A Composite Collaborative Tourism Supply Chain Risk Sharing Model

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Authors' contribution

This work was developed in collaboration by the both authors, who contributed equally to the literature review and writing of the manuscript. Both authors read and approved the final manuscript.

Original Research Article

ABSTRACT

Tourism supply chain (TSC) is a relatively new concept. In order to realize the effectiveness of TSC collaboration, how to share the risks of TSC fairly is a key issue. This paper analyzes the main risk factors in TSC, and proposes a composite risk sharing model. Incorporating the contribution of the individual enterprise to the profit making of the whole TSC profit, this paper presents an amended investment based risk sharing model for more fair and reasonable risk sharing.

1. INTRODUCTION

With demand volatility and accelerating globalization and competition, the tourist market competition of today is no longer faced by a single enterprise, but by the tourism supply chain as a whole. With the integration of tourism products, travel agencies, tourism destinations, hotels and other related enterprises have been cooperating for pronounced supply chain synergies. However, tourism supply chain enterprises are organizationally independent of each other. In order to achieve the maximization of self-interest, these enterprises may clash on the profit allocation and risk-sharing so that the overall effectiveness of the tourism supply chain

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will be affected. Enterprises in a supply chain might prioritize their own interests instead of the whole supply chain's, unless induced to adopt this holistic view. Risk sharing mechanism is a key factor to facilitate supply chain coordination as there are various forms of risks in a supply chain [1,2,3,4,5,6]. Risk sharing mechanism would incentivize the enterprises to share risk information and develop coordinated risk responses, such that it is possible to minimize surprises and disruptions, improve performance, and reduce costs. Risk sharing contracts are proposed as an effective mechanism [5,6]. Some supply chain revenue and risk sharing models have been presented [7,8,9,10,11], such as output distribution model, principal-agent model, option contract, and risk-benefit balancing model. Output distribution model focuses on reducing supply chain risk. Principal-agent model and option contract are oriented towards the reasonability of risk allocation among the nodal enterprises on the supply chain. Risk-benefit balancing model theoretically analyzes risk-sharing in consideration of benefit. Recently, profit or risk sharing in a supply chain by using Shapley value has gain increasing attention in the literature [9,10,11], which is demonstrated to be individually rational.

Tourism, as one of the largest and fastest growing services industries, may gain the large potential benefits of supply chain management advancement. The main differences between tourism supply chains and those of other sectors, are that tourists travel to the product, and the product that they buy has a particularly high service component. TSC may involve many components - not just accommodation, transport and excursions, but also bars and restaurants, handicrafts, food production, waste disposal, and the infrastructure that supports tourism in destinations. Tour operators can play a significant role in TSC. Like other supply chains. TSC may face many kinds of uncertainties and risks. In recent years the global tourism industry has experienced many crises and disasters including terrorist attacks, political instability, economic recession, biosecurity threats and natural disasters [12,13]. Therefore, how to share risks among the enterprises in TSC has been a key to the development of a collaborative TSC. However, research in this area has been scarce.

This paper presents a tourism supply chain collaborative risk-sharing model, which is based on nodal enterprises' investment amended by their contribution assessed by Shapley value.

Empirical analysis verifies the viability and effectiveness of the model.

2. Tourism Supply Chain Collaborative Risk-sharing

2.1 Shapley Value

Shapley value, named in honor of Lloyd Shapley, who introduced it in 1953, is a solution concept in cooperative game theory. It assigns a unique distribution among the players of a total surplus generated by the coalition of all players. Let N denote the set of n players：N={1，2，…，n}, for each subset (coalition) $S \leqslant N$, there exists a real function *v(S)* mapping S to a real number. *v(S)* describes the total expected sum of payoffs that the members of S can obtain by cooperation. In the collaborative TSC, hotels, transportation, catering and scenic spots will maximize the overall economic benefits. This kind of economic activity can be regarded as a cooperative game. Let Φidenote the profit amount that enterprise *i* gets. According to the Shapley value, it is given by the formula:

$$\Phi(v) = \left(\Phi_1(v), \Phi_2(v), \ldots, \Phi_n(v) \right) \qquad (1)$$

$$(2)\Phi_i = \sum_{i \in S} \{w(|S|)[v(S) - v(S\backslash i)]\} \qquad (2)$$

$$w(|S|) = \frac{(|S|-1)!(n-|S|)!}{n!} \qquad (3)$$

where

|S|: The total number of elements in S
v(S): TSC total profit with enterprise *i*in the collaboration.
v(S*i*): TSC total profit without enterprise *i*in the collaboration.
v(S)-*v*(S*i*): the contribution of enterprise *i*.
$\Phi(v)$:The weighted average of the contributions of enterprise *i* to all collaborations.

The profit of enterprise *i* is its contribution to the TSC.

2.2 Collaborative TSC Risk Sharing Based on Investment and Contribution

2.2.1 Notation

m	number of risks
w*j*	probability of risk j (j = 1,2,3…,m), 0 ≤w*j*≤ 1
r*j*	loss of risk j

$$R = \sum_{j=1}^{m} w_j r_j \quad \text{collaborative TSC's total risk loss}$$

n	number of enterprises
Ii	investment of enterprise i (i = 1,2,3…,n): capital, resource, and technology, etc
Ri	risk shared by enterprise i

2.2.2 Investment based risk sharing

Risk loss may occur due to uncertainties, such as volatile demand, and sometimes the loss may be significant, such as due to natural disasters.

According to the investmen, the risk loss shared by enterprise i is

$$R_i = R \times \frac{I_i}{\sum_{i=1}^{n} I_i} \quad (4)$$

In a TSC, the tour operators and the tour suppliers will share the TSC risk based on their investment, which can ensure the small enterprises with less investment or resource will bear accordingly fair (less) risk loss, and their profits will be safeguarded.

2.2.3 Contribution biased investment based risk sharing

The traditional investment based risk sharing mechanism only considers the investment with explicit value, such as capital. However, it ignores the implicit investment, such as manpower value, creativity and culture value, which are important contributions to the total TSC profit.

Shapley value can be used to assess the individual enterprise's contribution to the profit making of the whole TSC. The traditional investment based risk sharing mechanism can be amended by adding the contribution bias. The contribution biased investment based risk loss to enterprise i will be

$$R_i = R \times \frac{I_i}{\sum_{i=1}^{n} I_i} - R \times \left(\frac{\Phi_i(v)}{\Phi(v)} - \frac{1}{n} \right) \quad (5)$$

where, $\frac{\Phi_i(v)}{\Phi(v)}$ is the contribution weight of

enterprise i over the total TSC profit. $\frac{1}{n}$ is the average contribution weight. $R \times \left(\frac{\Phi_i(v)}{\Phi(v)} - \frac{1}{n} \right)$ will be the less risk loss born by enterprise i due to its contribution over the average. If $\frac{\Phi_i(v)}{\Phi(v)} > \frac{1}{n}$, then the contribution of enerprise i is larger than the average. To compensate its contribution, its risk loss sharing becomes less, and vice verse.

3. CASE ANALYSIS

For simplicity, but without loss of generality, it was assumed that a TSC consists of three enterprises, travel agent A, scenic spot B and hotel C, who will collaborate with each other to maximize the profit. The profits made by different collaborations are shown in Table 1.

v(A), v(B) and v(C) are the profits made by A, B and C respectively without any collaborations. v(A+B), v(A+C) and v(B+C) are profits with the collaborations of any two enterprises only，and v(A+B+C) is the total profit of the whole TSC collaboration.

3.1 Enterprises' Contributions Evaluated by Shapley Value

Shapley value gives the following contributions in Table 2.

Table 2 mainly shows the contribution of travel agent A. Therefore, the combinations in S includes the enterprises related to A, and hereby i represents A. v(S\i) is the TSC total profit without A involved. If only A in the combination (i.e., S=A), V(S\i) will be zero. When S = (A, B), v(S\i) is the profit of B operating independently. When S = (A, B, C), v(S\i) is the total profit of collaboration of B and C without A. v(S)- v(S\i) is the contribution of A to the whole TSC collaboration.

Multiplying $w(|s|) = \frac{(|s|-1)!(n-|s|)!}{n!}$, the weighted average of A's contributions to all collaborations (all combinations of {A, B, C}) can be obtained as

$$\Phi_A(v) = \text{w(|S|) [}v\text{(S)} - v\text{(S\i)].}$$

Table 1. Profits of collaborations

v (A)	v (B)	v (C)	v (A+B)	v (A+C)	v (B+C)	v (A+B+C)
40	30	20	80	70	55	120

Table 2. The contribution of travel agent A

S	A	A+B	A+C	A+B+C
v(S)	40	80	70	120
v(S\i)	0	30	20	55
v(S) − v(S\i)	40	50	50	65
|S|	1	2	2	3
w(|S|)	1/3	1/6	1/6	1/3
w (|S|) [v (S) − v (S\i)]	40/3	25/3	25/3	65/3

Table 3. Risk probability and loss

	Product development risk	Information communication risk	Technical risk
Probability w_i	1/3	1/5	1/6
Loss r_i	30	40	60

$$\Phi_A(v) = \frac{40}{3} + \frac{25}{3} + \frac{25}{3} + \frac{65}{3} = \frac{155}{3} \approx 52$$

Similarly,

$$\Phi_B(v) = 10 + \frac{20}{3} + \frac{35}{6} + \frac{50}{3} = \frac{235}{6} \approx 39$$

$$\Phi_C(v) = \frac{20}{3} + 5 + \frac{25}{6} + \frac{40}{3} = \frac{175}{6} \approx 29$$

It can be seen that $\Phi_A(v) > V(A) = 40$, $\Phi_B(v) > V(B) = 30$, $\Phi_C(v) > V(C) = 20$, which means the contribution of each enterprise to TSC with collaboration is bigger than its profit on its own.

$$\Phi(v) = \Phi_A(v) + \Phi_B(v) + \Phi_C(v) = \frac{155}{3} + \frac{235}{6} + \frac{175}{6} = 120$$

= v(A+B+C).

3.2 Conventional Investment Based Risk Sharing

It is assumed that there exist three kinds of risks, i.e., product development risk, information communication risk and technical risk, numbered as 1, 2 and 3 respectively. The probability and loss of risks can be assessed based on historical data shown in Table 3.

It is assumed that the investment of A, B and C are $I_A=12$, $I_B=8$ and $I_C=8$.

The total risk loss will be

$$R = \sum_{j=1}^{m} w_j r_j = w_1 \times r_1 + w_2 \times r_2 + w_3 \times r_3 = \frac{1}{3} \times 30 + \frac{1}{5} \times 40 + \frac{1}{6} \times 60 = 28$$

A's risk loss is

$$R_A = R \times \frac{I_A}{\sum I_i} = R \times \frac{I_A}{I_A + I_B + I_C} = 28 \times \frac{12}{12 + 8 + 8} = 12$$

B's risk loss is

$$R_B = R \times \frac{I_B}{\sum I_i} = R \times \frac{I_B}{I_A + I_B + I_C} = 28 \times 8 = 8$$

C's risk loss is

$$R_C = R \times \frac{I_C}{\sum I_i} = R \times \frac{I_C}{I_A + I_B + I_C} = 28 \times \frac{8}{12 + 8 + 8} = 8$$

3.3 Composite Risk Sharing Incorporating Investment and Contribution

Table 4 shows the final composite risking sharing of A, B and C. It can be noted that the risk loss of A becomes less compared with investment based risk loss because of its contribution to the whole TSC over the average. This means its risk sharing is compensated by its high contribution. The reduction of A's risk loss will be distributed to B and C, and the final risk sharing is R_A=9.3, R_B=8.2 and R_C=10.5. And the total risk loss will remain the same,

$$R_A + R_B + R_C = 9.3 + 8.2 + 10.5 = 28$$

Table 4. The composite risk sharing of A, B and C

	$R \times \dfrac{I_i}{\sum\limits_{i=1}^{n} I_i}$	$\Phi_i(v)$	$\dfrac{\Phi_i(v)}{\Phi(v)}$	$\dfrac{\Phi_i(v)}{\Phi(v)} - \dfrac{1}{n}$	$R \times \left(\dfrac{\Phi_i(v)}{\Phi(v)} - \dfrac{1}{n} \right)$	R_i
A	12	52	0.43	0.097	2.7	9.3
B	8	39	0.33	-0.007	-0.2	8.2
C	8	29	0.24	-0.093	-2.5	10.5

4. CONCLUSION

The collaboration of TSC has been paid more attention due to market volatility and competition. The risks faced by a TSC need to be shared by its members to improve the TSC colabration . The conventional investment based risk sharing model has no motivation to encourage the enterprises in the TSC to maximize their contributions to the TSC collaboration, especially with loose couplings. This paper presents a composite model to amend the investment based risk sharing model by incorporating the enterprises' contribution to the TSC profit making, which is more promising and fair in the collaborative TSC environment.

Incentive alignment should be considered in the risk sharing model such as all enterprises are willing to share risk information and form some colaborative response to the risks. The risk sharing model presented in this paper demonstrates this featue in the case study by using the well-known Shapley value concept. However, the real case application may need more scrutiny and face more challenges, including risk assessment, loss assessment, and information collection issues.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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