. The increase in low-carbon efforts will attract more consumers, thereby increasing market demand in distribution channels.

To further determine which financing model travel agencies should choose, a comparative analysis of overall revenue under the two financing methods leads.

Proposition 2.

When the interest rate of the delayed payment financing method is equal to the interest rate of bank loan financing, for travel agencies $r_n = r_b$,then ${p_{tY}}^* > {p_{tL}}^*, {\Pi_{tY}}^* > {\Pi_{tL}}^*$.

Proof.

$${\Pi_{tY}}^* = ({p_{tY}}^* - w)\ {d_{tY}}^* - r_n(w\ {d_{tY}}^* - B_r) - \frac{{{e_Y}^*}^2 k}{2} \quad (27)$$

$${\Pi_{tL}}^* = ({p_{tL}}^* - w)\ {d_{tL}}^* - r_b(w\ {d_{tL}}^* - B_r) - \frac{{{e_L}^*}^2 k}{2} \quad (28)$$

$${\Pi_{tY}}^* - {\Pi_{tL}}^* = ({p_{tY}}^* - w(1 + r_n))\ {d_{tY}}^* - ({p_{tL}}^* - w(1 + r_b))\ {d_{tL}}^* \quad (29)$$

According to proposition 1, it can be concluded ${d_{tY}}^* > {d_{tL}}^*$, we need to prove that the deferred payment financing, the travel agency's higher margin can be. To verify the plus or minus of $({p_{tY}}^* - w(1 + r_n)) - ({p_{tL}}^* - w(1 + r_b))$.

When $r_n = r_b$, $({p_{tY}}^* - w(1 + r_n)) - ({p_{tL}}^* - w(1 + r_b)) = {p_{tY}}^* - {p_{tL}}^* = -\frac{\beta \gamma^2 k^2 r_b w}{2(2\beta k - 1)(-2k\beta^2 + \beta + k\gamma^2)}$

Known quantity $-2k\beta^2 + \beta + k\gamma^2 < 0, 2\beta k - 1 > 0, {p_{tY}}^{D^*} - {p_{tL}}^{D^*} > 0$, so ${p_{tY}}^* > {p_{tL}}^*,\ {\Pi_{tY}}^* > {\Pi_{tL}}^*$, the conclusion proved.

Proposition 1 shows that compared to bank loan financing, the deferred payment financing method requires travel agencies to put in more efforts towards low-carbon initiatives. The travel agency's low-carbon efforts can increase sales through distribution channels but also incur additional costs. To ensure their own interests, travel agencies will raise the selling prices through

distribution channels to guarantee their expected profits when using deferred payment financing. However, when the interest rates of deferred payment financing are equal to those of bank loan financing, the deferred payment method allows travel agencies to obtain higher profits. Therefore, travel agencies tend to prefer the deferred payment financing strategy.

Numerical Analysis

In order to reflect the financing decision-making behavior of double-channel tourism supply chain more intuitively, this section analyzes the effect of the financing decision-making model through an example. At the same time, based on commercial bank lending rates, set the range of interest rate fluctuations changes within $[0.01,0.2]$, other parameter settings are set as $\alpha = 0.5, \beta = 0.7, \gamma = 0.4, Q = 40, w = 30$

The Impact of the Low-Carbon Effort Cost Coefficient on the Level of Low-Carbon Efforts and Financing Amount

Restrictions on k based on constraints, Set the range of possible values for k $[2,\ 5]$, financing rate $r_n = r_b = 0.05$. Keep the values of other variables unchanged, the changes in the level of low-carbon efforts, product demand in travel agency distribution channels, and financing amount can be obtained as k varies in the deferred payment financing mode and bank loan financing mode, as shown in Table 1.

Table 1. The impact of the variation in the cost coefficient k of low-carbon efforts

k	d_{tY}^*	d_{tL}^*	e_Y^*	e_L^*	$w\, d_{tY}^* - B_r$	$w\, d_{tL}^* - B_r$
2	10.7639	10.6249	7.6885	7.5892	322.9184	318.7482
2.5	9.0909	8.982	5.1948	5.1326	272.7278	269.4611
3	8.224	8.13	3.9162	3.8714	246.7202	243.9013
3.5	7.6946	7.6095	3.1407	3.1059	230.8393	228.286
4	7.3381	7.2588	2.6207	2.5924	220.1426	217.7644
4.5	7.0817	7.0065	2.2482	2.2243	212.4506	210.1965
5	6.8885	6.8164	1.9681	1.9475	206.6544	204.4926

Table 1 shows that in both the deferred payment financing model and the bank loan financing model, as the cost of low-carbon efforts increases, there will be a reduction in the investment in low-carbon initiatives, which will have a negative impact on the sales volume of tourism products in the distribution channels. However, the demand for funds from travel agencies will decrease. Conversely, as the cost of low-carbon efforts decreases and the level of low-carbon initiatives increases, the sales volume of products in the distribution channels will increase. Travel agencies will need a large amount of funds to purchase tourism products in advance, leading to an increase in their funding requirements. When their own funds are limited, there will be a larger funding gap, thus increasing the demand for financing.

The Impact of Financing Interest Rates on the Optimal Decision for the Two Financing Models

Assuming there is no consideration for the impact of the travel agency's own funds. Let $B_r = 0, k = 3$. The impact of the financing rate on the optimal decision-making under two financing modes is shown in Figure 1 and Figure 2 when the deferred payment rate is equal to the bank lending rate.

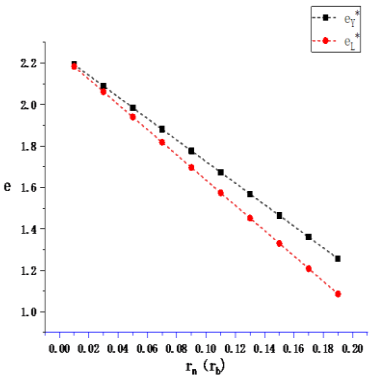

Figure 1. The impact of financing interest rates on low-carbon efforts

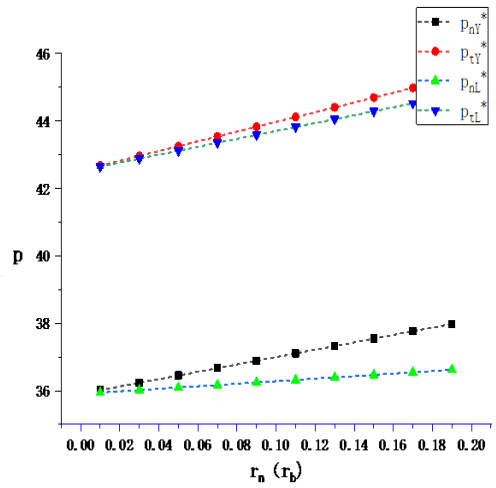

Figure 2. The impact of financing interest rates on channel prices

From Figure 1 and Figure 2, it observed that as the financing interest rate increases, the level of low-carbon efforts made by travel agencies decreases, and the selling prices of tourism products through various channels increase. Regardless of deferred payment or bank loan financing, an increase in the financing interest rate signifies that travel agencies have to bear higher financing costs. As a result, travel agencies may reduce their investment in low-carbon efforts and pass on the costs to consumers, leading to an increase in selling prices. Compared to the level of low-carbon efforts and selling prices through various channels, the deferred payment model consistently exceeds the bank loan model, which is consistent with proposition 1 and proposition 2.

The Impact of Travel Agency's Own Funds and Financing Interest Rates on Profits

Different financing models, along with financing interest rates and initial self-owned funds, can have varying impacts on the profits of tourism suppliers and travel agencies.

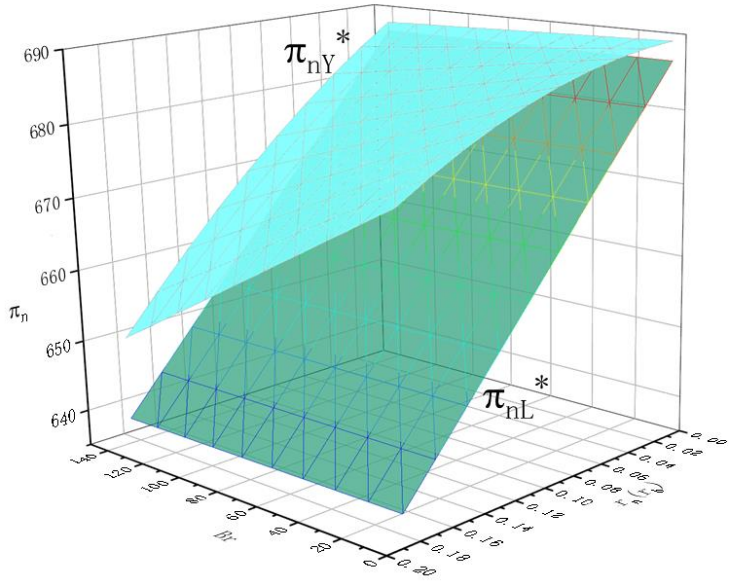

Figure 3. The impact of $r_n(r_b)$ & B_r on the profits of tourism suppliers

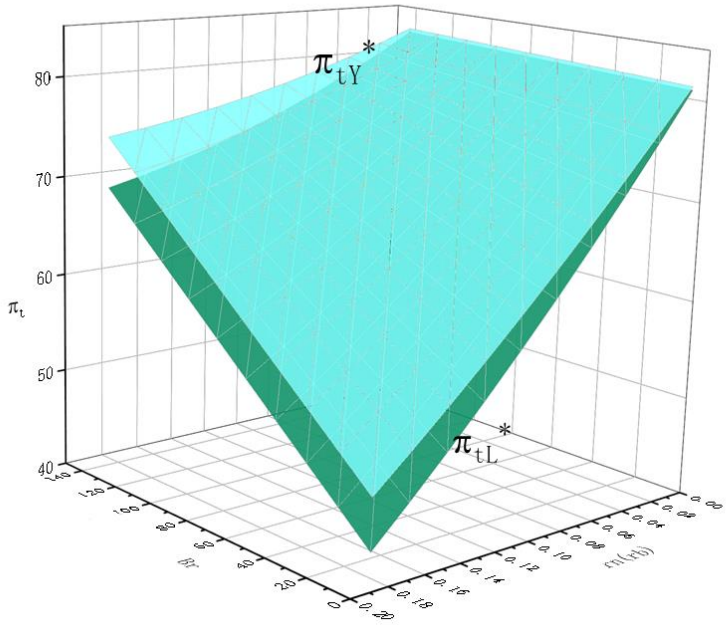

Figure 4. The impact of $r_n(r_b)$ & B_r on travel agency profits

From Figure 3 and Figure 4, it can be observed that when the financing interest rate is fixed, under the delayed payment financing model, the profits of travel agencies will continuously increase with the growth of their self-owned funds. However, the profits of tourism suppliers show an inverse trend. The important reason for this contrasting effect is that when the funding gap of travel agencies narrows, the interest income obtained by tourism suppliers through delayed payment financing decreases, consequently leading to a decrease in profits. Bank loans fall under the category of external financing models, where the profits of travel agencies increase with the growth of their self-owned funds, while the profits of tourism suppliers are not affected by changes in the travel agency's initial self-owned funds.

When the initial self-owned funds of a travel agency are kept at a certain level, an increase in the financing interest rate will lead to a decrease in profits for both the travel agency and the tourism suppliers. When the delayed payment interest rate is equal to the bank loan financing interest rate, the profits obtained under the delayed payment financing model are always higher for both the travel agency and the tourism suppliers compared to the bank loan financing model. Therefore, when conditions permit, travel agencies will always prioritize the delayed payment financing strategy because it is beneficial for both parties.

CONCLUSIONS

Taking into account the low-carbon efforts in the context of funding constraints for travel agencies, a dual-channel tourism supply chain financing decision model is constructed based on delayed payment financing and bank loan financing. An analysis and discussion on the impact of these two financing methods on tourism supply chain enterprises are conducted, providing reliable recommendations for funding-constrained travel agencies to choose their financing strategies.

The findings indicate that when travel agencies receive internal financing support through delayed payment, they are willing to exert higher levels of low-carbon efforts. However, as the level of low-carbon efforts increases, so does the cost. In such cases, travel agencies may raise channel sales prices to ensure their own interests. As the travel agency's own funds continue to decrease and financing interest rates continue to rise, their profits will decline rapidly. In a sluggish tourism product market where enterprises along the tourism supply chain have lower economic benefits, fund providers cannot profit from financing even with high interest rates. Therefore, both tourism suppliers and banks should not only pursue their own interests when determining loan interest rates but also consider the funding needs of the other party. By doing so, both parties can achieve coordination and a win-win situation.

The aforementioned study was conducted based on the assumption of moderate risk. However, in reality, the risk attitudes of members within the tourism supply chain are complex and subject to multiple factors from both internal and external market

environments. Therefore, further analysis of the impact of different risk attitudes between tourism suppliers and travel agencies on supply chain pricing and financing strategy choices will be a key focus and direction for future research.

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