Evaluating the symbiosis status of tourist towns: The case of Guizhou Province, China

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Abstract

This study examines the symbiosis status of tourist towns by analyzing the dynamism between two subsystems of tourist town development: the town subsystem and the tourism subsystem. Drawing on the Lotka-Volterra model, we first developed a model for evaluating the status of harmonious symbiosis development for tourist towns, and then formulated a set of indicators to measure the key components in the model. An empirical study applying the model was conducted focusing on 18 tourist towns in Guizhou Province, China. Recommendations were proposed for more harmonious development of the tourist towns. This is among the first tourism studies that adopt the symbiosis systems approach and our proposed model provides fresh insights into tourist town development.

Keywords: Tourist town; planning; development; symbiosis; Lotka-Volterra model; China

1. Introduction

It is well established in the tourism literature that the development of tourism has both positive and negative impacts on the tourist cities or towns (Haralambopoulos & Pizam 1996). Tourism is considered as an important driving force for economic development (Hernández-Maestro & González-Benito, 2014; Li, Ryan, & Cave, 2016). It creates jobs, generates taxes revenues, and attracts investment in urban regeneration, infrastructure, public services and others (Postma, Buda, & Gugerell, 2017). However, "more can be worse" (Caserta & Russo, 2002). Excess tourism development brings overcrowding, high living costs, commercial gentrification and subsequent residential displacement (García, Smith, & Mejías, 2007; Russo, 2002; Wilson &Tallon, 2012). In several European cities such as Venice, Barcelona, Salzburg, there exists an anti-tourism movement, local residents strongly protest against the "touristification" of urban spaces (García-Hernández et al., 2017; Postma et al., 2017; Stock, 2007). Therefore, for urban tourism to be sustainable, it is critically important that both the city planners and the tourism planners understand the interaction between tourism development and urban development (Briassoulis, 2003; Pasquinelli, 2017).

Achieving a harmonious symbiotic relation between tourism and its environment is thus a key factor that affects sustainable development of tourist towns (Budowski, 1976; Butler, 1991; Getz & Jamal, 1994). Girard (2010) uses the term "a new metabolism" to describe co-development of industrial-commercial and tourist spaces which are often in conflict but are rich in potential. Similarly, Al-hagla (2010) argues that urban development planning should balance the simultaneous development of all the aspects of a historical area by considering their interconnectedness. In the human history, the practice of urban planning dates back to the ancient civilization, it is an ongoing process that accompanies the growth and evolution of towns and cities. However, as pointed out by Orbasli (2002), tourism usually only enters the sphere of urban planning until its market expands and the pressure is felt. Tourism is often considered as negligible (Ashworth & Page 2011) and rarely incorporated in the early stage of urban planning (Russo & Van Der Borg, 2002). Consequently, there have been calls for urban planners to consider the co-development between the city and tourism to achieve symbiotic relationship among the different aspects of a city and the tourism sector (e.g. Budowski, 1976; Butler, 1991; Getz & Jamal, 1994; Pasquinelli, 2017; Russo & Van Der Borg, 2002). Modeling the interactions among sectors within the system provides a useful framework for predicting the outcomes, and the evolution and development path of tourist towns could be delineated, and strategy for development formulated (Murphy, 1983). Recently, Pasquinelli (2017) calls for more research into the integration of urban development with tourism development. Unfortunately, there has been very little research that examines the relation between urbanization and tourism development (Ashworth & Page 2011), and even fewer studies have looked into the industrial amalgamation of tourism and other sectors of the destination, especially their evolution process and symbiosis effects (Li, Zhang, & Lu, 2010; Zhong & Liu, 2012).

The social economic development of the human society resembles that of the biological system, and concepts and theories rooted in the biological science have been adopted to examine the socio-economics phenomena (Hung et al. 2017; Wei et al., 2017). Many terms in biology are commonplace in tourism research, such as tourism "life cycle", smart tourism "ecosystem", and others. Scholars have called for the use of biological theories and models to examine a tourism phenomenon. Brouder & Eriksson (2013) advocate the use Darwinism, complexity theory and path dependence, the central epistemological precepts evolutionary economic geography, to examine the micro-behavior of economic organizations and individuals, and the self-transformation of spatial economy in tourism destinations. Nicholls, Amelung, & Student (2017) promote the use of agent-based modeling, another common approach in ecology to study the complex systems of tourism. However, many challenges such as novelty, technical, and communications issues inhibit tourism researchers from adopting models borrowed from other disciplines (Johnson et al., 2017).

In this study, we apply a classic model in biology, the Lotka-Volterra model (Lotka, 1925; Volterra, 1926) for investigating the symbiosis status of tourist town system (Jamal & Getz, 1995), with an aim to provide practical solutions for sustainable tourism and urban development. To the best of our knowledge, this is among the first studies that adopt the Lotka-Volterra model in tourism research. We empirically examine the symbiosis status of 18 tourist towns in Guizhou Province, a less developed region in China. The rapid growth of urbanization and domestic tourism in China has given birth to numerous tourist towns in recent decades. In some small towns, the tourism sector has grown as an important pillar of the local economy (Zeng, 2010). These towns are confronted with many problems such as severe division between infrastructure planning and tourism development, and contradiction between preservation and exploitation (Li, 2010), providing an apt research context for the present study.

2. Conceptual background

2.1. Tourist town as a symbiotic system

A tourism destination is often regarded as a complex adaptive system with spatial and functional linkage among its components (Leiper, 1979; Yang, 2010). Similarly, a tourist town can be conceptualized as a system that consists of the interaction among its various components. System is a cognitive entity created with symbols and syntactic rules, and represents selectively constructed assumptions and models based on people's experiential units (Rosen, 1985). In other words, a system is what we intend to recognize as a system. We cannot discover a system; rather, we create or construct a system, and different systems can be constructed based on our experiences (Gaines, 1979). In a similar vein, tourist towns are socially constructed systems (Sanz-Ibáñez & Anton Clavé, 2014) and can be arranged by the stakeholders involved.

In this study we regard a tourist town as a system that is made up of two subsystems: the town subsystem and the tourism subsystem. The two subsystems are identifiable elements within the tourist town, and have distinct functionality. The tourism subsystem is the defining feature that marks a town as a tourist town and endues it with unique characteristics different from non-tourist towns and other tourist towns. The interaction and relationship between the two subsystems of the tourist towns starts with tourist expenditure at the destination, and the resulting exchange of materials, resources, and information within and outside the system. The town subsystem then provides various tangible and intangible resources (e.g., natural and cultural resources), infrastructure, capital, and labor for the operation of the tourist towns. The tourism subsystem transforms the inputs from the town subsystem into outputs by undertaking tourism related economic and social-cultural activities, thus promoting the overall development of the town. In this process, the components of the system are coupled together and interact with each other on adaptive basis, resulting in systematic spatial, functional, and industrial structure of the town. Such coupling is a dynamic evolutionary process, during which agglomerated enterprises engage in related industrial production, and the organization structure of the symbiotic system determines the stability of the symbiosis and the performance of the enterprise (Weng, Lv, & Li, 2016). Within certain temporal and spatial scope, the relationship among the components achieves dynamic equilibrium and retains a relatively stable structure, thus the tourism town system is established and differentiated from other systems and from its external environment.

From the perspective of the symbiosis theory (Oulhen, Schulz, & Carrier, 2016), a tourist town is a symbiotic system. The term “symbiosis” was first coined by the biologist De Bary in 1879 to describe the phenomenon of the living together of unlike organisms based on the materialistic relations and exchange between the organisms. According to Weng, Lv, & Li (2016), a symbiotic system consists of three elements, namely the symbiotic unit, symbiotic model and symbiotic environment. The symbiotic unit is the basic energy production and exchange unit that form the symbiotic relationship. Symbiosis model refers to the way of interaction and communicative forms (e.g., the exchange of material, energy and information) among the symbiotic units in the symbiotic system. The symbiotic environment is the external conditions for the existence and continuous existence of the symbiotic units and their relationships. It includes the sum of all the factors other than the symbiotic elements. In the process of symbiotic interaction, if functioned in mutually beneficial pattern, the symbiotic units will produce new energy, which will in turn promote the development of the symbiotic relationship to a more advanced form. Ultimately, the purpose of a symbiotic system is to enhance the survival and development capability of each symbiotic unit. Such capability may be reflected by different indicators under different biological or social sphere. For example, it could be the economic performance of enterprises, the ability to resist external risks, and the overall competitiveness of an industrial sector or a destination (Weng, Lv, & Li, 2016).

A tourist town can be conceived as a multidimensional and hierarchical symbiosis system consisting of the town and the tourism subsystems within a specific spatial scope (Figure 1). This is the theoretical conceptualization that guides our investigation about the interaction between the constituent parts of the tourist town. The focus of the current study is on both the nature and the level of the symbiotic relationship between the town and the tourism subsystems.

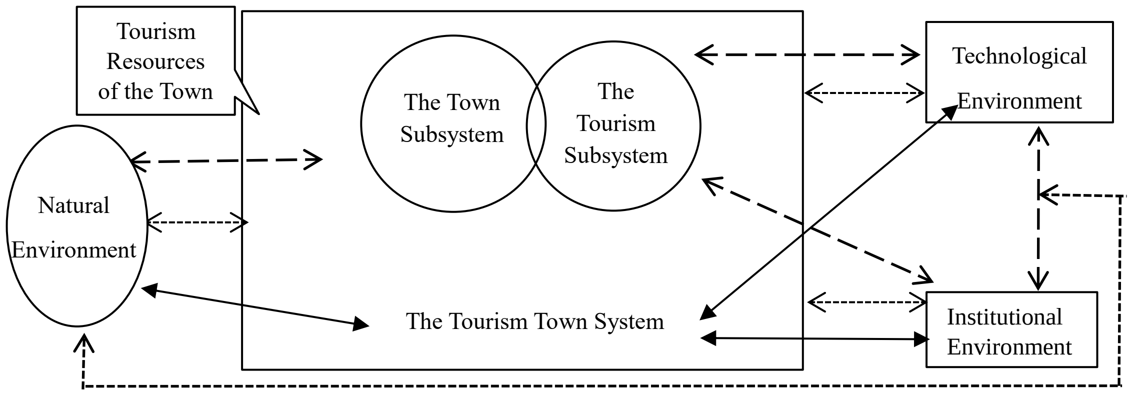


Figure 1. Hierarchical structure of the tourist town system

Note:

⟷ Represents symbiosis relation and evolution between the tourist town system and the external environment;

<– –> Represents symbiosis relation and evolution among the tourist town subsystems and the external environment;

<-----> Represents symbiosis relation and evolution among the tourist town system, its carrying capacity, and the components in the external environment.

2.2. The Lotka-Volterra model

The Lotka-Volterra model is widely used for studying interspecific competition (e.g. Chiang, 2012; Hung et al., 2017; Kreng & Wang, 2009; Lee, Lee, & Oh, 2005; Watanabe, Kondo, & Nagamatsu, 2003). The model focuses on the competition between two or more species for limiting resource, and explains the outcomes of the competitive interactions as well as the symbiotic and parasitic relations among species (Bazykin, 1998). These "species" can be any competing entities in a business ecosystem. For example, researchers have used the model to examine two enterprises (Wei et al., 2017); two semiconductor products (Chiang, 2012); two technological types of TV (Kreng & Wang, 2009); two TV broadcasting formats (Watanabe et al., 2003); two competing retail formats (Hung et al., 2017); two smartphone operating systems (Tseng, Liu & Wu, 2014) ; two competing stock exchange markets (Lee et al., 2005); two competing industries such as the coal versus electricity industries (Herui, Xu, and Yuqi, 2015) and the TV versus smartphone industries (Wang and Wang, 2016); or two competing social economic variables, such as: research and development investment versus gross domestic product, fixed assets investment versus consumer price index, and energy consumption versus gross domestic product (Wu, Liu, and Wang, 2012).

The model has been used for various research purposes, such as analyzing competitor relationship (Cerqueti, Tramontana, & Ventura, 2015; Kreng & Wang, 2009; Lee et al. 2005; Wang & Wang, 2016) and co-evolution (Herui et al. 2015; Tseng et al., 2014; Wei et al. 2017), as well as forecasting technology development trends including technology substitution (Chiang, 2012; Miranda & Lima, 2013; Morris & Pratt, 2003) and diffusion (Chakrabarti, 2016; Watanabe et al., 2003).

Despite its wide application across academic disciplines for various research purposes, Lotka–Volterra model has rarely been adopted in tourism research. To the best of our knowledge, there is only one study that makes use of the model: Lo (2013) uses it to forecast the volume of tourism demand. But the author does not address the symbiosis status of tourism destinations.

3. Model development

3.1. The Lotka-Volterra model

The Lotka-Volterra model provides the mathematical modeling of interactions between two or more species under the condition of limited resources. Modeling these interactions provides a useful framework for predicting outcomes, which include influence of the interaction on the species' evolution, the structure of the ecosystem in terms of which species coexist (and which don't), their distribution and relative abundance (Gross, 2003). In the current study, the Lotka-Volterra model is employed to model the interaction between the subsystems within the carrying capacity of the tourist town system, and to reveal the nature and level of their symbiotic interaction. In this sense, the subsystems within a tourist town are viewed as living organisms coexisting and impacting on each other in a given environment. Different types of relations between the subsystems are possible, as shown in Table 1.

The basic tenet of the Lotka-Volterra model is represented by equation (1), which models the rate of population increase (*dN/dt*) limited by both intraspecific and interspecific competition.

$$\begin{aligned} \frac{dN_1}{dt} &= r_1 N_1 \left(\frac{K_1 - N_1 - \alpha N_2}{K_1}\right) \\ \frac{dN_2}{dt} &= r_2 N_2 \left(\frac{K_2 - N_2 - \beta N_1}{K_2}\right) \end{aligned} \tag{1}$$

In equations (1), the numbers 1 and 2 represent the two species. N is the population size, t is time, K represents the carrying capacity, and r is the intrinsic rate of increase. α and β are the competition coefficients, representing the effect of one species on the other (i.e.,α represents the effect of species 2 on species 1, and β represents the effect of species 1 on species 2). *dN/dt*, therefore, denotes the growth rate of the species given the carrying capacity K.

By setting the growth rate (*dN/dt)* equal to zero and solving for N, we obtain the population size when the number of the species reaches equilibrium, namely the population does not increase or decrease, as shown in equation (2).

$$\begin{aligned} N_1 &= K_1 - \alpha N_2 \\ N_2 &= K_2 - \beta N_1 \end{aligned} \tag{2}$$

When $K1<K2/\beta$ and $K2<K1/\alpha$, intraspecific competition is bigger than interspecific competition, and the equilibrium population densities for both species will be reached at this point. Applying the Lotka-Volterra model to the tourist town system, the present study formulated the following assumptions:

a) The model is subject to the constraint of the carrying capacity (K), which represents the resource limit in the tourist town. Both the town and the tourism subsystems consume and compete for the limited resources within the spatial confinement of the town. The rate of growth slows down as the subsystems grow, until the magnitude of the subsystems reaches their carrying capacity.

b) The interaction between the town and the tourism subsystems can be positive, neutral or negative, and the diverse interaction could produce a wide range of relationship between the subsystems, similar to the typology of interspecific relations as shown in Table 1 (more detailed discussion later). The more positive the relation between the subsystems, the higher the overall level of development will be achieved for the tourist town, and vice versa. The effects of the interaction could be assessed by the average growth rate of the subsystems. A higher average growth rate indicates higher level of harmonious symbiotic relations, and vice versa.

c) The level of balanced development between the subsystems is measured by the degree of coupling. Coupling is a concept originated from physics. It refers to a phenomenon when two systems interact with and impact on each other, and eventually join together to become a union. This happens when the systems are inter-dependent and coordinate to bring about mutual benefits. The interaction between systems is the process of mutual influencing, reciprocal bonding, bilateral restricting, and may gradually couple together. It is also a process that they change the status, behavior, and direction of each other. In equation (3), α is the degree of coupling, and V represents the speed of evolution of the two subsystems (Qiao, & Fang, 2005). A value greater than zero indicates that the two subsystems move in the same direction and synergize with each other. Thus benign interaction between the subsystems will promote the development of the tourist town. On the other hand, a value less than zero suggests that the subsystems contribute little to each other, or may even clash. Meanwhile, changes in any of the subsystems will lead to changes in the overall system and the evolution of the tourist town.

$$\alpha = f\,(V_A, V_B) \tag{3}$$

Both the tourism and the town subsystems operate and develop under the constraint of the carrying capacity of the tourist town, thus the condition for inter-sector cooperation and competition was available. In the coupling process, the interaction between the subsystems could promote or inhibit the development of each other. Therefore, the Lotka-Volterra theory that models interspecific cooperation and competition is applicable to the tourist town system. The computational formulas are also consistent with basic idea of the degree of coupling as shown in equation (3). The Lotka-Volterra model was employed in the present study to reveal the status quo of competitive interaction between elements in the tourist town system. Modeling such interaction provides a useful framework for predicting outcomes.

The following graph (Figure 2) illustrates the effects of the interaction between the two subsystems, in which the scale of the town subsystem N(t) is plotted on the X-axis and the scale of the tourism subsystem L(t) is plotted on the Y-axis. Any point in this graph represents the co-existence of the two subsystems, subject to the limited resources defined by the carrying capacity of the tourist town. The two straight lines DA and BC are the zero isoclines for the town and tourism subsystems respectively, and are based on the law of diminishing marginal utility. The zero isocline is calculated by setting equation (4) equal to zero and solving for N. Therefore, any given point on the zero isocline (e.g., DA) represents a combination of the two subsystems when one subsystem (e.g., the town subsystem) does not increase or decrease. Based on the assumptions discussed above, the two isoclines cross one another at point E. This is the point that both subsystems do not increase or decrease, and thus an equilibrium is reached. This is exactly a harmonious stable co-development status described in equation (2), when the growth rates of both subsystems are set equal to zero.

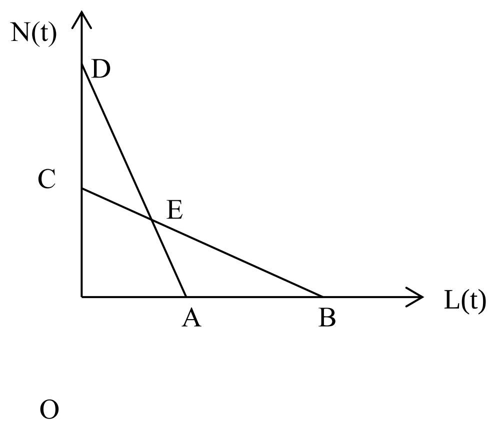


Figure 2. Effects of interaction between the subsystems of the tourism town

Within the constraint of the carrying capacity of the tourist town, the coupling relation between the town and the tourism subsystems produces positive, neutral, or negative effects, which consequently either promote or inhibit the development of the tourist town. Such effects resemble those of the interspecific cooperation and competition. However, the interaction among species is not simply cooperation and competition, and the range of relations between two species is described as a symbiotic continuum as shown in Table 1. The six types of relations represent the outcomes of the interaction sitting on a continuum from the most negative outcome (i.e., competition) to the most positive one (i.e., mutualism) (Lewis, 1985). Competition refers to a situation when the interaction produces negative impact on both species, while mutualism occurs when the outcomes of the interaction are beneficial to both side. In between, amensalism is a situation when one species is harmed while the other is unaffected; agonism represents a relation in which one species benefits and the other is harmed; neutralism refers to a situation in which both species coexist and are unaffected by each other; and commensalism represents the case when one species benefits while the other is unaffected.

Table 1. Typology of interspecific relations

Types	Effects on Species A	Effects on Species B	Effects of Interaction between Species
Competition	-	-	Mutually detrimental
Amensalism	-	0	One species is inhibited and the other is not affected.
Agonism	+	-	One species benefits at the expense of the other species.
Neutralism	0	0	Not affected
Commensalism	+	0	One species benefits and the other is not affected.
Mutualism	+	+	Mutually beneficial

Note: Modified from Lewis (1985). + indicates that the growth of the species is increased as a result of interspecific interaction; - indicates that it is decreased as a result of interaction; and 0 indicates it is not affected.

3.2. The theoretical model of tourist town

Applying the Lotka-Volterra model to the tourist towns, we have the following equations:

$$\frac{dN(t)}{dt} = r_1 N(t)\left[\frac{K_1(t) - N(t) - \alpha L(t)}{K_1(t)}\right]$$

$$\frac{dL(t)}{dt} = r_2 L(t)\left[\frac{K_2(t) - L(t) - \beta N(t)}{K_2(t)}\right] \tag{4}$$

In equation (4), the numbers 1 and 2 represent the two subsystems, and N(t) and L(t) represent the scale of the town and tourism subsystems respectively. K(t) is the carrying capacity of the subsystems, r is the rate of growth of the subsystems,α and β are the competition coefficients of the town and tourism subsystems respectively, and t refers to time. Therefore, α represents the effect of the tourism subsystem on the town subsystem, and likewise β represents the effect of the town subsystem on the tourism subsystem.

The competition coefficients indicate the competition between the two subsystems, and they constitutes the core indicators to evaluate the symbiosis status of the tourist towns. Assuming there is no vicious competition between the subsystems that would result in the competitive exclusion of one subsystem by another, then a stable equilibrium point would likely be reached when the two subsystems cooperate in harmonious symbiosis status.

When an equilibrium is obtained, namely when equation (4) is set to be equal to 0, the competition coefficients (α and β) are solved as:

$$\partial_i = \frac{K_i - N_i}{L_i} \tag{5}$$

$$\beta_i = \frac{K_i - L_i}{N_i} \tag{6}$$

The competition coefficients provide important tools to evaluate the effects of the interaction between the subsystems. Based on the values of the coefficients, the effects of subsystem interaction lead to three symbiotic models (Table 2). If α > 0 and β > 0, this indicates that the two subsystems compete viciously with each other and lead to inharmonious relation that neither party benefits from the competition. In this case, the results are detrimental to both subsystems and the tourist town as a whole. If one of the coefficients is positive and the other is negative (e.g., $\alpha > 0$ and $\beta < 0$, or $\alpha < 0$ and $\beta > 0$), the symbiosis relation brings benefits to one subsystem at the cost of the other subsystem. Under such situation, the overall development of the tourist town will likely be restrained and cannot achieve its optimal level. Finally, a situation where $\alpha < 0$ and $\beta < 0$ indicates mutualistic relationship that is beneficial to both parties. Achieving such symmetric and mutually beneficial symbiotic relationship is the rational and optimal result for all parties involved (Weng, Lv, & Li, 2016).

Table 2. Effects of the interaction between subsystems based on competition coefficients α & β.

No	Competition coefficients	Types of symbiosis relations
1	$\alpha < 0, \beta < 0$	Mutually beneficial interaction
2	$\alpha > 0, \beta < 0$ $\alpha < 0, \beta > 0$	Inharmonious development
3	$\alpha > 0, \beta > 0$	Vicious circle

Moreover, based on the above competition coefficients, the index for the Relationship of Harmonious Symbiosis (RHS) of tourist towns is constructed as equation (7). It measures the symbiosis relations between the subsystems and the extent that they coexist in mutually beneficial relations, when an equilibrium point is obtained by each of the subsystems.

$$RHS = \frac{\alpha + \beta}{\sqrt{\alpha^2 + \beta^2}} \tag{7}$$

The threshold value of RHS provides guideline to evaluate the symbiosis status of the tourist town system as a result of the interaction between the subsystems (as shown in Table 3). First, when $\alpha + \beta \leq 0$ and RHS □ $[-\sqrt{2}, -1]$, it indicates mutually beneficial interaction between the subsystems, and different sectors in the tourist town exhibits coordinated development. Second, if RHS □ $[-1, 1]$, this is a scenario in which the subsystems interact inharmoniously and the development of one subsystem suppresses the growth of the other subsystem. This scenario can be further classified into two situations. In one situation, when $\alpha + \beta \geq 0$, RHS values will fall within the range of [0, 1] (based on equation 7). In the other situation, when $\alpha + \beta \leq 0$, RHS values will be within the range of [-1, 0]. The higher the RHS value, the greater the negative impacts of one subsystem on the other as well as the suppression effect. Finally, when $\alpha + \beta \geq 0$ and RHS □ $[1, \sqrt{2}]$, it suggests a vicious competition cycle between the subsystems, which in the long run will likely lead to decline and regression of the tourist town.

RHS provides a useful tool for predicting outcomes of competitive interactions between the subsystems. Another aspect that is of equal importance is the level of development of the subsystems and its impact on the overall development of the tourist town. For this purpose, the index for the Level of Harmonious Symbiosis (LHS) is proposed to evaluate the level of development of the overall tourist town system (equation 8). Assuming that both N(t) and L(t) are greater than zero, then the larger the value of LHS, the higher the overall development level of the tourist town. This is because if the equilibrium points for both subsystems are at a higher level, it means that the competitive power of the subsystems as well as that of the tourist town is also greater.

$$LHS = \sqrt{N(t)^2 + L(t)^2} \qquad (8)$$

Equation 8 can be illustrated in a graph as shown in Figure 3, where the X-axis represents the scale of the town subsystem N(t) and the Y-axis represents the scale of the tourism subsystem L(t). For point A in the graph, LHS equals to the value of the line OA, which is calculated as $OA = \sqrt{OD^2 + AD^2}$. OA is bigger than OB, indicating that point A has a higher level of symbiotic development level than point B.

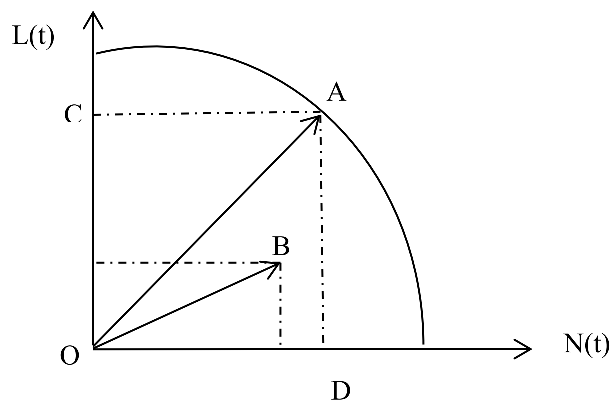


Figure 3. Geometric representation of symbiotic development level with the LHS index

Based on the above deduction and calculation, an evaluation model of harmonious symbiosis development of tourist towns is established, as shown in Table 3. The status of a tourist town's harmonious symbiosis could be assessed and classified based on the criteria set up in the model. Based on the values of the α, β, RHS, and LHS, the status of symbiosis development of tourist towns is classified into three types of symbiotic relations and three levels of symbiosis development, which make a total of nine (3 × 3 = 9) theoretical scenarios.

Table 3. Evaluation Model of Harmonious Symbiosis Status for Tourist Towns

No.	Competition coefficients	RHS	Types of symbiosis relations	LHS	Status of symbiosis development
1	$\alpha < 0, \beta < 0$	RHS □ $[-\sqrt{2}, -1]$	Mutually beneficial interaction	LHS $< I_1$	low level, coordinated development
				LHS □ $[I_1, I_2]$	medium level, coordinated development
				LHS $> I_2$	high level, coordinated development
2	$\alpha > 0, \beta < 0$ $\alpha < 0, \beta > 0$	RHS □ $[-1, 1]$	Inharmonious development	LHS $< I_1$	low level, inharmonious development
				LHS □ $[I_1, I_2]$	Medium level, inharmonious development
				LHS $> I_2$	high level, inharmonious development
3	$\alpha > 0, \beta > 0$	RHS □ $[1, \sqrt{2}]$	Vicious circle	LHS $< I_1$	low level, regression
				LHS □ $[I_1, I_2]$	medium level, regression
				LHS $> I_2$	high level, regression

Note: I_1 and I_2 are the threshold values obtained from the results of cluster analysis of the LHS index.

3.3. Development of the measurement indicators

The development of a tourist town reflects an area's overall population, economic, environmental, and social-cultural capability. Any single indicator is not sufficient to capture the town’s harmonious symbiosis state. Therefore, a set of indicators are proposed to measure the status of harmonious symbiosis for the tourist town system. These indicators are developed from the literature (e.g., Li & Zeng, 2010; Li, Zhang, & Lu, 2010; Peng, Zhou, & Wang, 2005; Zhou, 2010), incorporating the relevant ideas in China’s 13th Five-Year Plan for

Economic and Social Development formulated by China's central government in 2016. This five-year plan states that China's development in the new era will be an innovative, coordinated, eco-friendly, open, and shared development.

Specifically, we follow several guiding principles for constructing the indicators (Yang, 2010). The first principle is the comprehensiveness, meaning that the indicators should cover a broad scope to capture the multiple relations in the hierarchic complex tourist town system. The second principle is representativeness, suggesting that the indicators should represent various aspects and their typical features in the system and subsystems. The third principle is the comparability, stipulating that the indicators should be comparable in the dimensions of both space and time, so that they could accommodate to empirical data covering different spatial areas and temporal periods. The fourth one is the nonlinear principle, which is based on the fact that the various elements in the tourist town system have their own characteristics and complexity, and they operate on relatively independent spatial dimensions. Thus nonlinear systems theory provides the underpinning for building up the indicators. Finally, the practicability principle make compromise between what is optimal and what is doable, and take into consideration of the availability of data. Thus the indicators constructed can be applied in the empirical study.

We initially proposed a total of 23 indicators to measure three aspects of the tourist town system (namely, the town subsystem performance, the tourism subsystem performance, and the carrying capacity). We conducted two rounds of expert panel review to assess the importance of the indicators. Eight items were deemed unimportant and deleted accordingly (The eight indicators were shown with * in Table 4). Finally, the weights of the indicators were assigned using the entropy-weight method (explained in more detail in the next section). The final hierarchical measurement model composes of one overall system, three second-order subsystems, and 15 indicators (Table 4).

Table 4. Indicators of Harmonious Symbiosis Status for the Tourist Town System

Overall System	Second-order Subsystems	Indicators	Weights（W_{ij}）
The Tourist Town System	The Town Subsystem Performance	A_1: Urbanization rate (%)	0.812
		A_2: Per capita GDP (RMB)	0.086
		A_3: Per capita public finance revenue (RMB)	0.048
		A_4: Per capita investment in fixed assets (RMB)	0.021
		A_5: Per capita total retail sales of consumer goods (RMB)	0.020
		A_6: Per capita disposable income of urban residents (RMB)	0.007
		A_7: Per capita net income of rural residents (RMB)	0.004
		A_8: Number of high schools	0.002
		*A_9: Employment in the secondary and tertiary industries (%)	-
		*A_{10}: Number of hospitals per every 1000 people	-
		Total	1.000
	The Tourism Subsystem Performance	B_1: Tourism receipt as a percentage of GDP (%)	0.250
		B_2: Tourism employment as a percentage of total employment (%)	0.250
		B_3: Total tourism receipt (RMB)	0.250
		B_4: Number of tourist arrivals	0.250
		*B_5: Number of tourism resources	-
		*B_6: Number of tourism products	-
		*B_7: Number of travel agencies	-
		Total	1.000
	The Carrying Capacity	C_1: Low-carbon transportation (kilometer/population)	0.481
		C_2: Green ecological area (meter/population)	0.391
		C_3: Smart tourism (RMB/population)	0.128
		*C_4: Number of scenic spots per every 10,000 people	-
		*C_5: Number of star-rated hotels per every 10,000 people	-
		*C_6: Per capita green spaces (square kilometer/population)	-
		Total	1.000

Note: Indicators with * were deleted based on expert panel review.

Key indicators representing the performance of the town and the tourism subsystems are summarized in Table 4. The carrying capacity captures the key resources of the tourist town, which constitute the limit for the overall development of the town. In this table, the weights of the indicators are calculated using the entropy-weight method. The value of the weight is determined by the extent of variation of an indicator. In other words, if an indicator has a smaller information entropy (i.e., unpredictability), it contains less new information and thus lower weight, and vice versa. Before the calculation of the weights, the raw data set is standardized with the equation (9). In this formula, x_i^* represents the standardized value, x_i is the original value, μ_i is the mean, and δ_i is the variance.

$$x_i^* = (x_i - \mu_i) / \sqrt{\delta_i} \tag{9}$$

There are four major steps in the entropy-weight method adopted to calculate the weights of the indicators. First, assuming a matrix $X = (X_{ij})_{m \times n}$ contains *m* objects and *n* indicators, because the indicator represents different dimensions, magnitudes, and measurement, the raw data set is standardized before calculating the weights. The standardized matrix $F = (f_{ij})_{m \times n}$ is obtained with equation 10.

$$f_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}}, 0 \le f_{ij} \le 1 \tag{10}$$

In the second step, the information entropy e_j is calculated using equation 11.

$$e_j = -k \sum_{i=1}^{m} f_{ij} \ln f_{ij} \tag{11}$$

In the above equation, *k* is a constant related to the sample size (i.e., the number of objects *m*), *i* represents the *i*th object in the sample, and *j* represents the *j*th indicator. A system with perfectly disordered information has the highest entropy with e = 1. In other words, if the *m* objects in the sample are distributed disorderly, we have $f_{ij} = \frac{1}{m}$. Thus equation 12 becomes equation 13 as shown below.

$$e = -k\sum_{i=0}^{m}\frac{1}{m}\ln\frac{1}{m} = k\sum_{i=1}^{m}\frac{1}{m}\ln m = k\ln m = 1 \qquad (12)$$

Then, the value of k is obtain by the following equation.

$$k = \frac{1}{\ln m} \qquad (13)$$

However, when $k = \frac{1}{\ln m}$, certain assumption is required to make f_{ij} definable. For instance, when f_{ij} = 1, $f_{ij} * \ln f_{ij} = 0$. However, when f_{ij} = 0, $\ln f_{ij} = 0$; but this is unreasonable and inconsistent with the meaning of information entropy. Therefore, a modified definition of f_{ij} is given in equation 14.

$$f_{ij} = \frac{1+x_{ij}}{\sum_{i=1}^{m}(1+x_{ij})}, 0 \le f_{ij} \le 1 \qquad (14)$$

Thirdly, the weights of the indicators are calculated. e_j provides the information to measure the utility value of the *j*th indicator. When $e_j = 1$, it suggests that the utility of the *j*th indicator is zero. Namely, it contributes little to the evaluation indices. Therefore, a measure of the utility value of the *j*th indicator is given by the following equation (15).

$$h_j = 1 - e_j \qquad (15)$$

Thus the measure h_j provides the tool to calculate the weights of the indicators. The higher its value, the greater the significance and contribution of an indicator to the indices. Finally, the weight w*j* of the indicator *j* is determined by equation 16.

$$w_j = \frac{h_j}{\sum_{j=1}^{n} h_j}, \sum w_j = 1, 0 \le w_j \le 1 \qquad (16)$$

4. Empirical study

4.1. Research context: Guizhou Province, China

The current small town development policy in contemporary China is inspired by the towns with unique features in other countries, such as the Davos in Switzerland, Greenwich in Connecticut, USA, and Provence in France. In China, the economic transformation through the development of new township was pioneered in Zhejiang Province in 2015. Similar initiatives are adopted by local governments across China, as part of the transformation of the country's economy in a new era. This new economic model is different from the high-speed growth economy in the past decades. It features a more sustainable, medium to high rate growth, with an emphasis on high efficiency and low costs (China Daily, 2014). A town following the new model of development is termed as "small town with unique characteristics", defined as a relatively independent area that has explicit industrial positioning and cultural orientation, which combines multiple functions such as industrial production, living, tourism, and residence. It is a platform with specific spatial delimitation, and exhibits featured industries, integrated functions, ecologically sound environment, and flexible institution (Zhejiang Provincial Government, 2015).

The current wave of small town development in China is inextricably linked to the global production network. Traditional towns in China are administrative areas between metropolitan and rural areas. They are the economic centers for the local economy, and also serve as public service centers (Wu & Xu, 2018). Through strategic coupling with metropolitan or global actors, local places are able to take on an upgrading process that enables them to improve their position in the international trade networks, and take on new local or regional development trajectories (Sanz-Ibáñez & Anton Clavé, 2016). Depending on their economic specialization, resource advantage, and geographical location, towns in China have adopted different strategies to join the global production network or to meet the consumer demand from big metropolitan areas. Many historical towns (such as Zhouzhuang and Wuzhen) that are about 1-2 hours' drive from mega-cities such as Shanghai and Hangzhou have now become renowned tourist destinations (Ma, Weng, & Yu, 2015). These tourist towns have been increasingly integrated with the metropolitan and global consumer market. This model of small town development has experienced success in the more developed eastern coastal regions of China, however it is not clear whether the successful experiences could be duplicated in the western part of the country (Wu & Xu, 2018).

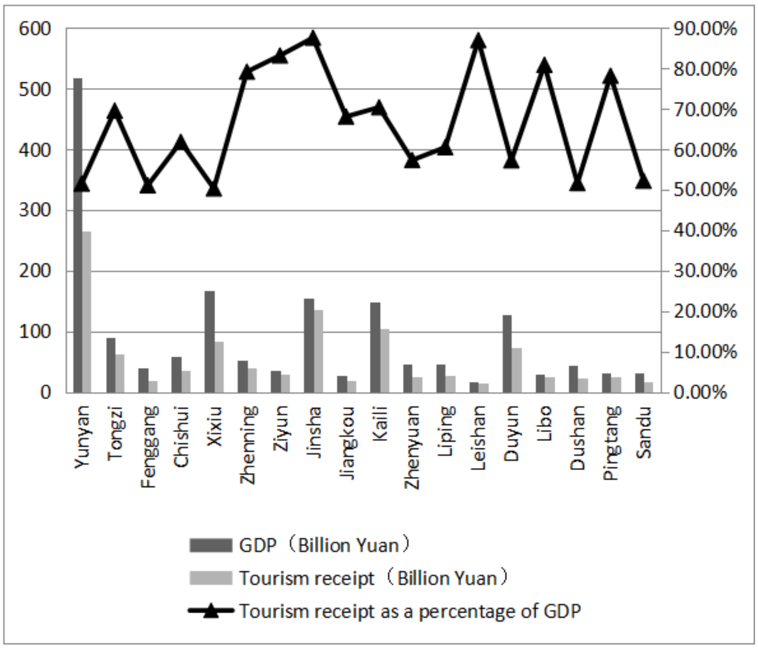
The empirical context for this study is the Guizhou Province of China, which has about 39% of the population made up of minority ethnic groups. Mountainous and hilly regions cover 92.5% of the land, and 61.9% of which is Karst formation. As an inland area located on the hilly Yungui plateau, the Guizhou Province lags behind most of the other provinces in China in the past and present. The Gross Regional Product (GRP) of the Province was about 1050.26 billion RMB in 2015, accounting for 1.55% of the GDP of the country. Its GRP ranked 25th among the 31 provincial regions in mainland China (National Bureau of Statistics of China, 2016).

Along with the rapid development of both domestic and international tourism in China, the province's great potential for tourism development is well recognized by the government. The province has unspoiled charm with its pristine environment, and the diverse and unique cultures within the ethnic minority groups. In its 13th Five-Year Plan for Economic and Social Development (2016-2020), the provincial government has established strategies for promoting tourism development as a springboard to upgrade its economy and service industries. According to the report by the Guizhou Tourism Development Committee, for the first half year of 2016 the Province had received a total of 257 million domestic and international tourist arrivals, and its tourism revenue was about 224.14 billion RMB, representing growth rates of 39.2% for domestic arrivals and 41.1% for international arrivals, compared with the same period in 2015. At the national level, the country's domestic and international tourist arrivals were approximately 2.24 billion (representing a year-on-year increase of 10.47%) and 13.47 million (an increase of 9.0%) respectively, and the total tourism revenue was 2250 billion RMB (an increase of 12.4%) in the first half year of 2016 (China National Tourism Administration, 2016).

4.2. Data

Following the most commonly used technical definition, we operationalize tourist towns as those towns (or counties) where tourism receipts account for over 50% of the towns' GDP, and the tourism industry become an important pillar of the local economy (Zeng, 2010). Among the 88 towns (counties) in Guizhou Province, there are only 18 towns whose tourism receipts as a percentage of their respective GDP reached 50% or above, based on their average percentage between 2009 and 2014. These 18 towns are qualified as tourist towns and included in the study sample (as shown in Figure 4). The data used in this study were collected from government statistical yearbooks and websites.

GDP and Tourism Receipt



Tourism Receipt as a percentage of GDP

Figure 4. Tourism Receipt and GDP of 18 Tourist Towns in Guizhou Province, China (Average of the Years 2009 - 2014)

4.3. Results of the competition coefficients

The competition coefficients provided tools to evaluate the effects of the interaction between the subsystems, and the results could be interpreted using Table 1 as guidance. In Table 1, the positive symbol (+) indicates that the effects of one subsystem on the other is beneficial, which corresponds to negative competition coefficients (α and β), and vice versa. Figure 5 below shows the average values of the competition coefficients (α and β) from 2009 to 2014 for each of the 18 tourist towns respectively.

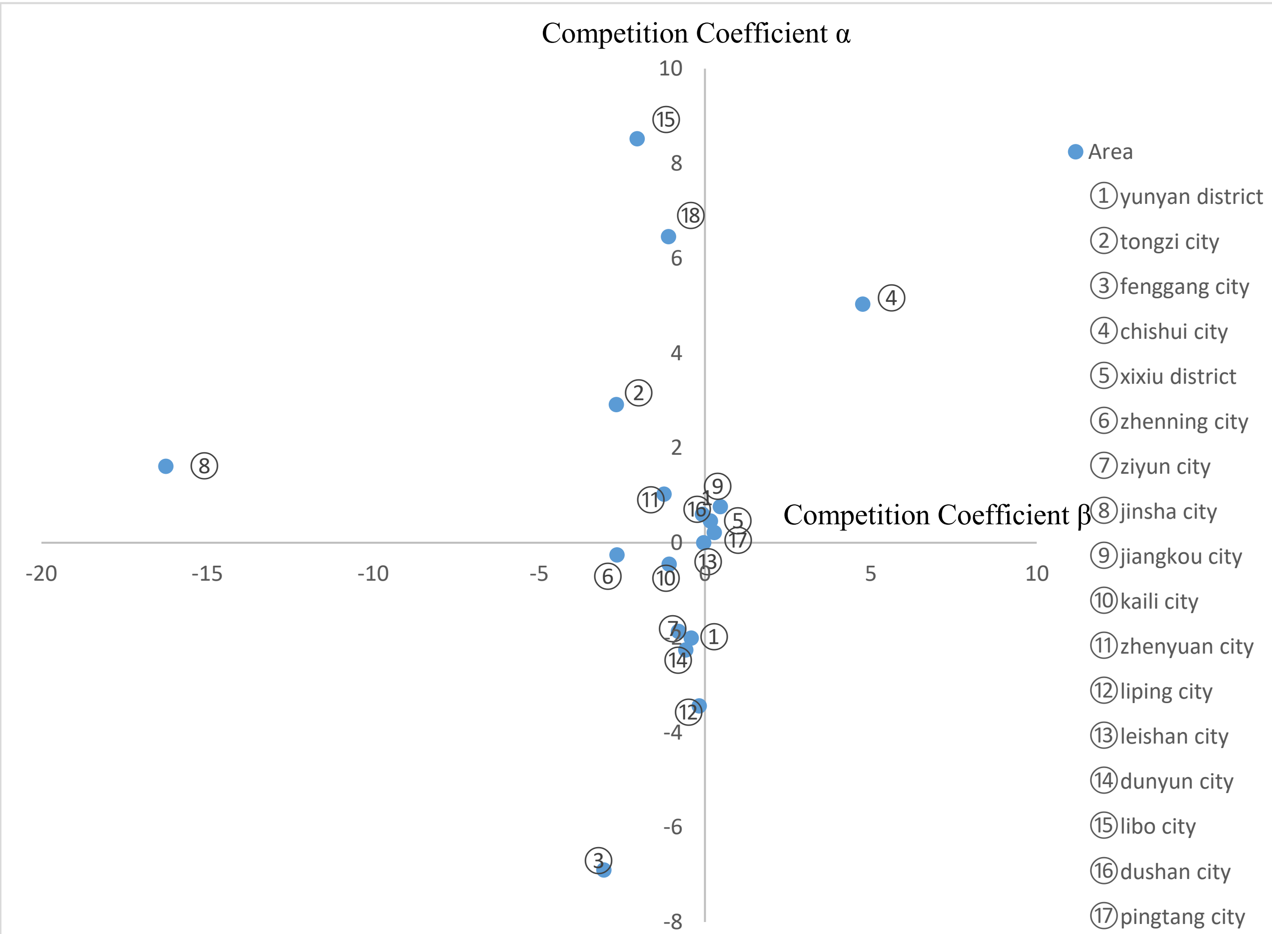


Figure 5. The distribution of the competition coefficients of the 18 towns in Guizhou

The 18 towns fell into three quadrants and with different RHS values. First, four counties had positive values for both α and β, and their corresponding points were all located in the first quadrant. This indicated that the two subsystems within the tourist town demonstrated mutually detrimental effects on each other. Counties falling within this category included Chishui, Xixiu, Jiangkou, and Pingtang. On the other hand, the eight counties that had both negative α and β (located in the third quadrant) included Yunyan, Fenggang, Zhenning, Ziyun, Kaili, Liping, Dunyun, and Leishan. Therefore, the subsystems within these tourist towns had harmonious and benign interactive relations. Finally, the rest of the 6 counties all appeared in the second quadrant (with $\alpha > 0$ and $\beta < 0$). These included Tongzi, Jinsha, Zhenyuan, Libo, Dushan, and Sandu, which represented asymmetrical symbiotic relationship between the subsystems, which in the long term could inhibit the development of the tourist towns. As α represented the effect of the tourism subsystem on the town subsystem, and β represented the effect of the town subsystem on the tourism subsystem, the positive α and negative β indicated that the tourism subsystem had detrimental competitive impact on the town subsystem, while the town subsystem had beneficial impact on the tourism subsystem in the 6 towns. The counties in the second quadrant could be further divided into two situations (more detailed discussion later). In one situation, when $\alpha + \beta \geq 0$, RHS □ [0, 1] (based on equation 7). In the other situation, when $\alpha + \beta \leq 0$, RHS □ [-1, 0]. The higher the RHS value, the greater the negative impacts of tourism subsystem on the town subsystem. There were no counties located in the fourth quadrant (with $\alpha < 0$ and $\beta > 0$).

4.4. Results of the Harmonious Symbiosis Relationship

The RHS values for the 18 tourist towns were calculated based on equation (7). Figure 6 shows the distribution of the values. Based on the thresholds established in Table 3, it was found that three counties (Yunyan, Kaili, and Duyun) had RHS values within the interval of

(−√2, −1), indicating mutually beneficial interaction among the subsystems. In other words, the economic development of the towns contributed positively to the tourism industry, and vice versa. One county Jiangkou had RHS value within the interval of (1, √2), which suggested that the subsystems had suppressing effects on each other. The result implied that the tourist town was in a vicious circle of development. Jiangkou's economy mainly relied on the agricultural industry, and currently no single industry was strong enough to promote rapid economic growth. The remaining counties (77.78%) revealed RHS values between −1 and +1, indicating inharmonious development among the subsystems. Namely, the growth in one subsystem caused decline in the other subsystem. Figure 6 revealed that the 18 tourist towns differed greatly in terms of their harmonious symbiosis status.

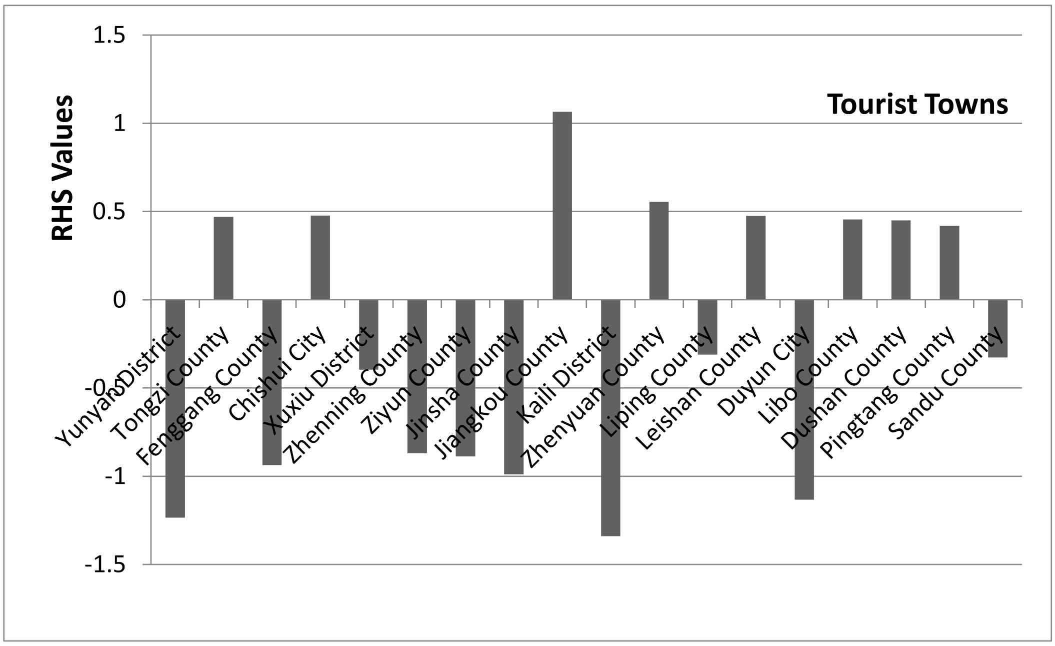


Figure 6. The distribution of the RHS values of the 18 tourist towns in Guizhou

4.5. Results of the LHS

The LHS values were calculated for the years between 2009 and 2014 for each of the 18 towns, and Figure 7 presents the average values for the 6 years. In contrast to the wide variance shown in the RHS values across the towns, the LHS values revealed much smaller gap across the towns. Except for Yunyan, all of the other towns had positive LHS values between 0 and 2.226. Yunyan stood out with a much higher value (3.444), and it was the only area that had achieved a high level of overall development - whereas the other towns all fell within the medium to low levels.

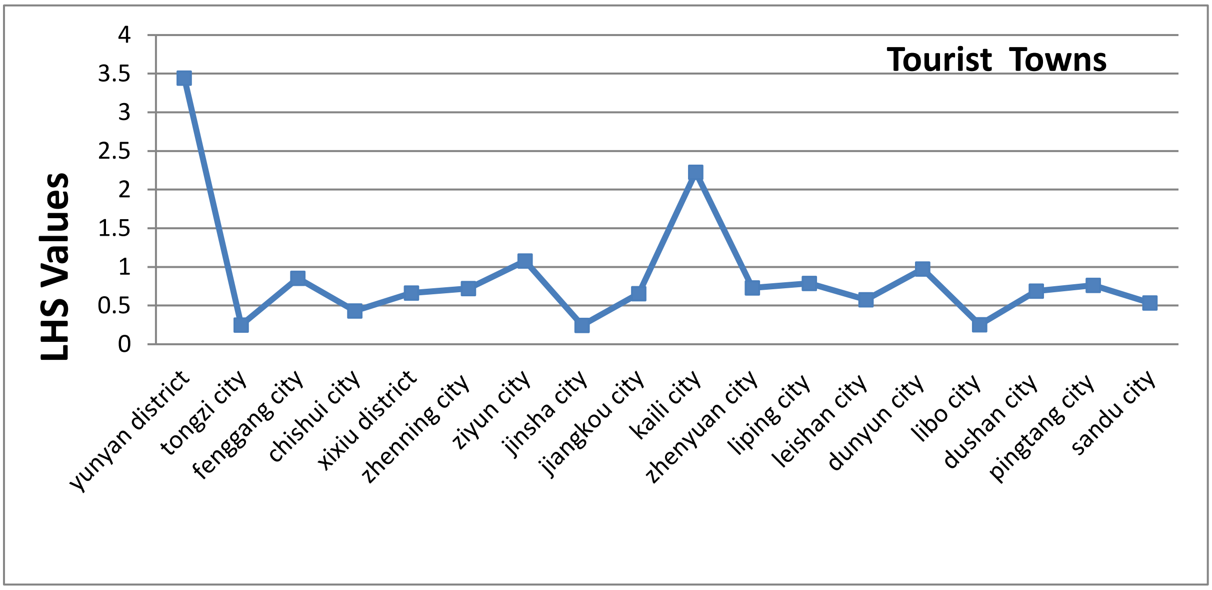


Figure 7. The Distribution of the LHS Values of the 18 Tourist Towns in Guizhou Province

4.6. Typology of Harmonious Symbiosis Status

After the RHS and LHS values were established, the typology of the tourist towns' harmonious symbiosis status was assessed based on cluster analysis. Among the nine theoretical scenarios shown in Table 3, the empirical results exhibited six types for the 18 towns (Table 5).

Table 5. Typology of Harmonious Symbiosis Status of the Tourist Towns in Guizhou Province

No.	Areas	Average RHS (2009-2014)	Average LHS (2009-2014)	Mean of LHS	SD of LHS	Typology of Harmonious Symbiosis Status
1	Yunyan	-1.235	3.444	3.444	N/A	High level, coordinated development
2	Kaili	-1.340	2.226	1.653	0.811	Medium level, coordinated development
3	Ziyun	-0.887	1.080			Medium level, inharmonious development
4	Duyun	-1.133	0.976	0.608	0.226	Low level, coordinated development
5	Fenggang	-0.937	0.853			Low level, inharmonious development
	Liping	-0.311	0.788			
	Pingtang	0.419	0.761			
	Zhenyuan	0.555	0.728			
	Zhenning	-0.869	0.721			
	Dushan	0.450	0.688			
	Xixiu	-0.396	0.662			
	Leishan	0.476	0.576			
	Sandu	-0.326	0.534			
	Chishui	0.476	0.430			
	Libo	0.456	0.255			
	Tongzi	0.470	0.250			
	Jinsha	-0.990	0.245			
6	Jiangkou	1.065	0.653			Low level, regression

The first type can be characterized by the coordinated development between the subsystems as well as high level of overall development. Yunyan is the only area belonging to this category, with overall development level well above the other towns. It is an area with advanced economic and urban development, exemplified by high levels of residents' income, education, and consumption. The mutually beneficial interaction between its two subsystems (indicated by its RHS value) provides strong foundation for the optimal development of the town in its totality (as shown by its LHS value).

The second type has mutually beneficial relations between subsystems and medium level of overall development. Kaili is the only area falling within this category. The first two types benefit from the benign interaction between the town and the tourism subsystems, which promotes industrial coupling and amalgamation between the tourism industry and other sectors in the tourist towns. Such reciprocal relationship between the subsystems is conducive to high level of development of the tourist towns. Both Yunyan and Kaili demonstrate flourishing tourism industry and well-constructed infrastructure and superstructure.

The characteristic of the third type is inharmonious development between subsystems and a medium level of overall development, represented by the county of Ziyun, which had an average LHS value of 1.080, ranking the third in the list. This suggests that the county had an overall development level higher than most of the other areas. However, its town subsystem poses a competitive threat to the tourism subsystem, and vice versa. The lack of coordinated development between the subsystems could hinder further development in the area.

The fourth type exhibits coordinated development between subsystems, albeit at a low level of overall development. The only representative in this category is Duyun. The county is under-developed in most aspects and required long-term planning and investment to make improvement.

The majority of the tourist towns (i.e., 13 of the 18 tourist towns, or 72.22%) belong to the fifth type, featuring inharmonious relation between subsystems and low overall development. The low LHS values indicate that these towns were still at a backward development stage on the whole. The competition between subsystems for limited resources might have inhibited the development of the towns. The results suggest that in general tourist towns in Guizhou Province were not highly developed and in need of improvement.

The last type is characterized by mutually detrimental relation between subsystems and low overall development. In other words, the tourist town is in a vicious circle of regression because of the inhibition and competition between subsystems. Jiangkou County is the only area belonging to this category.

4.7. Models of development based on symbiosis status

According to their harmonious symbiosis status (shown in Table 5), we further categorize the tourist towns into three development models based on the RHS and LHS values (see Figure 8). The X-axis represents the RHS value; and the relation between subsystems changes from harmonious to inharmonious when the value changes from a negative value on the left to a positive value on the right of the X-axis. The Y-axis represents the LHS value; and the higher the value, the higher the overall development level of the tourist town. Figure 8 sets zero as the origin of coordinates. Because the LHS values of the 18 towns are all positive, all the points are located in the first and second quadrants in the coordinate plane. Borrowing the idea of symbiotic continuum from Lewis (1985), we name the three development models as antagonism, skewed commensalism, and mutualism respectively.

Firstly, the towns located in the first quadrant are classified in the antagonism development model, characterized by poor performance in both the RHS and LHS indices. The positive RHS value indicates detrimental interaction between the subsystems, and the low LHS value indicates low levels of overall development. The counties in the first quadrant can be further divided into two situations. In one situation, when $\alpha > 0$, $\beta < 0$, and $\alpha + \beta \geq 0$, then RHS □ [0, 1] (based on equation 7). As the positive α and negative β indicate that the tourism subsystem has detrimental competitive impact on the town subsystem, while the town subsystem has beneficial impact on the tourism subsystem, the results represent a situation when the negative impact of the tourism subsystem is bigger than the positive impact of the town subsystem. This includes the six counties of Pingtang, Zhenyuan,Dushan, Leishan, Chishui, Libo, and Tongzi. The other situation is characterized by $\alpha >$, $\beta > 0$, and RHS □ $[1, \sqrt{2}\,]$. This is represented by Jiangkou only. The positive α and β suggest that the two subsystems of the tourist town have mutually detrimental impact on each other, and the negative impact is big enough (shown with an RHS value bigger than 1) to lead to vicious competition between the subsystems as well as a backward state of development of the tourist town in general.

Secondly, the skewed commensalism model include the points located in the lower section of the second quadrant. Among the 18 tourist towns, 8 (44.44%) belong to this model, including Duyun, Ziyun, Fenggang, Liping, Zhenning, Xixiu, Sandu, and Jinsha. They had RHS between (or close to) the range of -1 and 0, and LHS values between (or close to) the range of 0 and +1. For the cases under study, an RHS value between -1 and 0 was generated by the following two scenarios. One was when both $\alpha < 0$ and $\beta < 0$, indicating mutually beneficial impact between the subsystem; and the other was when $\alpha > 0$, $\beta < 0$, and $\alpha + \beta \leq 0$, suggesting that the negative impact from the tourism subsystem was less than the positive impact caused by the town subsystem. The results suggest more or less benign relation between the subsystems. However, the beneficial impact as a result of the interaction between the subsystems was weak as shown by an RHS value bigger than -1. Moreover, LHS values less than 1 indicates low overall development for these towns. This reflects the general situation of the province, whose economic development lagged behind most of the other provinces in China. Moreover, its location in the inland plateau region also poses problems for accessibility and openness to the outside world. Therefore, it may take considerable time for the tourist towns to reach the harmonious symbiotic status of development.

Thirdly, the mutualism model represents the optimum status for tourist towns, characterized by low RHS values (below -1) and high LHS values (above +2). It indicates harmonious symbiotic interaction between the subsystems, and medium to high levels of overall development. Currently, only two areas Yunyan and Kaili were able to achieve such results, as shown by their location on the upper left section in the second quadrant of Figure 8. For example, the Yunyan area had an LHS value of 3.444, which was three times more than most of the other areas (except for Kaili, with an LHS value of 2.226).

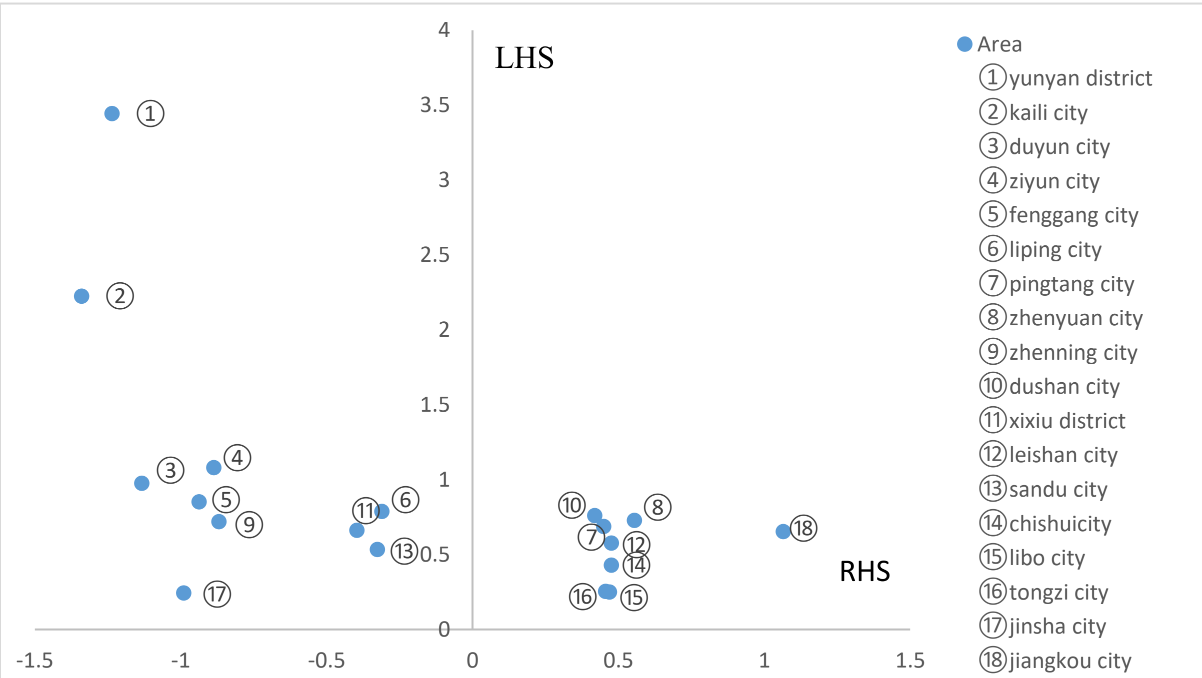


Figure 8. Classification of the Tourist Town Development Models in Guizhou Province

4.8. *Discussion*

The mutualism model (represented by the Yunyan and Kaili) shows coordinated development between subsystems as well as medium to high levels of overall development. In terms of the RHS value (as shown in Table 5), Yunyan, Kaili, and Duyun were the top performers with a value less than -1, indicating relatively strong and mutually beneficial interaction between the subsystems. All the other towns had an RHS bigger than -1. The results suggest that most of them either had negative impact from the tourism subsystem on the town subsystem; or in a few cases, the impact from the tourism subsystem was positive but small. In terms of the LHS value, compared with Yunyan and Kaili, which had an LHS value of 3.444 and 2.226 respectively, the other towns showed much lower overall development (with LHS values between 0.245 and 1.080). The results indicate strikingly unbalanced development across different regions in Guizhou Province.

The two counties of Yunyan and Kaili are located at the centers of the provincial or prefectural/regional administrative areas. Therefore, they are able to integrate the political, economic, social and cultural resources to promote higher levels of development at the administrative center, and to forge stronger coupling between the tourism sector and other sectors in the town system. On the other hand, the counties falling within the commensalism model are located in areas populated by ethnic minority groups, and eight of these counties are designated as poverty-stricken counties by the national government. With a landscape of Karst formation and lofty mountains, these areas have limited arable land, natural resources, and infrastructure. Modern transportation is developed only in the recent decade. Given the limited resources, the sectors in the tourist town may have to compete with each other to promote their own development. Thus, the prioritization given to one sector would likely lead to the suppression of another sector. Moreover, although Guizhou Province possesses great potential for tourism, its current level of tourism development is still at an early stage, which mainly relied on sightseeing activities. Tourism related products such as dining, accommodation, recreation, entertainment, events, and vacationing facilities are not fully developed, consequently, the multiplier effects of the tourism industry and its coupling with other sectors in the tourist towns are minimal. Thus these towns exhibit inharmonious relations between subsystems. The results may be related to the phenomenon of metropolitan shadow, which means that there is a development gap between central cities and their surrounding rural areas, as indicated by Sun, Zhang, Hu, et al. (2013) and Wang & Wei (2015). It creates siphon effects that the aggregation of production factors in the central areas put them at an advantageous position to draw high quality resources from peripheral areas, leading to further development at the centers, and at the same time marginalizing the peripheral areas (Fu, 2005). The formation of metropolitan shadow can be related to multiple factors, such as natural resources, geographical location, policy bias, transportation conditions, and industrial structure (Pan & Yao, 2017).

Moreover, similar to most of the regions in the western part of China, the economy in Guizhou Province features dual economic structure between the rural and urban areas, and the income gap between urban and rural population had been widening (Wang & Li, 2011). According to Wang and Li (2011), the dual economic structure is the main cause of the sharp income gap between urban and rural areas in the western part of China. Such economic structure shows the coexistence of modern industry in urban centers and traditional small-scale agricultural practice in rural areas. The urban centers enjoy an advantageous position in the accumulation of physical capital, human capital, and technological progress, whereas the rural areas struggle with labor outflow, human capital loss, and lack of investment (Xu, Shi, & Huang, 2014). Given the scarce land resources and fragile ecological environment in Guizhou Province, the fast development in provincial and prefectural centers may exacerbate the marginalization of the poorer peripheral areas. The contrast between the mutualism model with only 2 towns and the other 16 towns under study may be a reflection of the broader dual economic structural pattern that is common in Western China. Moreover, Yunyan and Kaili may be the only towns under study that have successfully integrated their tourism industry with visitor demand from nearby and nationwide metropolitan centers, and their relatively better performance could be attributed to their proximity to centers of large population, with more developed economic and social structure, and efficient transportation networks.

Finally, Jiangkou is a special case representing the agonism model as defined by Lewis (1985). It is a poverty-stricken county relying on traditional agriculture, with minimal development in secondary and tertiary industry. However, tourism is an important sector for the local economy, as the county is blessed with Fanjing Mountain, which is one of the most important national nature reserve and must-visit attraction in Guizhou Province. With a forest coverage of 95%, it is a protected area for many endangered species. Nevertheless, because the county lags behind in infrastructure and tourism-related superstructure (such as accommodation and recreation services), its tourism receipt predominantly comes from the admission tickets. Majority of the visitors are same-day visitors, and the industrial linkage between tourism and other sectors is weak.

The above results suggest that to become a successful tourist town, a coupling process between the tourism sector and other sectors in the town system should be in place; so that the sectors in the town become mutually dependent to act for common objectives. Moreover, in an era of globalization in the information age, tourist towns need to connect with the metropolitan and global consumer demand for expanded leisure space and quality environmental and cultural experiences. However, certain conditions or prerequisites are required before a town could make things happen to improve its competitive position. These may include, for example, human capital, economic basis, geographical location, and transportation networks. More investigation needs to be conducted to examine the conditions and process that would enable the coupling and integration process both within the tourist town and with the metropolitan and global market outside of the town.

The findings have several practical implications. The antagonism and skewed commensalism models represent inferior situations that required improvement to move towards the mutualism model. First, a town could choose an evolutionary path by taking consideration of its comparative strength and weakness in the town system. A larger positive RHS value indicates more inharmonious interaction between subsystems, while a smaller RHS value (negative value) suggests the opposite. Eight of the 18 tourist towns belonging to the antagonism model had a positive RHS value, including Pingtang, Zhenyuan, Dushan, Leishan, Chishui, Libo, Tongzi, and Jiangkou (as shown in Table 3). The results indicate that the negative interaction between the subsystems within the tourist towns had reached a level that exacerbated the conflicts in the towns. Therefore, the strategy for further development should focus on reducing the conflicts first before the towns can be lifted to a higher level of performance. The evolutionary path for these towns would be to move horizontally from the first quadrant to the second quadrant as the first step, and then move up perpendicularly in the second quadrant. Moreover, as the negative impact was mainly created by the tourism subsystem on the town subsystem, these towns should scrutinize the model of tourism development and products they have pursued, and examine their compatibility with the resource endowment and other sectors of the tourist town.

Second, the skewed commensalism model includes 8 towns that have a negative RHS value (yet bigger than -1), including Ziyun, Duyun, Fenggang, Liping, Zhenning, Xixiu, Sandu, and Jinsha. The interaction between the subsystems generally produced benign overall results. For some of the towns, although inharmonious interaction between subsystems still exists, it is at a moderate or minor degree that might not pose fatal bottleneck for further development. These towns are at very low level of development in most aspects, as such they have much potential to improve the strategic coupling between the subsystems and in doing so will likely promote their overall development to a higher level. Consequently, the priority for these towns is to pursue further development in both the tourism and other sectors. With the growth in various sectors, the restructuring of the system will create new functions and industrial relations. Opportunity might arise in which more harmonious relations could emerge at a higher level of equilibrium. These towns could follow an evolutionary path by moving up perpendicularly first, and then horizontally to achieve an optimum state.

5. Conclusion

Tourist towns are first and foremost places to be lived in, and the tourism attractions come with them, including the physical quality of the townscape as well as the life within the places (Orbasli, 2002). A symbiotic systems perspective is adopted in this study to examine the status of interaction between the two subsystems of tourism and town development within tourist towns in a less developed province, Guizhou of China. The study regards a tourist town as an open system where the town provides the resources and delimits the carrying capacity for tourism development. Drawing on the theory of interspecific competition, specifically the Lotka-Volterra model (Lotka, 1925; Volterra, 1926), this study proposes two critical indices, namely the RHS and LHS, to assess the symbiotic relations between the subsystems and the overall development level of the tourist towns respectively. A set of indicators were formulated to measure the key components in the model, including the carrying capacity K, the performance of the town subsystem and the tourism subsystem. The symbiosis development status of these towns was classified into 6 types and 3 development models, and recommendations were proposed for the towns to choose an evolutionary path that could help them to achieve a more harmonious and higher level of development. This line of research is especially valuable given the rapid development of tourist towns in China. As demonstrated in our empirical case study, our proposed model could be used to diagnose the strengths and weaknesses in the development of a tourist town, and provide practical guidance for government policy intervention.

This study demonstrates that such knowledge of a tourist town system could provide valuable practical guidance for sustainable tourism development. By proposing the use of system symbiosis approach to examine status of tourist town development, the present study provides a useful starting point to inspire more scholarly studies on this topic. Inharmonious development between tourism and other sectors of the town system is not an uncommon phenomenon in the case study area. Similar situations have been observed in other tourist towns and cities in China (Peng, Zhou, & Wang, 2005; Qian, Feng, & Zhu, 2012). However, knowledge is scarce on how to facilitate successful tourism urbanization and upgrading of the tourist destinations. As argued by Anton Clavé and Wilson (2017), the process of urbanization and urban transformation underpinned the evolution of the tourism sector, and the interplay between the tourism and other sectors in the tourist town system warrants further investigation.

The study has some limitations which open up new avenues for further research. First, the model was simplified to include only two subsystems to capture the main components in the tourist town, and the indicators used for the operationalization of the model were parsimonious due to the lack of official data in China, especially at the county and town level. The indicators were localized to fit the empirical context and may need adjustment when applied to other regions. Moreover, future research could adapt the model to analyze the dynamism among competing species within a tourism ecosystem, which could be any products, industries, technologies and many others; as well as to forecast the development trends of the competing species to support tourism policy development and implementation. Second, the indicators are mainly economic ones with few social and cultural indicators. Future studies could expand the set of indicators to include key social and cultural indicators that are indispensable for long term sustainable development. Third, the study identifies the symbiotic status of the 18 tourist towns by drawing on a single model of the Lotka-Volterra. It would be interesting for future studies to compare the results with those obtained with different methods. For example, principal components analysis or other well-established classification model could be employed to identify the patterns of tourist town development. This could provide valuable cross validation of the current study. Models such as industrial spatial linkage (Sun, Zhang, Hu, et al., 2013) could be applied to address issues related to tourist town development. Despite the limitations, the study contributes to the tourism literature by providing a new approach to examining tourism development from a symbiotic systems perspective with original model indices, and demonstrating its practical application that generates insights for tourism policy development. The study would stimulate future tourism studies that view tourism development as a co-evolution process with other components of the destination's ecosystem.

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