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Can the Diffusion Modes of Green Technology Affect the Enterprise's Technology Diffusion Network towards Sustainable Development of Hospitality and Tourism Industry in China?

Keke Sun [1], Xia Cao [1,*] and Zeyu Xing [2,*]

[1] School of Economics and Management, Harbin Engineering University, Harbin 150001, China; sunkeke@hrbeu.edu.cn
[2] School of Management, Zhejiang University of Technology, Hangzhou 310023, China
* Correspondence: caoxia@hrbeu.edu.cn (X.C.); xingzeyusmile@zjut.edu.cn (Z.X.)

Abstract: In the post-epidemic era, encouraging enterprises to implement green technology innovation in the hospitality and tourism industry is important, which can reduce resource consumption, decrease environmental pollution and promote sustainable industrial development. Based on evolutionary game theory and Exponential Random Graph Models (ERGM), this paper develops an evolutionary game model between focal and marginal enterprises and analyzes the dynamic evolutionary process and the steady state of the evolutionary strategy of the major stakeholders. The impact of different technology diffusion modes on the enterprise's technology diffusion network is quantitatively verified using ERGM and MPNet software. The results show that the neighborhood effect has a positive impact on the technology diffusion network of enterprises in the hospitality and tourism industry, the partner effect has a negative impact on the technology diffusion network of enterprises, and the social circle effect has a significant positive effect on the technology diffusion network of enterprises in the hospitality and tourism industry. This study can help governments to develop more targeted policies that can serve as a basis for enterprises to develop dynamic strategies and can further facilitate the implementation and diffusion of green technology innovations in the hospitality and tourism industry.

Keywords: sustainable development; hospitality and tourism industry; green technology; technology innovation diffusion; innovation network

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1. Introduction

Sustainability is important as it can decrease environmental pollution, eliminate wasteful outputs, and reduce unnecessary losses [1,2]. For countries with relatively scarce resources, sustainable development is even more important in terms of the situation that should prevail in all areas [3]. In recent years, the development of hospitality and tourism has also generally been faster than the growth of a country or region's GDP, a development trend that has reinforced the importance of hospitality and tourism in economic development, which, by its very nature, also includes functions such as the conservation of natural resources and cultural heritage, education, and social welfare, etc. Due to the overly singular positioning of functions, hospitality and tourism resources and the environment are in danger of being destroyed or even lost. The hospitality and tourism industry, which is currently the world's leading industry, is at a crossroads, and the choice between pursuing economic functions or focusing on resource and environmental protection in hospitality and tourism development has become a dilemma. Especially in China, to achieve sustainable development in the hospitality and tourism industry, enterprises need to be able to actively share their innovative experiences and creative ideas, build awareness, and measure the impact of the economic and social benefits of sustainable

development [4], thus contributing to all of the 2030 Sustainable Development Goals. It is against this background that the concept of "green innovation" and "green technology innovation" were born. Green innovation in the hospitality and tourism industry refers to the process of developing tourism that is saves resource is and environmentally friendly through product innovation, process innovation, management innovation, system innovation, and other innovation activities, adhering to the principle of sustainable development [5]. Green technology innovation in the hospitality and tourism industry has significant contribution in reducing resource consumption and environmental pollution in the process of industry development, which helps to realize the sustainable development of hospitality and tourism resources and becomes a powerful power source to transform the development mode of the industry to achieve high-quality development [6]. Green technology innovation in the hospitality and tourism industry refers to the innovation of various green technologies throughout the whole process of innovation activities. According to the industries involved, it can be divided into green technology innovation in various industries such as accommodation, catering, transportation, sightseeing, shopping, entertainment, etc. These technologies include green technology in accommodation facilities, green catering technology, green transportation technology, and green sightseeing technology, etc. According to the nature and characteristics of green technology, these technologies include clean production technologies in the hospitality and tourism processes, hospitality and tourism environmental pollution management technologies, and hospitality and tourism resource protection technologies, among which hospitality and tourism clean production technologies mainly include clean energy technologies, such as simultaneous heat and power generation technologies, solar water heating system technologies, photovoltaic system technologies, wind power generation technologies, biofuel technologies, small hydroelectric system technologies, etc. The hospitality and tourism industry environmental pollution control technology includes tourism waste treatment technology, sewage treatment technology, vegetation restoration technology, etc. The hospitality and tourism industry resource protection technology refers to various high-tech means applied in the hospitality and tourism industry resource protection, such as modern information technology, 3S technology, etc. [6]. With the expansion of the digital economy, China's government proposed the opinion on deepening "Internet + Sustainability + Tourism" to promote high-quality tourism development and emphasized that green technology innovation can facilitate a paradigm shift in innovation, driving companies towards sustainable and responsible development and achieving a win-win situation for both economic and environmental effects.

The research and development, promotion, and application of green technology innovations are important in the hospitality and tourism industry, which can help to realize sustainable and environmentally friendly development of hospitality and tourism resources [7,8]. Recently, many developed and developing countries have adopted a range of promotional policies in the hospitality and tourism industries, such as R&D subsidies, government procurement, tax incentives, green finance, etc. [8–11]. However, the diffusion of green technology in the hospitality and tourism industry is still slow, especially in China. The enterprise, as providers of green technology, are very unmotivated to innovate in green technology due to the long innovation cycles, high technology risks, high innovation costs, and uncertainty that the hotel and tourism industry [12–14]. As a result, the implementation of green technology innovation policies in the hospitality and tourism industry and the observation of the effectiveness of their implementation has received a great deal of attention from scholars even though there are significant barriers to green technology innovation and green technology diffusion [15–18].

Although the importance and value of the green technology innovations has been demonstrated in the hospitality and tourism industries, there is a very limited literature examining the diffusion of green technology innovations from a dynamic systems perspective [19]. In our study, we analyze the relationship between focal enterprises and marginal enterprises in a cooperative innovation network and reveal the green technology innova-

tion diffusion mechanism in the hotel and tourism industries. Based on the theoretical analysis, a network evolution game model for the green technology innovation diffusion is developed by introducing a complex network approach. Then, we use the patent data to further analyze the influence of different methods of green technology innovation diffusion on the technology diffusion network of the hospitality and tourism industry. Compared to previous studies, our paper has two contributions. First, we focus on the focal enterprises and marginal enterprises on green technology innovation diffusion in terms of an evolutionary game model and analyze the green technology innovation diffusion mechanism through focal enterprises and marginal enterprises in the hospitality and tourism industry. Second, we analyze how the different methods of green technology innovation diffusion affect the technology diffusion network of the hospitality and tourism industry. Based on the findings of this study, we provide countermeasures and recommendations for enterprises and government.

2. Literature Review

2.1. The Diffusion of Technology Innovation in the Innovation Network

Roger first proposed the theory of innovation diffusion [20]. Innovative technologies affect economic and social development only when they are diffused and widely used [8,21,22]. Since its introduction, the theory has attracted much attention from scholars [23–26]. In recent years, this important theory has attracted the attention of innovation network scholars. Hospitality and tourism are characterized by multidisciplinary intersections, innovation inputs and risks, high technological complexity, and market uncertainty [27]. Therefore, the creation of an innovation network to fund innovation activities is necessary [28]. An innovation network is a structure composed entirely of individuals (or organizations). Researchers refer to them as "nodes" or "actors"; one or more specific types of relationships, such as collaboration, trust, shared interests, knowledge, or technology, link these nodes together (connectivity, both strong and weak ties). Innovation network analysis uses social network theory to explain relationships between organizations [19,29]. A node with many edges has multiple options to meet a specific need, which mediates its dependence on other organizations [30–32]. In innovation networks, a node is in an important position if it has more ties compared to other nodes in the innovation network, which we call a "focal node"/"focal firm"/"focal enterprise" [33–36]. On the other hand, researchers have observed weak edges, which are considered as "edge nodes"/"edge firms"/"marginal enterprises"/"marginal firms" when the relationship between groups is poorly structured [37–39]. The previous literature recognizes that networks have the ability to convey information and to induce innovation through knowledge exchange and shared strategies. Nonetheless, there is limited research on whether focal and marginal enterprises can be used as an innovative process in innovation networks to support hospitality and tourism enterprises [40,41]. As a result, it is widely recognized that the application of green technology innovation in the hospitality and tourism industry is important for the formation of technology diffusion networks and the promotion of sustainable development [42–47].

2.2. Application of Evolutionary Game in Green Technology Innovation Diffusion

Neoclassical economics is based on atomistic and mechanistic theories which assume that participants are perfectly rational and have consistent preferences. It assumes that participants are perfectly rational and agree on their preferences and that they can find an optimal solution under the given conditions. For example, producers can find a production solution that maximizes their returns given certain technology and resources, consumers can find a consumption solution that maximizes their utility given a certain budget, etc. Game theory adds to neoclassical economics the interaction between actors, making the theory more relevant to reality. Game theory assumes that the actor has perfect rational thinking, i.e., the actor always aims for his own best interests, has the ability to judge and make decisions to maximize his own interests in various environments, has the ability to

judge and make perfect predictions in the game environment where there is interaction, and will not make mistakes, will not be impulsive, and is not irrational. Moreover, one of the most important assumptions in game theory is the assumption of 'common knowledge' of the actors on both sides of the game, i.e., that all participants are rational, all participants know that all participants are rational, and so on to infinity. This is an unimaginably infinite process of reasoning and is a very strict assumption in terms of the actors' ability to know the real world. Obviously, the real world is usually not guaranteed by such assumptions. In general, however, game theory still does not go beyond the framework of neoclassical economics. As a result, the assumptions made about relationships when using game theory to build models are often unrealistic. Abandoning the assumption of perfect rationality, evolutionary game theory, based on Darwinian biological evolution and Lamarck's theory of genetics, takes a systems approach to the process of adjustment of group behavior as a dynamic system in which the behavior of each individual and its relationship with the group are individually portrayed [48,49]. As a methodological tool, evolutionary game theory has been applied to many fields [48–53]. Evolutionary game theory is a theory that combines game-theoretical analysis with the analysis of dynamic evolutionary processes. Methodologically, it differs from game theory in its focus on static equilibrium and comparative static equilibrium, emphasizing a dynamic equilibrium. Evolutionary game theory has its roots in the theory of biological evolution and has been quite successful in explaining certain phenomena in biological evolution. Today, economists have also had impressive success in using evolutionary game theory to analyze the factors that influence the formation of social habits, norms, institutions, or systems and to explain the processes that shape them. Evolutionary game theory is an important analytical tool in evolutionary economics and is gradually developing into a new field of economics [52,53]. In recent years, evolutionary game theory has been increasingly applied in the field of green technology innovation [25,54–58]. Chen et al. [59] used an evolutionary game approach to study green behavior and the generation of green supply chains in the hospitality industry. He et al. [60] explored an effective green incentive mechanism for the government to develop traditional tourism into green tourism by building a dynamic evolutionary game model between the government, tourism enterprises, and tourists.

We can learn from the above literature review, evolutionary game theory has focused mainly on the different industrial sector, with less attention paid to the hospitality and tourism industries. Previous studies have mainly considered the behaviors of green technology innovation between government and firms or consumers and firms in other industries. However, few scholars have examined the diffusion of green technology innovations in the hospitality and tourism sectors from the perspective of the relationship between focal and marginal enterprises in innovation networks. It is also difficult to see the application of evolutionary games in the hospitality and tourism industry.

3. Model Building and Analysis

3.1. Problem Description and Assumptions

In China's administrative system, the government released the "14th Five-Year Plan for Science and Technology Innovation in Hospitality and Tourism". The Plan makes it a development goal to lead and support the development of hospitality and tourism with science and technology innovation, improve the level of hospitality and tourism production factors, promote better integration of hospitality and tourism into the new development pattern, and achieve high-quality development. At the same time, the green technology innovation in the hospitality and tourism industry has significant contribution in reducing resource consumption and environmental pollution in the process of industry development, which helps to realize sustainable and environmentally friendly development of the hospitality and tourism resources and becomes a powerful power source to transform the development mode of industry to achieve high-quality development [6]. In terms of the connotations of hospitality and tourism and green technology innovation, the hospitality and tourism industry emphasizes that its objects are not damaged, while green

technology innovation emphasizes environmental protection as its goal and starting point, so environmental protection is their essential requirement. In practice, environmental protection is a fundamental requirement of hospitality and tourism, and green technology innovation is an important means of making ecotourism meet the requirements of environmental protection. The development of hospitality and tourism activities seeks to protect the ecological environment of tourist areas to the greatest extent possible and to reduce the negative impact of tourism on resources and the environment. Green technology innovation uses the power of science and technology to reduce the environmental impact of hospitality and tourism while meeting the needs of tourists, so the use of green technology in hospitality and tourism and its continued innovation is therefore a viable solution to this challenge. In conclusion, according to the connotations of hospitality and tourism and green technology innovation, green technology innovation and hospitality and tourism are closely linked in terms of the practical requirements of hospitality and tourism. The green technology innovation of the hospitality and tourism industry is mainly impacted by two drivers: focal enterprises and marginal enterprises [6,61–63]. The focal enterprises have strong ties in the hospitality and tourism industry, and they can easily facilitate the flow of any type of information, especially knowledge and technical information, through their direct relationships [6,7,42,46,63]. The focal enterprises can select from two strategies: positively coordinating the hospitality and tourism industry development (what we call "positive") and inactively intervening industrial development (what we call "negative"). In the "positive" situation, the focal enterprises will cooperate with the marginal enterprises that push green technology innovation timely. In the "negative" case, the focal enterprises will give up the green technology innovation. Marginal enterprises have weak ties within the hospitality and tourism industry but still have the possibility to acquire and provide new knowledge to the industry [43,45,47]. The strategies that can be selected by marginal enterprises include actively implementing green technology innovation or not carrying out green technology innovation. If the focal and marginal enterprises choose to collaborate, both can reap not only the benefits of the primary innovation conditions, but also some additional income. However, they must pay a price for their cooperation. If the focal or marginal enterprise chooses not to implement green technology innovation, then the betrayed firm will suffer more [56,62,63]. If both parties do not implement, then they can only benefit from the normal innovation situation.

In order to explore the influence of various parameters exiting in the process of the game on the final evolutionary stability strategy (ESS), the following basic explanations are given:

Assumption 1. *The marginal enterprises and focal enterprises are limited rational players, and their strategy selection space is (positive/negative, implement/non-implement).*

Assumption 2. *Suppose that the probability that a focal enterprise chooses to implement a green technology innovation strategy is x, and the probability that it chooses not to implement a green technology innovation strategy is $1 - x$. Then, if the proportion of marginal enterprises choosing a positive strategy is y, then the proportion choosing a negative strategy is $1 - y$. The state of system evolution can be expressed by (x, y) in terms of the available area $[0, 1] \times [0, 1]$.*

Assumption 3. *If the focal enterprises and marginal enterprises implement primary innovation, the focal enterprises' benefit is P1, and the marginal enterprises' benefit is P2. When the marginal enterprises cooperate with the focal enterprises to implement green technology innovation, the extra benefits for the focal enterprises and the marginal enterprises are R1 and R2, respectively. At the same time, they will pay the cost $(1 - \mu)$ I1 and $(1 - \mu)$ I2, respectively. If only one side implements green technology innovation, they need to pay the cost I1 or I2.*

Assumption 4. *Especially in post-pandemic era, they will obtain a bonus from government Q_1 and Q_2. In addition, no matter what the focal enterprises or the marginal enterprises are, if they give up on implementing green technology innovation, they will pay a penalty F.*

3.2. Model Building

According to the assumptions, we can obtain the game payment matrix of focal enterprises and marginal enterprises, as shown in Table 1.

Table 1. Payment matrix of the focal enterprises and marginal enterprises.

Focal Enterprises	Marginal Enterprises	
	Positive (y)	**Negative ($1-y$)**
Implement green technology innovation (x)	$P_1 + R_1 + Q_1 - (1-\mu)I_1; P_2 + R_2 + Q_2 - (1-\mu)I_2$	$P_1 + Q_1 - I_1 + F; P_2 + Q_2 - F$
Non-implement green technology innovation ($1-x$)	$P_1 + Q_1 - F; P_2 + Q_2 - I_2 + F$	$P_1 + Q_1; P_2 + Q_2$

3.3. Analysis of Evolutionary Game Strategy

The benefits of focal enterprises choosing to implement green technology innovation are:

$$U_{F1} = y(P_1 + R_1 + Q_1 - (1-u)I_1) + (1-y)(P_1 + Q_1 + F - I_1) \quad (1)$$

The benefits of focal enterprises choosing to non-implement green technology innovation are:

$$U_{F2} = y(P_1 + Q_1 - F) + (1-y)(P_1 + Q_1) \quad (2)$$

The average fitness is:

$$U_1 = xU_{F1} + (1-x)U_{F2} \quad (3)$$

The benefits of marginal enterprises choosing to positive strategy are:

$$U_{M1} = x(P_2 + R_2 + Q_2 - (1-u)I_2) + (1-x)(P_2 + Q_2 + F - I_2) \quad (4)$$

The benefits of marginal enterprises choosing to negative strategy are:

$$U_{M2} = x(P_2 + Q_2 - F) + (1-x)(P_2 + Q_2) \quad (5)$$

The average fitness is:

$$U_2 = yU_{M1} + (1-y)U_{M2} \quad (6)$$

The focal enterprise replication dynamic equation is:

$$\frac{dx}{dt} = x(1-x)[y(R_1 + uI_1) + F - I_1] \quad (7)$$

The marginal enterprise replication dynamic equation is:

$$\frac{dy}{dt} = y(1-y)[x(R_2 + uI_2) + F - I_2] \quad (8)$$

Let $\frac{dx}{dt} = 0$, $\frac{dy}{dt} = 0$, the equilibrium point of system $R = \{(x,y)|0 \le x \le 1, 0 \le y \le 1\}$ is (0,0), (0,1), (1,0), (1,1), (x^*, y^*). Especially, $x^* = \frac{I_2 - F}{R_2 + uI_2}$ and $y^* = \frac{I_1 - F}{R_1 + uI_1}$ are system's equilibrium point when $0 < x < 1$, $0 < y < 1$.

3.4. Stability Analysis of Evolutionary Game Strategy

According to Equations (7) and (8), the local stability of the Jacobi matrix to the stability analysis of the equilibrium point of the system is:

$$J = \begin{bmatrix} (1-2x)[y(R_1 + uI_1) + F - I_1] & x(1-x)(R_1 + uI_1) \\ y(1-y)(R_2 + uI_2) & (1-2y)[x(R_2 + uI_2) + F - I_2 \end{bmatrix} \quad (9)$$

When $DetJ > 0$, $TrJ < 0$, the equilibrium point of the replication dynamic equation is an evolutionarily stable strategy (ESS) [64]. Set $W_i = F - I_i$, combined with $DetJ$, TrJ and the system phase diagram, the stability of equilibrium points under 7 situations is analyzed [65], as shown in Tables 2–7 and Figures 1–4.

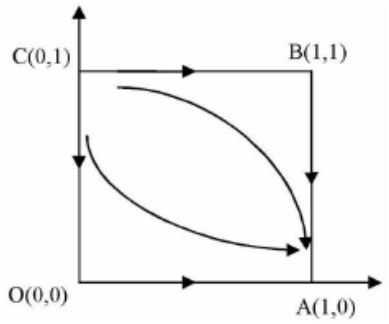


Figure 1. $W_1 > 0 > W_2$.

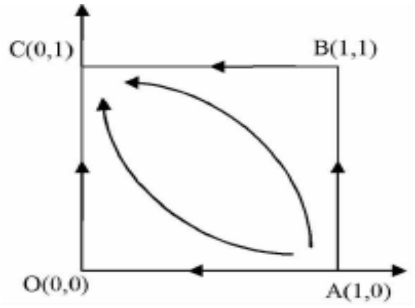


Figure 2. $W_1 < 0 < W_2$.

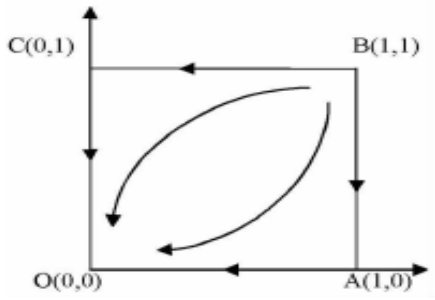


Figure 3. $W_1 < 0$, $W_2 < 0$.

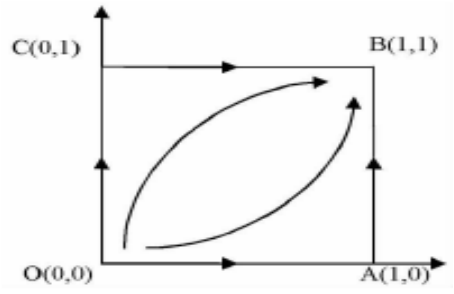


Figure 4. $W_1 > 0$, $W_2 > 0$.

Table 2. System stability analysis when $W_1 > 0 > W_2$.

(*x*, *y*)	DetJ	TrJ	Stability
(0, 0)	−	Uncertain	Saddle point
(0, 1)	+	+	Instability
(1, 0)	+	−	ESS
(1, 1)	−	Uncertain	Saddle point

Table 3. System stability analysis when $W_1 < 0 < W_2$.

(*x*, *y*)	DetJ	TrJ	Stability
(0, 0)	−	Uncertain	Saddle point
(0, 1)	+	−	ESS
(1, 0)	+	+	Instability
(1, 1)	−	Uncertain	Saddle point

Table 4. System stability analysis when $W_1 < W_2 < 0$.

(*x*, *y*)	DetJ	TrJ	Stability
(0, 0)	+	−	ESS
(0, 1)	−	−	Saddle point
(1, 0)	−	+	Saddle point
(1, 1)	+	+	Instability

Table 5. System stability analysis when $W_2 < W_1 < 0$.

(*x*, *y*)	DetJ	TrJ	Stability
(0, 0)	+	−	ESS
(0, 1)	−	+	Saddle point
(1, 0)	−	−	Saddle point
(1, 1)	+	+	Instability

Table 6. System stability analysis when $W_1 > W_2 > 0$.

(*x*, *y*)	DetJ	TrJ	Stability
(0, 0)	+	+	Instability
(0, 1)	−	+	Saddle point
(1, 0)	−	−	Saddle point
(1, 1)	+	−	ESS

Table 7. System stability analysis when $W_2 > W_1 > 0$.

(*x*, *y*)	DetJ	TrJ	Stability
(0, 0)	−	+	Instability
(0, 1)	−	+	Saddle point
(1, 0)	−	+	Saddle point
(1, 1)	+	−	ESS

Situation 1: When $W_1 > 0 > W_2$, regardless of the strategy chosen by the marginal firm, the benefits of the focal firm choosing to implement green technology innovation

are greater than the benefits of choosing not to implement green technology innovation. The local equilibrium points are shown in Table 2, and the dynamic evolution of the two sides of the game is shown in Figure 1. The $(x, y) = (1, 0)$ is the evolutionary stability strategy (ESS). When the benefit of the marginal enterprises is relatively low and the focal enterprises implement green technology innovation has a highly benefit, both the marginal enterprises and the focal enterprises are pursuing their own interests for maximization and tend to choose the most suitable strategy (negative, implement technology innovation).

Situation 2: When $W_1 < 0 < W_2$, regardless of the strategy chosen by the focal firm, the benefits of choosing a positive strategy by the marginal firm are greater than the benefits of choosing a negative strategy. Regardless of the strategy chosen by the marginal firm, the gain of the focal firm choosing not to implement green technology innovation is the best. The local equilibrium points are shown in Table 3, and the dynamic evolution of the two sides of the game is shown in Figure 2. The $(x, y) = (0, 1)$ is ESS.

Situation 3: When $W_1 < 0$, $W_2 < 0$, regardless of the strategy chosen by the marginal firm, the profits of the focal firm that chooses not to implement green technology innovation are greater than the profits of the focal firm that chooses to implement green technology innovation. Regardless of the strategy chosen by the focal firm, the profit of the marginal firm choosing negative green technology innovation is the best choice. The local equilibrium points are shown in Tables 4 and 5, and the dynamic evolution of the two sides of the game is shown in Figure 3. The $(x, y) = (0, 0)$ is ESS. This means that a negative strategy is the best option for marginal firms when the positive costs are high. When the cost of implementing green technology innovation is high, a strategy of not implementing green technology innovation is the best option for the focal firm.

Situation 4: When $W_1 > 0$, $W_2 > 0$, the marginal firm chooses a positive strategy, the profits of the focal firm that chooses to implement green technology innovation are greater than the profits of the focal firm that chooses not to implement green technology innovation. The local equilibrium points are shown in Tables 6 and 7, and the dynamic evolution process is shown in Figure 4. The $(x, y) = (1, 1)$ is ESS. This indicates that the high benefit of the marginal firm choosing to be positive leads to a greater profit for the marginal firm choosing to actively implement green technology innovation than for the marginal firm choosing a negative strategy. In order to maximize the marginal firm's own interests, choosing the positive strategy is the best strategy. Therefore, implementing green technology innovation is also the best option.

Situation 5: It follows from the replication dynamic Equation (7) when $x = x^* = \frac{I_2 - F}{R_2 + uI_2}$, $dy/dt = 0$, then the proportion of marginal enterprises adopting strategy is stable [8]. When $x \neq \frac{I_2 - F}{R_2 + uI_2}$, and $y = 0$, $y = 1$. If $x > \frac{I_2 - F}{R_2 + uI_2}$, then the steady state is $y = 1$. If $x < \frac{I_2 - F}{R_2 + uI_2}$, then the steady state is $y = 0$. The marginal enterprise's dynamic phase evolution diagram is shown in Figure 5.

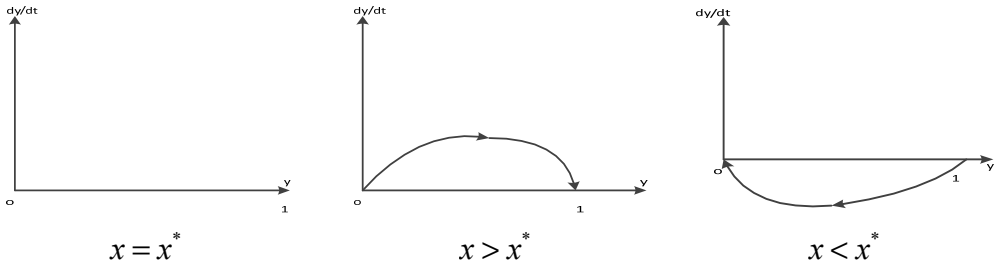


Figure 5. Dynamic evolution diagram of marginal enterprises.

Situation 6: It follows from the replication dynamic Equation (8) when $y = y^* = \frac{I_1 - F}{R_1 + uI_1}$, $dx/dt = 0$, then the proportion of focal enterprises adopting strategy is stable. When $y \neq \frac{I_1 - F}{R_1 + uI_1}$, and $x = 0$, $x = 1$. If $y > \frac{I_1 - F}{R_1 + uI_1}$, then the steady state is $x = 1$. If $y < \frac{I_1 - F}{R_1 + uI_1}$, then the steady state is $x = 0$. The focal enterprise's dynamic phase evolution diagram is shown in Figure 6.

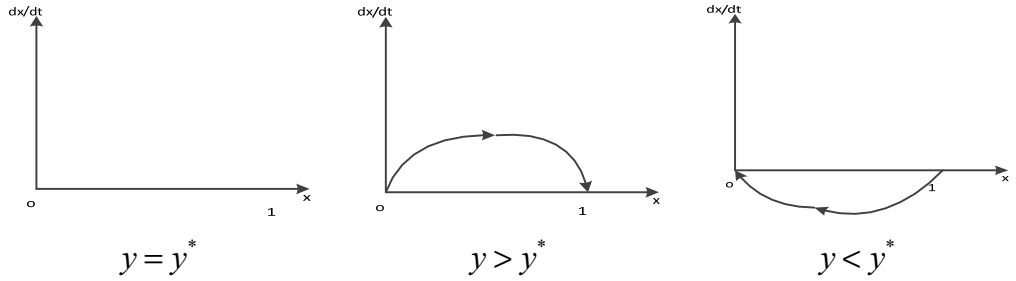


Figure 6. Dynamic evolution diagram of enterprises.

Finally, the critical values of $x = x^* = \frac{I_2 - F}{R_2 + uI_2}$ and $y = y^* = \frac{I_1 - F}{R_1 + uI_1}$ divide the evolutionary game phase diagram into four regions: I, II, III, and IV. When the initial state of the system is different, the evolutionary game converges to $(0,0)$, $(1,0)$, $(1,1)$, $(0,1)$, respectively. From the above analysis, it is clear that the exact path along which the system will reach which state is closely related to the payoff matrix of the game and the initial state of the game when it occurs. When the initial state of the system is near the threshold (x^*, y^*) at which the evolutionary characteristics of the system change, a small change in the initial state will have an effect on the final outcome of the system, indicating that the system is more sensitive to the initial conditions. The dynamic diagram of system evolution of focal enterprises and marginal enterprises strategy is shown in Figure 7.

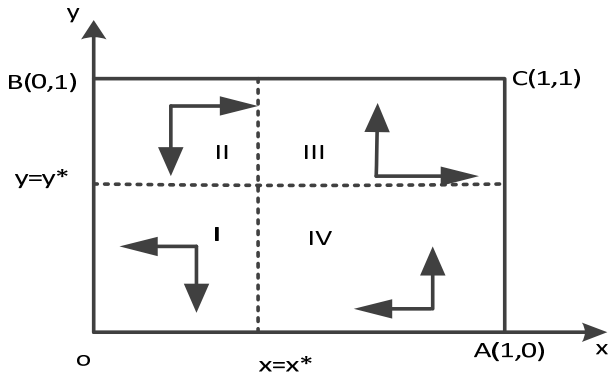


Figure 7. Dynamic diagram of system evolution of focal enterprises' and marginal enterprises' strategies.

4. Data Analysis and Results

4.1. Data and Measures

We have tested our hypotheses by collecting data from the Sino Intellectual Patent Office (SIPO) database. Our data represents green technology innovation information from the mainland of China between 2015 and 2019. We adopted SIPO data to track the hospitality and tourism enterprises' green technology innovation activities. The data contain details about patents, including applicants, inventors, application dates, announcement dates, industrial classifications, technological classifications.

To accurately identify focal enterprise and marginal enterprise cooperation patent from the SIPO database, we closely followed the title, abstract, or keywords search strategy [66]. We searched for patents containing the term "green technology" or other related terms (such as "sustainable technology", "low-carbon technology") combined with "innovation" in the hospitality and tourism industry. The applicants entered in the applicant field of the search criteria are a combination of enterprise and enterprise, enterprise and firm, and firm and firm in the hospitality and tourism industry. The patents irrelevant to enterprise cooperative innovation were ignored during the data search. For example, a patent whose applicant was "_Corporation" alone would be ignored. However, at any given time, the definitions of focal enterprise and marginal enterprise are consistent throughout patent data. In our research, we use the degree centrality of cooperative innovation network to

define the focal enterprise and marginal enterprise [34,67,68]. Moreover, we consider the forward citation to measure the technology diffusion network.

4.2. Exponential Random Graph Models

Exponential random graph models (ERGMs) set the network structure as endogenous based on the assumption that network ties are conditionally dependent, in other words, the existence of one network tie depends on the existence of other network ties constraining the rest of the network [69–74]. For multilevel network models, however, network ties are interdependent not only within levels but also between levels. The interpretation of ERGM parameters makes it possible to test hypotheses about the structure of multilevel networks [75–78].

According to the introduction of ERGM above, In the simplest form as shown in Figure 8, a two-level network can be seen as a combination of two within-level one-mode networks (labeled here as A and B), and a bipartite meso-level network (X).

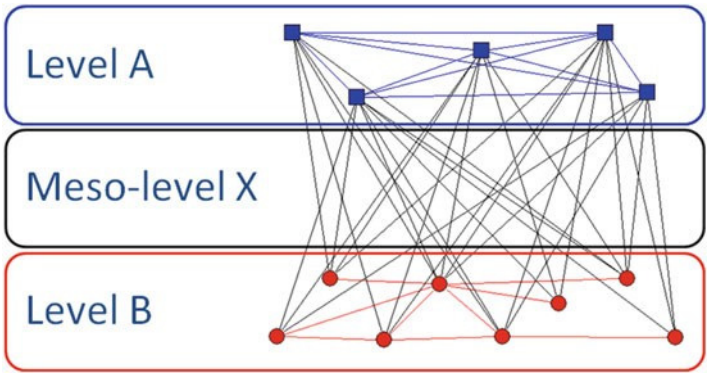


Figure 8. A two-level network representation.

We can learn that there is an inter-network effect pattern in the network, and that the inter-network effect pattern allows us to test the dependency relationship between networks [75]. This dependency relationship in the network can affect the innovation diffusion network of the enterprise.

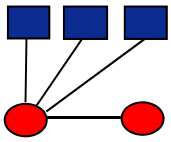
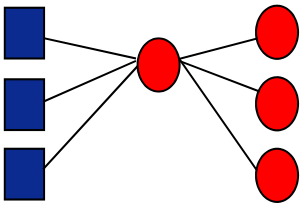
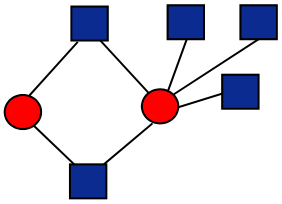
The neighborhood effect. According to the knowledge expansiveness and prestige effect between two-level networks, the Markov expansiveness and prestige effect between two-level networks can be represented by the star structure bureau of two-level networks without using scale [75]. We adopt the dependency assumption in our model to extend the effect between two-level networks, which indicates that focal and marginal enterprises can share knowledge in a connected way for the purpose of innovation diffusion and enhance the innovation diffusion of firms through the above-mentioned way [79].

The partner effect. We describe the partner effect in our model by using three innovative firms connected by a focal enterprise to achieve connectivity with marginal enterprise, which resembles a kind of intermediary to form common knowledge and achieve the purpose of promoting firm innovation diffusion [80].

The social circle effect. We use the alternating connection structure between focal and marginal enterprises in our model to describe the social circle effect, which represents a knowledge base with a large amount of common knowledge that can continuously contribute to the diffusion of the technology innovation as the knowledge sources increase and thus act on the corresponding firms, corresponding to XAECB [81].

The MERGMs model constructed with the aid of MPNet was run using data from the 2015–2019 two-level networks of collaboration. The final results of the parameter estimates obtained after model convergence are shown in Table 8 below (circles: focal enterprises; squares: marginal enterprises).

Table 8. Operation results of ERGMs.

Name	Green Technology Diffusion Modes	Coefficient	Standard Error
StarAX1B		0.534 *	0.152
StarAXAB		−2.254 *	0.818
XAECB		3.412 *	1.510

Note: Effects with a star are significant with a t-ratio less than 0.05 (approached Wald test [82]).

4.3. Results from ERGM Analysis

From Table 8, it can be seen that the StarAX1B mode has a positive impact on the technology diffusion network of enterprises of the hospitality and tourism industry, and the XAECB mode has a significant positive effect on the technology diffusion network of enterprises of the hospitality and tourism industry. However, the StarAXAB has a negative impact on the technology diffusion network of enterprises of the hospitality and tourism industry.

5. Conclusions and Policy Recommendations

5.1. Conclusions

From the perspective of the hotel and tourism industry, the green technology innovation diffusion model of the focal and marginal enterprises is embedded in a cooperative innovation network to construct an evolutionary game model between the focal and marginal firms. The following conclusions are drawn.

When the benefit of the marginal enterprises is relatively low and the focal enterprises implement green technology innovation has a high benefit, both the marginal enterprises and the focal enterprises are pursuing their own interests for maximization and tend to choose the most suitable strategy (negative, implement green technology innovation):

1. Marginal firms will be more likely to implement green technology innovations if they are highly profitable. However, even focal enterprises may be deterred from implementing green technology innovations if they cannot afford the high cost.
2. The high profits of a positive strategy make marginal firms more likely to implement green technology innovations. However, the low cost of not implementing green technology innovation makes focal firms more likely to forgo implementing green technology innovation.
3. A negative strategy is the best option for marginal firms when the positive cost is high. When the cost of implementing green technology innovation is high, a strategy of not implementing green technology innovation is the best option for the focal firm.
4. The high returns when the marginal firm chooses the positive strategy lead to the marginal firm choosing to implement green technology innovation with greater

profits than the marginal firm choosing the negative strategy. In order to maximize the marginal firm's own interests, choosing negative is the best strategy.

5. The neighborhood effect has a positive impact on the technology diffusion network of enterprises of the hospitality and tourism industry, the partner effect has a negative impact on the technology diffusion network of enterprises, and the social circle effect has a significant positive effect on the technology diffusion network of enterprises of the hospitality and tourism industry.

5.2. Theoretical Contribution

This research extends the current knowledge on the hospitality and tourism industry with some important research dimensions. Most of the previous studies considered the hospitality and tourism industry to be a simple view. This study introduces the innovation network in the hospitality and tourism industry and focuses on the focal enterprises and marginal enterprises on cooperation innovation in terms of an evolutionary game model. Focal companies have strong and important links to many of the structural gaps in the hospitality and tourism innovation network. They can facilitate the flow of knowledge, technology and information through the network in the way they prefer. This strong relationship removes their suspicion of each other and makes everything flow smoothly in the network. If a focal firm finances green technology innovation activity in the hospitality and tourism industry, they can easily foster trust between the participants and other firms throughout the network, leading to rapid imitation of their innovations [61]. Even if marginal firms are weakly connected, they can still easily generate new ideas and information. They have the ability to access and provide new green technologies and knowledge to innovation networks in the hospitality and tourism industry [61].

Most of the previous studies especially emphasized the whole system evolution of the enterprises' green technology innovation diffusion strategy and ignored how the different green technology innovation diffusion modes influence the technology diffusion network of enterprises of the hospitality and tourism industry. This study goes beyond the dominant focus the final ESS and highlights the process of the diversity of green technology innovation diffusion modes. Thus, the different diffusion modes can influence the technology diffusion network of enterprises of hospitality and tourism industry.

5.3. Practical Implications

For the enterprises, demand can be cultivated for hospitality and tourism and using the market to guide enterprises in green technology innovation. Tourists need green technology innovations in the hospitality and tourism industry. Tourists have a high level of environmental awareness, and as they seek a pristine tourism environment, they will try to use green tourism techniques in their travels, so they expect hospitality and tourism attractions and other hospitality and tourism enterprises to consciously use green techniques to maintain this pristine ecological environment. However, if hospitality and tourism enterprises deviate from their demands, these tourists will choose to 'vote with their feet' and abandon those that do not meet their requirements. As the hospitality and tourism market becomes more and more tourist in the true sense of the word, it is inevitable that hospitality and tourism enterprises will actively engage in green technology innovation in order to compete for tourists. In addition, enterprises can promote hospitality and tourism certification and regulate information about hospitality and tourism enterprises. A more effective way to address the problem of incomplete or asymmetrical information in a market mechanism is to establish the "credibility" of the enterprise. Reputation can be seen as a subjective evaluation of a company's behavior by the consumer and is easier to establish when the relationship between buyer and seller is relatively fixed and repeatedly played. However, hospitality and tourism are often a one-off transaction, and in this case, it is more difficult to establish a reputation mechanism, so here the market mechanism is not a good solution to the problem of information asymmetry in the ecotourism market. In this context, it is necessary for the government to regulate information about ecotourism

enterprises. The purpose of information regulation is to ensure that consumers receive adequate and correct information about the market, i.e., to increase the 'transparency' of the market so that they can make the right choices. In the hospitality and tourism market, the most effective way for the government to regulate information is to introduce hospitality and tourism certification in the hospitality and tourism market. The government should firstly develop a standard system of hospitality and tourism certification for enterprises, secondly issue "the hospitality and tourism enterprise" labels and allow them to use the slogan "hospitality and tourism enterprise" based on careful examination of the hospitality and tourism enterprises applying for certification, and finally provide strict post-event supervision and management of these certified enterprises. If they do not meet the certification requirements, they will be given a deadline to rectify the situation or even have their title of "the hospitality and tourism enterprise" cancelled. By promoting hospitality and tourism certification in the hospitality and tourism market, the government has made it possible for information about hospitality and tourism enterprises to be displayed, so that eco-tourists can easily distinguish between genuine hospitality and tourism enterprises and general public tourism enterprises, thus helping tourists to make a reasonable choice. Once the information asymmetry in the hospitality and tourism market is resolved, genuine hospitality and tourism enterprises will receive higher returns than the average enterprise due to their popularity with tourists, which will lead some non-ecotourism enterprises to actively engage in green technology innovation to complete the transformation from non-ecotourism enterprises to ecotourism enterprises, and some existing hospitality and tourism enterprises will actively and continuously engage in green technology innovation to maintain their inherent market position and image.

Then, the government should promote the construction of a new generation of network infrastructure, integrating convergence infrastructure and intelligent terminal infrastructure to provide a new type of infrastructure guarantee for the development of the hospitality and tourism industry. At the same time, the enterprise should actively promotes the application of 5G, big data, cloud computing, the Internet of Things, artificial intelligence, virtual reality, augmented reality, block chain, and other revolutionary information technology achievements in the green innovation activity, and accelerates the empowerment of the green innovation process by technology At the same time, the government should encourage and support tourism green innovation and entrepreneurship and stimulate vitality for the development of the hospitality and tourism industry. On the one hand, the government encourages the integration and innovation of the hospitality and tourism industry. On the other hand, the government promotes the establishment of a mechanism for cooperation between industries, universities, and research institutes and actively carries out applied R&D supported by scientific and technological innovation and the incubation of innovative results so as to continuously input intellectual support for the development of a modern industrial system. In addition, the government should accelerate the intelligent construction of scenic tourism spots and promote digitalization, networking, and the intelligent transformation of scenic spots, resorts, museums, etc. They should also carry out tourism marketing reform and increase the marketing of online tourism with the help of the Internet, enrich the digital presentation of tourism products and services, and support the development of new industries such as cloud tourism, cloud performing arts, cloud entertainment, cloud live streaming, cloud exhibitions, etc. Finally, they should encourage tourism market players to develop new tourism products from marketing to channels to production methods and at the industry chain level.

Finally, the cultivation of a green technology diffusion environment for the hospitality and tourism industry requires some government intervention and adaptive governance. The cultivation and governance of the technology diffusion environment should be softer. In addition, government guarantees should be used to leverage a wider range of third parties to participate in green technology innovation and diffusion, pooling more social capital. Many green technologies have multiple path options for diffusion, and it is important to cultivate green technologies from unconscious path dependence to conscious

path options through social capital and government guidance to so that social stakeholders can be involved in green technology choices in a timely manner and the value of social capital can be explored.

5.4. Limitations and Future Research

Although this study has significant theoretical and practical implications, it also has several limitations that could be explored in future research. Focal enterprises and marginal enterprises have been defined in different approaches in the extant literature. In this paper, we defined a focal enterprise and marginal enterprise based on the degree centrality of the cooperative innovation network. In future research, we may consider other approaches to define the focal enterprise and marginal enterprise. Moreover, we considered the forward citation to measure the technology diffusion innovation network, and maybe other measures will be used in the future research.

Our study data are from the SIPO, which can be further excavated for other databases such as WIPO, UPSTO, and EPO in future research. The research on two-level networks needs to be further expanded. The innovative significance given by the attributes of different galaxies will open another door for us to innovate in the network.

Other players are important subject that should be considered when establishing the evolutionary game model. Future research may investigate universities, research institutes, and their corresponding networks on technological collaborations.

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References

1. Horng, J.S.; Liu, C.H.; Chou, S.F.; Tsai, C.Y.; Chung, Y.C. From innovation to sustainability: Sustainability innovations of eco-friendly hotels in Taiwan. *Int. J. Hosp. Manag.* **2017**, *63*, 44–52. [CrossRef]
2. Pikkemaat, B.; Peters, M.; Bichler, B.F. Innovation research in tourism: Research streams and actions for the future. *J. Hosp. Tour. Manag.* **2019**, *41*, 184–196. [CrossRef]
3. Yousaf, Z.; Radulescu, M.; Sinisi, C.; Serbanescu, L.; Paunescu, L. Harmonization of Green Motives and Green Business Strategies towards Sustainable Development of Hospitality and Tourism Industry: Green Environmental Policies. *Sustainability* **2021**, *13*, 6592. [CrossRef]
4. Hall, C.M. Constructing sustainable tourism development: The 2030 agenda and the managerial ecology of sustainable tourism. *J. Sustain. Tour.* **2019**, *27*, 1044–1060. [CrossRef]
5. Hjalager, A.-M. Innovation patterns in sustainable tourism: An analytical typology. *Tour. Manag.* **1997**, *18*, 35–41. [CrossRef]
6. Liu, J.; Song, Q.-Y. Space network structure and formation mechanism of green innovation efficiency of tourism industry in China. *China Popul. Resour. Environ.* **2018**, *28*, 127–137.
7. Gavrilović, Z.; Maksimović, M. Green innovations in the tourism sector. *Strat. Manag.* **2018**, *23*, 36–42. [CrossRef]
8. Deng, Y.; You, D.; Zhang, Y. Can the Behavioural Spillover Effect Affect the Environmental Regulations Strategy Choice of Local Governments? *Int. J. Environ. Res. Public Health* **2021**, *18*, 4975. [CrossRef]
9. Hjalager, A.-M. Innovation policies for tourism. *Int. J. Tour. Policy* **2012**, *4*, 336. [CrossRef]
10. Bagur-Femenías, L.; Martí, J.; Rocafort, A. Impact of sustainable management policies on tourism companies' per-formance: The case of the metropolitan region of Madrid. *Curr. Issues Tour.* **2015**, *18*, 376–390. [CrossRef]
11. Dalonso, Y.S.; Lourenco, J.M.; Remoaldo, P.; Netto, A.P. Tourism experience, events and public policies. *Ann. Tour. Res.* **2014**, *46*, 181–184. [CrossRef]
12. Hall, C.M.; Gössling, S.; Scott, D. Tourism and sustainability: Towards a green (er) tourism economy? In *The Routledge Handbook of Tourism and Sustainability*; Routledge: Oxfordshire, UK, 2015; pp. 508–537.
13. Pan, S.-Y.; Gao, M.; Kim, H.; Shah, K.; Pei, S.-L.; Chiang, P.-C. Advances and challenges in sustainable tourism toward a green economy. *Sci. Total Environ.* **2018**, *635*, 452–469. [CrossRef] [PubMed]

14. Grilli, G.; Tyllianakis, E.; Luisetti, T.; Ferrini, S.; Turner, R.K. Prospective tourist preferences for sustainable tourism development in Small Island Developing States. *Tour. Manag.* **2021**, *82*, 104178. [CrossRef]
15. Jamal, T.; Camargo, B.A. Tourism governance and policy: Whither justice? *Tour. Manag. Perspect.* **2018**, *25*, 205–208. [CrossRef]
16. Siakwah, P.; Musavengane, R.; Leonard, L. Tourism Governance and Attainment of the Sustainable Development Goals in Africa. *Tour. Plan. Dev.* **2020**, *17*, 355–383. [CrossRef]
17. Kim, S.; Bramwell, B. Boundaries and boundary crossing in tourism: A study of policy work for tourism and urban regeneration. *Tour. Manag.* **2019**, *75*, 78–89. [CrossRef]
18. Lionardo, A.; Kurniawan, R.; Nasirin, C. Local Government Income Revenue: A Brief Study of the Policy Impact of Pandemic Covid-19 on Tourism Recovery. In Proceedings of the 5th NA International Conference on Industrial Engineering and Operations Management, Detroit, MI, USA, 10–12 August 2020; pp. 2164–2168.
19. Zhang, W.; Yang, J.; Ding, X.Y.; Zou, X.M.; Han, H.Y.; Zhao, Q.C. Groups make nodes powerful: Identifying in-fluential nodes in social networks based on social conformity theory and community features. *Expert Syst. Appl.* **2019**, *125*, 249–258. [CrossRef]
20. Singhal, A.; Quinlan, M.M.; Rogers, E.M. *Diffusion of Innovations*; Routledge: Oxfordshire, UK, 2014; pp. 432–448.
21. Pavitt, K.; Stoneman, P. *The Economic Analysis of Technological Change*; Oxford University Press: Oxford, UK; New York, NY, USA, 1983.
22. Freeman, C. The economics of technical change. *Camb. J. Econ.* **1994**, *18*, 463–514. [CrossRef]
23. Geroski, P. Models of technology diffusion. *Res. Policy* **2000**, *29*, 603–625. [CrossRef]
24. Liu, X.; Gao, X. A survey analysis of low carbon technology diffusion in China's iron & steel industry. *J. Clean. Prod.* **2016**, *129*, 88–101.
25. Liu, L.; Zhu, Y.; Guo, S. The evolutionary game analysis of multiple stakeholders in the low-carbon agricultural innovation diffusion. *Complexity* **2020**, *2020*, 6309545. [CrossRef]
26. Parmentola, A.; Simoni, M.; Tutore, I.; Wallis, S.E. Boosting the spread of new technologies: An integrative proposi-tional analysis of diffusion policies. *Technol. Anal. Strateg. Manag.* **2020**, *32*, 133–145. [CrossRef]
27. García-Villaverde, P.M.; Elche, D.; Martínez-Pérez, Á.; Ruiz-Ortega, M.J. Determinants of radical innovation in clustered firms of the hospitality and tourism industry. *Int. J. Hosp. Manag.* **2017**, *61*, 45–58. [CrossRef]
28. Ying, T.; Norman, W.C. Personality Effects on the Social Network Structure of Boundary-Spanning Personnel in the Tourism Industry. *J. Hosp. Tour. Res.* **2017**, *41*, 515–538. [CrossRef]
29. Du, R.; Wang, Y.; Dong, G.; Tian, L.; Liu, Y.; Wang, M.; Fang, G. A complex network perspective on interrelations and evolution features of international oil trade, 2002–2013. *Appl. Energy* **2017**, *196*, 142–151. [CrossRef]
30. Ozkan-Canbolat, E.; Beraha, A. Evolutionary knowledge games in social networks. *J. Bus. Res.* **2016**, *69*, 1807–1811. [CrossRef]
31. Moon, H.; Ham, S.; Kim, S.-C.; Lee, B.Y. Influential factors for successful knowledge transfer in restaurant franchises. *J. Hosp. Tour. Manag.* **2021**, *46*, 224–232. [CrossRef]
32. Liu, M.; Ma, Y.; Song, L.; Liu, C. Understanding the game behavior with sentiment and unequal status in cooperation network. *Knowl.-Based Syst.* **2021**, *212*, 106588. [CrossRef]
33. Chellappa, R.K.; Saraf, N. Alliances, Rivalry, and Firm Performance in Enterprise Systems Software Markets: A Social Network Approach. *Inf. Syst. Res.* **2010**, *21*, 849–871. [CrossRef]
34. Behrendt, S.; Richter, A.; Trier, M. Mixed methods analysis of enterprise social networks. *Comput. Netw.* **2014**, *75*, 560–577. [CrossRef]
35. Kermani, M.A.M.A.; Ardestani, S.F.F.; Aliahmadi, A.; Barzinpour, F. A novel game theoretic approach for mod-eling competitive information diffusion in social networks with heterogeneous nodes. *Phys. A Stat. Mech. Its Appl.* **2017**, *466*, 570–582. [CrossRef]
36. Sasabe, M. Mathematical epidemiological analysis of dynamics of delay attacks on pull-based competitive information diffusion. *Comput. Netw.* **2020**, *180*, 107383. [CrossRef]
37. Goerzen, A.; Beamish, P.W. The effect of alliance network diversity on multinational enterprise performance. *Strat. Manag. J.* **2005**, *26*, 333–354. [CrossRef]
38. Wassmer, U. Alliance Portfolios: A Review and Research Agenda. *J. Manag.* **2010**, *36*, 141–171. [CrossRef]
39. Potter, A.; Paulraj, A. Unravelling supplier-laboratory knowledge spillovers: Evidence from Toyota's central R&D laboratory and subsidiary R&D centers. *Res. Policy* **2021**, *50*, 104200.
40. Morrison, A.J.; Teixeira, R. Small business performance: A tourism sector focus. *J. Small Bus. Enterp. Dev.* **2004**, *11*, 166–173. [CrossRef]
41. Costa, C.; Breda, Z.; Costa, R.; Miguéns, J. The Benefits of Networks for Small and Medium Sized Tourism Enterprises. In *Network Analysis and Tourism*; Channel View Publications: Bristol, UK, 2008; pp. 96–114.
42. García-Pozo, A.; Sánchez-Ollero, J.-L.; Cappa, M.O. ECO-innovation and economic crisis: A comparative analysis of environmental good practices and labour productivity in the Spanish hotel industry. *J. Clean. Prod.* **2016**, *138*, 131–138. [CrossRef]
43. Aboelmaged, M. Direct and indirect effects of eco-innovation, environmental orientation and supplier collaboration on hotel performance: An empirical study. *J. Clean. Prod.* **2018**, *184*, 537–549. [CrossRef]
44. del Rosario, R.S.M.; René, D.P. Eco-innovation and organizational culture in the hotel industry. *Int. J. Hosp. Manag.* **2017**, *65*, 71–80. [CrossRef]
45. Musavengane, R. Small hotels and responsible tourism practice: Hoteliers' perspectives. *J. Clean. Prod.* **2019**, *220*, 786–799. [CrossRef]

46. Tan, Y.; Despotis, D. Investigation of efficiency in the UK hotel industry: A network data envelopment analysis approach. *Int. J. Contemp. Hosp. Manag.* **2021**, *33*, 1080–1104. [CrossRef]
47. Agyapong, A.; Mensah, H.K.; Ayuuni, A.M. The moderating role of social network on the relationship between innovative capability and performance in the hotel industry. *Int. J. Emerg. Mark.* **2018**, *13*, 801–823. [CrossRef]
48. Friedman, D. On economic applications of evolutionary game theory. *J. Evol. Econ.* **1998**, *8*, 15–43. [CrossRef]
49. Chiong, R.; Jovanovic, J. Collaborative Learning in Online Study Groups: An Evolutionary Game Theory Perspective. *J. Inf. Technol. Educ. Res.* **2012**, *11*, 081–101. [CrossRef]
50. Tian, Z.; Gao, X.; Su, S.; Qiu, J.; Du, X.; Guizani, M. Evaluating Reputation Management Schemes of Internet of Vehicles Based on Evolutionary Game Theory. *IEEE Trans. Veh. Technol.* **2019**, *68*, 5971–5980. [CrossRef]
51. Ji, P.; Ma, X.; Li, G. Developing green purchasing relationships for the manufacturing industry: An evolutionary game theory perspective. *Int. J. Prod. Econ.* **2015**, *166*, 155–162. [CrossRef]
52. Tian, Y.; Govindan, K.; Zhu, Q. A system dynamics model based on evolutionary game theory for green supply chain management diffusion among Chinese manufacturers. *J. Clean. Prod.* **2014**, *80*, 96–105. [CrossRef]
53. Lin, D.-Y.; Juan, C.-J.; Ng, M. Evaluation of green strategies in maritime liner shipping using evolutionary game theory. *J. Clean. Prod.* **2021**, *279*, 123268. [CrossRef]
54. Zhang, L.; Xue, L.; Zhou, Y. How do low-carbon policies promote green diffusion among alliance-based firms in China? An evolutionary-game model of complex networks. *J. Clean. Prod.* **2019**, *210*, 518–529. [CrossRef]
55. Hu, Y.; Wang, Z.; Li, X. Impact of policies on electric vehicle diffusion: An evolutionary game of small world network analysis. *J. Clean. Prod.* **2020**, *265*, 121703. [CrossRef]
56. Zhao, D.; Ji, S.-F.; Wang, H.-P.; Jiang, L.-W. How do government subsidies promote new energy vehicle diffusion in the complex network context? A three-stage evolutionary game model. *Energy* **2021**, *230*, 120899. [CrossRef]
57. Wang, L.; Zheng, J. Research on low-carbon diffusion considering the game among enterprises in the complex net-work context. *J. Clean. Prod.* **2019**, *210*, 1–11. [CrossRef]
58. Fan, R.; Dong, L. The dynamic analysis and simulation of government subsidy strategies in low-carbon diffusion considering the behavior of heterogeneous agents. *Energy Policy* **2018**, *117*, 252–262. [CrossRef]
59. Chen, M.-H.; Wei, H.; Wei, M.; Huang, H.; Su, C.-H. Modeling a green supply chain in the hotel industry: An evolutionary game theory approach. *Int. J. Hosp. Manag.* **2021**, *92*, 102716. [CrossRef]
60. He, P.; He, Y.; Xu, F. Evolutionary analysis of sustainable tourism. *Ann. Tour. Res.* **2018**, *69*, 76–89. [CrossRef]
61. Xing, Z.; Cao, X. Promoting Strategy of Chinese Green Building Industry: An Evolutionary Analysis Based on the Social Network Theory. *IEEE Access* **2019**, *7*, 67213–67221. [CrossRef]
62. Asadi, S.; Pourhashemi, S.O.; Nilashi, M.; Abdullah, R.; Samad, S.; Yadegaridehkordi, E.; Aljojo, N.; Razali, N.S. Investigating influence of green innovation on sustainability performance: A case on Malaysian hotel industry. *J. Clean. Prod.* **2020**, *258*, 120860. [CrossRef]
63. Dincer, F.I.; Akova, O.; Ertugral, M.S.; Cifci, M.A. Green innovation practices in hotel enterprises. *Eurasian Soc. Sci. J.* **2017**, *1*, 58–73.
64. Harley, C.B. Learning the evolutionarily stable strategy. *J. Theor. Biol.* **1981**, *89*, 611–633. [CrossRef]
65. Mai, Y. Evolutionary Game Analysis of Government Regulation and Enterprise Emission from the Perspective of Environmental Tax. In *IOP Conference Series: Earth and Environmental Science, Proceedings of the 1st International Global on Renewable Energy and Development (IGRED 2017), Singapore, 22–25 December 2017*; IOP Publishing: Bristol, UK, 2017; Volume 100, p. 012208.
66. Guan, J.; Liu, N. Exploitative and exploratory innovations in knowledge network and collaboration network: A patent analysis in the technological field of nano-energy. *Res. Policy* **2016**, *45*, 97–112. [CrossRef]
67. Badi, S.; Wang, L.; Pryke, S. Relationship marketing in Guanxi networks: A social network analysis study of Chinese construction small and medium-sized enterprises. *Ind. Mark. Manag.* **2017**, *60*, 204–218. [CrossRef]
68. Liang, X.; Liu, A.M. The evolution of government sponsored collaboration network and its impact on innovation: A bibliometric analysis in the Chinese solar PV sector. *Res. Policy* **2018**, *47*, 1295–1308. [CrossRef]
69. Frank, O.; Strauss, D. Markov graphs. *J. Am. Stat. Assoc.* **1986**, *81*, 832–842. [CrossRef]
70. Lusher, D.; Koskinen, J.; Robins, G. (Eds.) *Exponential Random Graph Models for Social Networks: Theory, Methods, and Applications*; Cambridge University Press: New York, NY, USA, 2013; Volume 35.
71. Snijders, T.; Pattison, P.; Robins, G.; Handcock, M.S. New Specifications for Exponential Random Graph Models. *Sociol. Methodol.* **2006**, *36*, 99–153. [CrossRef]
72. Robins, G.; Pattison, P.; Kalish, Y.; Lusher, D. An introduction to exponential random graph (p*) models for social networks. *Soc. Netw.* **2007**, *29*, 173–191. [CrossRef]
73. Erdös, P.; Rényi, A. On the evolution of random graphs. In *The Structure and Dynamics of Networks*; Princeton University Press: Princeton, NJ, USA, 2011; pp. 38–82.
74. Pattison, P.; Snijders, T. Modelling social networks: Next steps. In *Exponential Random Graph Models for Social Networks: Theory, Methods, and Applications*; Lusher, D., Koskinen, J., Robins, G., Eds.; Cambridge University Press: New York, NY, USA, 2013; pp. 287–301.
75. Wang, P.; Robins, G.; Pattison, P.; Lazega, E. Exponential random graph models for multilevel networks. *Soc. Netw.* **2013**, *35*, 96–115. [CrossRef]

76. Wang, P.; Robins, G.; Pattison, P.; Lazega, E. Social selection models for multilevel networks. *Soc. Netw.* **2016**, *44*, 346–362. [CrossRef]
77. Brennecke, J.; Rank, O. The firm's knowledge network and the transfer of advice among corporate inventors—A multilevel network study. *Res. Policy* **2017**, *46*, 768–783. [CrossRef]
78. Amati, V.; Lomi, A.; Mascia, D.; Pallotti, F. The Co-evolution of Organizational and Network Structure: The Role of Multilevel Mixing and Closure Mechanisms. *Organ. Res. Methods* **2021**, *24*, 285–318. [CrossRef]
79. Ma, D.; Yu, Q.; Li, J.; Ge, M. Innovation diffusion enabler or barrier: An investigation of international patenting based on temporal exponential random graph models. *Technol. Soc.* **2021**, *64*, 101456. [CrossRef]
80. Box-Steffensmeier, J.; Campbell, B.; Christenson, D.; Navabi, Z. Role analysis using the ego-ERGM: A look at environmental interest group coalitions. *Soc. Netw.* **2018**, *52*, 213–227. [CrossRef]
81. Windzio, M. Immigrant children and their parents: Is there an intergenerational interdependence of integration into social networks? *Soc. Netw.* **2015**, *40*, 197–206. [CrossRef]
82. Koskinen, J.; Daraganova, G.; Lusher, D.; Robins, G. Exponential random graph model fundamentals. In *Exponential Random Graph Models for Social Networks: Theory, Methods, and Applications*; Cambridge University Press: New York, NY, USA, 2013; pp. 49–76.