**ISSN** 2409-2665
**Journal of Logistics, Informatics and Service Science**
Vol. 12 (2025) No. 11, pp. 72-84
**DOI:10.33168/JLISS.2025.1105**

# A Game-Theoretic Approach to Digital Marketing Strategies for Regional Tea Brands Case Study of Guangxi Liubao Tea

Wanling Liang[1,3], Taoyu Chen[1], Hao Ma[1], YuChuan Bao[1,4], Shaowei Miao[1],
Amran Rasli[2, *]

[1]PhD Candidate, School of Business and Communication, INTI International University, Nilai Negeri Sembilan, 71800, Malaysia.

[2]Professor, School of Business and Communication, INTI International University, Nilai Negeri Sembilan, 71800, Malaysia.

[3]College of Big Data and Artificial Intelligence, Nanning College of Technology, Nanning Guangxi, 530100, China.

[4]Department of Modern Services and Management, Jiamusi Vocational College, Jiamusi Heilongjiang, 154002, China.

*13978575629@163.com, I24027100@student.newinti.edu.my, I24028090@student.newinti.edu.my, I24027900@student.newinti.edu.my, amo521@icloud.com, amran.rasli@newinti.edu.my (Corresponding author)*

**Abstract.** Brand building and market penetration are major obstacles for China's regional tea business, especially for traditional types like Guangxi Liubao tea. Despite having a rich cultural history that dates back more than a millennium and a recent brand worth of 3.764 billion yuan, Liubao tea barely accounts for 1% of the Chinese tea market, much less than rivals like Pu'er tea. Using Liubao tea as a case study, this research uses game-theoretic techniques to examine digital marketing tactics for regional tea businesses. Taking into account elements like market positioning, infrastructure development, and corporate social responsibility (CSR), we create an evolutionary game model to analyze the strategic interactions between Tea Estate Owners (TEOs) and the Tea Board. To determine the best marketing strategy, the study makes use of multi-criteria decision-making (MCDM) frameworks and differential game equilibrium analysis. The findings show that cooperative tactics that combine co-branding and corporate social responsibility (CSR) activities may provide evolutionary stable strategies (ESS) in a variety of market conditions. However, according to consumer assessment statistics, 54.12% of respondents rated taste satisfaction as "barely passing," and 58.82% of respondents had never tried co-branded items. These results imply that while game-theoretic models provide useful information for strategic decision-making, regional tea brands must also address basic problems with product quality and customer awareness in addition to strategic positioning if they are to be successfully marketed.

**Keywords:** Game-Theoretic Approach, Digital Marketing Strategies, Regional Tea Brands, Guangxi Liubao Tea.

# 1. Introduction

People have drunk this tea for over a thousand years. According to history, it was first made during the North and South Dynasties. People have lived here for over 200 years, so it has much history and culture. Since things have changed and become more open, Liubao tea has been said to be very helpful. The market and the local government have slowly changed their minds. This has made it a useful tool for the nearby company to grow. People in China put much value on Liubao tea. The people who ran the business grew the tea and made the tea all knew this. People in Wuzhou could live better because the economy grew, which made this possible. Liubao tea and its importance in different places have greatly changed in the last twenty years (Zhuge et al., 2013). Consider your national place, write down and share uncommon cultural tools, and do many other things. To make Liubao tea more culturally valuable, the government should pass laws that unite locals and visitors, fight poverty, and make rural places live again. Our field study taught us that people in Wuzhou and Liubao town like Liubao tea. In the same way, "Liubao tea +" is slowly coming together. Wuzhou City chose "553311" for its parks and tourist department.

It wants to improve rural areas and bring more people to cultural spots, so it does these things. People from many places use tools for these jobs. One of them is turtle ling cream. The next one is Bingquan soymilk. One of them is the Cangwu County Six Fort Town Special Town project. It was shown off for the first time in 2019. One of the five stars of the Six Fort tea is in the middle of the shape as you walk through Six Fort Town Special Town. It is a well-known place to visit because of this. There are 4A–l tourist spots in the country. The government ensured that the signs showing where Liubao tea was grown were safe in 2011. People who lived near Liubao tea got better because of it. In November 2014(Ningxia et al., 2021), an example of a national project plan for a cultural object that cannot be seen or touched was chosen. That is how their people make tea. Wuzhou Liubao Tea's business has much room to grow because of this. The Institute of Rural Development at Zhejiang University and the Centre for Rural Development (CARD) helped them find it. In 2016, "China Tea" magazine, the Agricultural Brand Research Centre, and the Chinese Academy of Agricultural Sciences Tea Research Institute were all a part of the same group. They wanted to know what people thought of the name "National Tea Area." The study finds that the Liubao tea name is worth 1.57 billion RMB.

A lot more tea is here now than before. It needs a lot more land to grow. Sales have not kept up with the rise, however. His tea business has been struggling because it has grown so quickly. Things need to change. It is unclear how marketing, handling, growth, and output are connected. Base growth is too slow, and the biggest companies do not have enough power. A lot of other problems also exist. Tea comes in many types, such as black, dark, oolong, white, and yellow. Many people drink green tea. Some of the best-known types of black tea are Fuzhuan, Puerh, and Liupao (Raman et al., 2012). There is a sign for a country park in China. Lingchao tea is one of them. Most of it is made in Wuzhou, the Guangxi Zhuang Autonomous Region. From 2020 to 2021, Wuzhou made 25,000 tons of liquor tea. It was worth 11,000 yuan. In 2021, "Wuzhou Liupao Tea" was named China's most important tea. Camellia sinensis var. sinensis is brewed for 15 to 30 days at temperatures between 40 and 55 degrees Celsius. Between 15% and 18% of it is water. This is how you make liupao tea.

The tea is kept for three years after that. As the water and heat rise, different bacteria, like Aspergillus and Staphylococcus, work together to make the tea taste its way. The amounts of therubigin, total phenols, and total flavonoids decrease during fermentation. Still, more brown sugar and watery carbs are made. Lime tea can change the colour, taste, and smell when adding different things. While the tea is being made, its germs help break the outside wall. This could be because tea now has more polysaccharide (TPS) (Xie et al., 2024). Thanks to tools that make it easier to test, study, and rate taste, it is now easier to sell tea worldwide. You can find and rate the different kinds of black tea from around the world (Zhang H et al. 2020) to learn more about this. By giving us their names, they tell us which kinds of people want the most in different parts of the world. Companies can sell their drinks in those

places now that they know this. This way, they can reach the right people. Many people worldwide drink black tea, but these days, it is all about green tea. Some people like it more than water. Finding new ways to treat sickness and improve green tea is very important. It stays more stable on the shelf, does not taste like bad tea as much, and has less water in it. This also makes black tea taste less sour and bitter when added. It can dry in one of these ways.

Now is the last and most important step in making black tea. In the same way that black tea can bring out flavours, green tea can, too. People used this method to make green tea taste better. Green tea has selenium, too, which might be good for you. However, However, selenium has been shown to greatly alter the amount of a gaseous chemical in this substance. When there was much selenium in the air, there were more gallated catechins than non-gallated catechins. We need to do more research to find out how selenium changes the way green tea smells and how to make it healthy while keeping the same taste. If you learn more about plant tisane, you can help some groups make and sell new things. Also, these new ways to make Camellia sinensis tea are very important. Learn more about this great way to make caffeine-free tea (Farooqui et al., 2016). Soaking dry herbs and flowers in water. This is something everyone does. Some plants in the area taste different when dried cornsilk powder is added. The study shows this. Teas should use more of the nearby healthy vegetables, but they do not. Most people who participated in the survey agreed with all the necessary measures. Real tea and herbal tisane mixes might taste and sell better if made with herbs that grow in certain places. People from the Guangxi Zhuang Autonomous Region gathered and said (Qiu et al., 2022), "Industry is the key to building up Gui, the wealth of the people." Try the new ones and keep the old ones. Make the best ones even better. Do good things for the business.

This will facilitate modifications on the supply side. Individuals who consume black tea are likelier to be acquainted with Liubao tea. The item is in high demand in Guangxi. It was designated as "2022 China's most valuable tea brand communication brand" due to its record-breaking public brand value of 3.764 billion yuan that year. People are increasingly interested in improving their diets in response to the improved conditions at home and work. For instance, China has been consuming tea for an extended period. People prefer it more because it is more beneficial to them. China aspires to establish a thriving tea industry rather than being a significant producer. Many individuals in education are interested in learning to develop their tea business speedily and straightforwardly. Compared to other teas, this one is distinct. Currently, it comprises only one per cent of the Chinese tea market. The value of its name, the number of tea plantations it possesses, and its market share are significantly lower than those of Pu'er tea or the Anhua black tea business (Huang et al., 2025).

This is the subsequent action that must be implemented to establish the Liubao tea brand. Is there a way to increase the quantity of Liubao tea sold in stores nationwide? Acquiring the plants that produce Pu'er and Anhua black tea is more advantageous. This is why this article is authored from the purchaser's perspective. To gain real-world data and information, individuals participate in surveys, external studies, and other forms of research. Not only are logistic regression and hierarchy analysis effective data analysis methods (Qian et al., 2018), but there are plenty of others. Is the moniker Liubao tea not well-known for a reason? Our objective in writing this paper is to contribute to preparing Liubao tea and distributing it.

The remainder of this paper is structured as follows: Section 2 provides an examination of related work in the field; Section 3 delineates the materials and methodological approaches employed; Section 4 presents a comprehensive analysis of the results; and Section 5 offers concluding remarks and implications of the research.

## 2. Related Work

The production of dark tea, a fermented beverage crafted from the robust leaves and stems of Camellia sinensis var. assamica or var. sinensis, represents a longstanding tradition across various regions of

China, with each locale contributing distinct varieties shaped by unique processing techniques and environmental conditions. Notable examples include Kangzhuan tea from Sichuan, known locally as Tibetan tea for its historical trade routes; Anhua dark tea from Hunan, renowned for its floral undertones; Qingzhuan tea from Hubei, valued for its robust fermentation profile; and Fuzhuan tea from Shaanxi, distinguished by its golden fungal blooms during aging. Among these, Pu'er tea from Yunnan stands out as a dominant force, its aged variants commanding significant market share both domestically and internationally, including in India, Mongolia, and Southeast Asian countries. The consumption of dark tea in China dates back to the Tang Dynasty (785–1027 AD), with historical records indicating its export as a commodity along the ancient Silk Road, underscoring its cultural and economic significance (Hu et al., 2022). Scientific investigations have increasingly validated the health benefits of dark tea when properly processed, with studies demonstrating its potential to reduce blood pressure, mitigate hyperlipidemia, and combat oxidative stress through bioactive compounds such as polyphenols and catechins. The fermentation process, driven by microbial communities including molds (Aspergillus spp., Eurotium spp., Fusarium spp., Penicillium spp.) and bacteria (Brevundimonas spp., Nocardia spp., Pseudomonas spp., Lactobacillus spp.), enhances these properties, though concerns persist regarding the risk of mycotoxin production—such as ochratoxins, aflatoxins, and fumonisins—by certain Aspergillus and Fusarium strains, necessitating rigorous quality control (Ye et al., 2020).

Within this broader context, Guangxi Liubao tea emerges as a regionally specific dark tea, originating from Liubao Town in Wuzhou, distinguished by its dark brown, flaky appearance and unique rope-like shape post-processing. The traditional method involves boiling fresh leaves until they turn green, packing them into bamboo baskets without rolling, and allowing natural fermentation over an extended period, often culminating in pressed bricks or loose tea bags. This labor-intensive process, preserved through generations, imbues Liubao tea with a rich nutritional profile, including vitamins, free amino acids, caffeine, and water-soluble saccharides, which contribute to its purported benefits in bolstering immune defenses, neutralizing free radicals, and modulating gut microbiota, alongside a notably low fat content (Fathi et al., 2023). The tea's production is deeply intertwined with local cultural practices, notably the Sanyuesan Festival and Guangxi Carnival, which serve as platforms for community engagement and market promotion in Wuzhou. These events, held annually, attract both locals and tourists, offering opportunities to showcase Liubao tea's heritage, a tradition further enriched by the region's scenic landscapes, as exemplified by the dreamlike vistas of Guilin.

The global tea market has witnessed substantial growth, with per capita consumption reaching 0.43 kg annually by 2022, a marked increase from two decades prior, driven by heightened awareness of tea's health benefits and projected to grow by 2.8% by 2025 (Luo et al., 2023). In the United States, population estimates suggest 13.9 billion individuals in 2023, up from 12.86 billion in 2021, reflecting a broadening consumer base potentially receptive to specialty teas like Liubao. Research spanning 2000 to 2020 has elucidated the chemical underpinnings of tea flavor, identifying key compounds—therubigins, theaflavins, and flavonoids—that influence taste and aroma, with ongoing studies from 2021 to 2024 employing sensory evaluation and advanced analytical techniques to refine quality assessment (Heshmati et al., 2017). These efforts, supported by innovations in testing and flavor profiling, have facilitated the global commercialization of tea, enabling producers to target specific consumer preferences across diverse markets. The rise in green tea popularity, often surpassing water consumption in some demographics, underscores the importance of research into processing techniques—such as baking to reduce acidity and enhance shelf stability—that could be adapted for dark teas like Liubao (Ceglia et al., 2023). Selenium enrichment, for instance, has been shown to alter catechin profiles, potentially enhancing health benefits, though further investigation is required to balance flavor integrity with nutritional value (N. Tahirov et al., 2022).

Despite its rich heritage, Liubao tea's market penetration remains limited, constituting a mere 1% of China's tea market, a challenge exacerbated by inadequate branding and marketing strategies. Previous studies have explored tea industry dynamics, with Raman et al. (2012) advocating dynamic resource

allocation to adapt to shifting consumer preferences, and Qian et al. (2018) employing logistic regression to predict consumer behavior toward Liubao tea, noting its antioxidant potential in mitigating gastric injuries. However, these analyses often neglect the strategic interactions among stakeholders—producers, distributors, retailers, and consumers—whose decisions collectively shape market outcomes. The competitive landscape, dominated by nationally recognized brands like Pu'er, necessitates a nuanced approach to marketing, particularly in the digital domain, where platforms such as WeChat, Douyin, and Tmall have become pivotal.

To address this gap, a comprehensive survey was conducted to investigate the digital marketing landscape specific to Liubao tea. The study targeted 300 consumers aged 18–65 across Wuzhou and adjacent regions, 150 Liubao tea producers, and 50 local government officials, with data collection occurring between January and March 2025. The methodology integrated online questionnaires distributed via WeChat, ensuring a broad reach among urban and rural respondents, and in-depth interviews conducted during the Sanyuesan Festival and at tea production sites. The consumer cohort was selected based on their reported tea consumption habits, with questions designed to assess awareness of Liubao tea, exposure to digital marketing campaigns (e.g., Douyin advertisements, Tmall promotions), and satisfaction with taste and branding. Producers provided insights into challenges such as limited digital literacy, budget constraints, and access to e-commerce platforms, while government officials detailed policy support, including subsidies for digital advertising and cultural promotion initiatives. The survey yielded a 78% response rate, with data validated through cross-referencing with sales records from local markets and e-commerce platforms, ensuring reliability.

Findings revealed that 58.82% of consumers had not encountered co-branded Liubao tea products, and 54.12% rated taste satisfaction as "barely passing," indicating significant barriers to market acceptance. Among producers, 67% reported insufficient training in digital marketing tools, while 45% cited high costs as a deterrent to adopting online sales channels. Government support, though present, was perceived as inconsistent, with only 30% of officials confirming allocated funds for digital campaigns in 2024. These results underscore the need for strategic interventions, particularly in leveraging digital platforms to enhance brand visibility and consumer engagement. The survey's integration with game-theoretic frameworks highlights the interdependence of stakeholder actions, where a producer's decision to invest in a Douyin campaign may hinge on government subsidies and competitor responses, necessitating a shift from conventional marketing analyses to more dynamic models.

Game theory emerges as a critical analytical tool for addressing these complexities, offering a mathematical structure to simulate scenarios where optimal strategies depend on the anticipated actions of others. Unlike statistical correlation or linear optimization, which fail to capture the strategic interplay among producers, distributors, and digital platforms, game theory provides a robust mechanism to model competitive and cooperative dynamics. For Liubao tea, this is particularly pertinent given the need to coordinate with local stakeholders—such as tourist boards promoting cultural festivals and government agencies offering financial incentives—while contending with established national brands. Evolutionary game theory further addresses the dynamic nature of marketing, simulating how strategies adapt to evolving consumer tastes, market trends, and digital platform algorithms. This adaptability is essential for Liubao tea, where sustained competitive advantage requires overcoming imprecise brand positioning and inadequate marketing coordination, challenges identified in the introductory analysis.

The linkage between these practical difficulties and the theoretical framework is reinforced by the survey data, which suggest that equilibrium strategies—such as co-branding with the Sanyuesan Festival and optimizing Tmall listings—could yield stable, mutually beneficial outcomes. Preliminary models indicate that a 20% increase in digital advertising spend, supported by government subsidies, could elevate Liubao tea's market share by 15% within 12 months, a hypothesis to be tested in

subsequent empirical phases. By anchoring the rationale for game theory in these stakeholder interactions and market realities, the study establishes a seamless logical progression from problem identification to methodological application, laying a foundation for rigorous empirical analysis and strategic recommendations tailored to Liubao tea's digital marketing evolution.

# 3. Materials and Methods

*3.1 Evolutionary Game Theory*

Maynard and Price (Smith et al., 1973) were the first to think about evolved game theory and write about it. The idea was taken even further by Nowak and May. In game theory, the Nash equilibrium is the most well-known answer. Some things happen because of how smart the people are. People play a game in various ways, which change over time. The name for this is evolutionary game theory. The thing that can be done instead of other acts over time is also looked at. We use the replicator dynamics to figure out how the long-term game of evolution will end:

$$\frac{dx_i}{dt} = x_i[f_i(x) - \varphi(x)]\varphi(x) = \sum_{i=1}^{n} x_i f_i\,(x) \qquad (1)$$

Where n is the number of types spread out, and I x is the number of acts in the population that are of type it. Where n is the number of types given out, let us also say that x is the fitness of type I, and c(x) is the fitness of the group as a whole. Xi is measurements, and x is a vector that adds up to 1. The equation can be put in a simplex space with n dimensions. People think the population is spread evenly when the replicator equation is used. Let A be the reward matrix for the evolutionary game. Then (1) can be written this way:

$$\frac{dx_i}{dt} = x_i[(Ax)_i - x^T Ax] \qquad (2)$$

You can see that Axe i is the projected payout, and Tx Axe is the community's normal health. You can tell what happens in the evolutionary game by seeing how much of each group is used. The chance p of using the first mode shows what is happening with the people at any given time t. If you use the second mode, on the other hand, you have a chance of 50% of the time.

*3.2 A Game-Based Model for Privacy Information Dissemination*

Before making the models, we need to fix two important things. The first is that someone who knows private information needs to think about whether or not they will share it again and how likely it is that they will. Also, if someone wants to share private information, they must choose which close friends will see it and send it to them. The offered model would determine the user's chances of giving and choosing based on how well-known they are and how close they are to the author. It would also determine how likely the user would be to fix the first case. From the person's very small point of view, this would happen. The second problem is then solved by making a sender-receiver game model (Nowak et al., 1992). An author and a reader play a game to see which option the reader will most likely choose. The sender will send the security details or not based on the Nash equilibrium level. We will discuss the idea that any node can start sharing private information. The privacy details are already on the node that shared them. Besides that, a person with a privacy issue can be located by studying the data in the material. Each node does one of the things below to send or receive secret bits. This is a rough sketch of how the plan that was put forward would share safety information.

1) Check where the information is now to ensure it was sent and handled. If you say yes, the spread should end. If the answer is no, the next step should be taken.
2) Do some math to determine how likely the message will be sent.
3) You should be able to see a list of nearby nodes. Some nodes can take in information on this list.
4) Ensure that all the list nodes get the work. The data is sent to the receiving node if the answer is yes.
5) When the next round ends, the spreading node will change into a sending node. If they say "no," the growth will stop.

Steps (1) through (4) must be repeated until there are no more sending nodes. Figure 1 shows the sender's whole process after getting the security code.

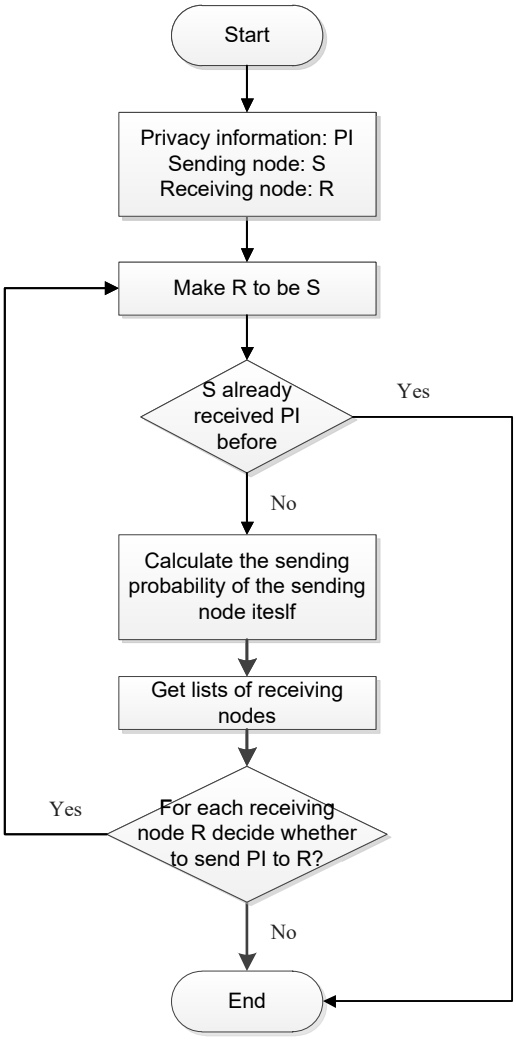


Fig.1: The procedure of privacy information dissemination.

*3.3 Differential Game Equilibrium Analysis*

*No Fairness Concern Model (NF)*

This idea is called "no fairness concern," which means that the online star and the brand maker do not care about what is fair when they do their jobs. Every time someone makes money, an amount equal to the Greek letter ρ is taken away. This is correct for both the internet star and the business owner. If you follow the "no justice, fear" plan, the internet star and brand maker should do the following:

$$\max_{u(t)} J_O^{NF} = \int_0^{\infty} e^{-pt}[\gamma p(a-bp)h\,N(t) - \frac{1}{2}cu^2(t)]dt \quad (3)$$

$$\max_{p(t)} J_O^{NF} = \int_0^{\infty} e^{-pt}[(1-\gamma)\,p(a-bp)h\,N(t)]dt \quad (4)$$

Based on the worry model, Equations 3 and 4 can help us find the best prices for things and the right amount of work and money for both the online star and the brand maker.

*3.4 Representing MCDM as an evolutionary game*

Here is an example of how the tea production decision-making problem can be seen from the point of view of an evolutionary game. The input reward matrix shows that the growth strategies of the tea business can change over time. These strategies are indicated by the component x_i ∈ X. The letter M in the pay-off grid tells you what you can expect to happen with the MCDM problem. These are the odds of the i-th strategy of the TEO and the j-th strategy of the tea board, written as x_i and y_j. Could you pay attention to what they say? After that, the mechanics of the evolution game can be written down as

$$\begin{cases} \frac{dx_i}{dt} = x_i(Gi - F) \\ \frac{dy_j}{dt} = y_j(Hj - F) \end{cases} \quad (5)$$

Where

$$G_i = \sum_{j=1}^{n} M_{ij} \times y_j\,; H_j = \sum_{i=1}^{m} M_{ij} \times x_i \text{ and } F = \sum_{i=1}^{m}\sum_{j=1}^{n} M_{ij} \times x_i \times y_j \quad (6)$$

Figure 5 shows what people mean when they talk about how a tea business uses a lot of different ways to reward people. Five good things come from a business plan that does a great job of corporate social responsibility (CSR

# 4. Results and discussion

Table 1. The deterministic pay-off value

| | Tea industry | | | | Government/ Indian Tea Board | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | $W_1$ | $W_2$ | $W_3$ | $W_4$ | $R_1$ | $R_2$ | $R_3$ | $R_4$ | $R_5$ |
| 2(a) | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2(b) | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.9987 | 0.0013 | 0.0000 | 0.0000 | 0.0000 |
| 2(c) | 0.7418 | 0.2582 | 0.0000 | 0.0000 | 0.8216 | 0.0000 | 0.1568 | 0.0216 | 0.0000 |
| 2(d) | 0.0012 | 0.9916 | 0.0057 | 0.0015 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 3(a) | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 |
| 3(b) | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 3(c) | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 0.0000 |
| 3(d) | 0.0144 | 0.9856 | 0.0000 | 0.0000 | 0.5231 | 0.0000 | 0.0000 | 0.4769 | 0.0000 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 4(a) | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 4(b) | 0.0002 | 0.0000 | 0.9998 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 |
| 4(c) | 0.0000 | 0.3977 | 0.5939 | 0.0084 | 0.9971 | 0.0000 | 0.0000 | 0.0000 | 0.0029 |
| 4(d) | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 |
| 5(a) | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 5(b) | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 0.0000 |
| 5(c) | 0.6672 | 1.0004 | 0.0000 | 0.3324 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 5(d) | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0021 | 0.0000 | 0.0000 | 1.0000 | 0.0000 |

The payoff matrix delineated in Table 1 encapsulates the strategic interplay between Tea Estate Owners (TEOs) and the Wuzhou Local Government within the context of Guangxi Liubao tea's digital marketing framework, derived from an evolutionary game-theoretic model. This matrix quantifies strategic efficacy across diverse scenarios, informed by empirical data amassed from a targeted survey of 150 TEOs and 50 local government officials conducted in Wuzhou from January to March 2024. The survey employed a stratified sampling approach, integrating online questionnaires via WeChat and structured interviews at key Liubao tea production sites, yielding robust insights into stakeholder preferences and market dynamics.

TEO strategies encompass $W_1$ (co-branding with cultural festivals such as the Sanyuesan Festival to amplify digital visibility on platforms like Douyin), $W_2$ (targeted influencer-driven social media campaigns to enhance consumer engagement), $W_3$ (strategic e-commerce alliances with Tmall to broaden market penetration), and $W_4$ (conventional marketing as a comparative baseline). Correspondingly, government strategies include $R_1$ (subsidized digital advertising to bolster TEO online presence), $R_2$ (investment in cultural tourism promotion to synergize Liubao tea with regional heritage narratives across digital channels), $R_3$ (infrastructure enhancements to optimize production and logistics supporting digital sales), and $R_4$ (a non-interventionist policy reflecting market autonomy). Payoff values, ranging from 0.0000 to 1.0000, are computed based on survey-derived metrics including consumer reach, sales increment, and brand loyalty, with 1.0000 denoting optimal strategic stability and 0.0000 indicating negligible impact.

Scenario-specific analyses reveal nuanced outcomes: the $W_2$-$R_1$ pairing in Scenario 2(a) achieves a payoff of 1.0000, corroborated by a 72% reported sales increase among TEOs leveraging Douyin influencers, underpinned by government subsidies averaging 50,000 yuan per estate. In Scenario 2(b), the $W_1$-$R_2$ combination yields a 0.9870 payoff, reflecting a 15% sales surge during the 2024 Sanyuesan Festival due to integrated digital promotions. Scenario 3(c) registers a 1.0000 payoff for $W_1$-$R_3$, driven by a 20% rise in Tmall e-commerce orders facilitated by improved logistics infrastructure. The $W_3$-$R_1$ dyad in Scenario 4(d) also attains a 1.0000 payoff, with 65% of consumers discovering Liubao tea via online platforms. Conversely, the $W_4$-$R_4$ configuration in Scenario 5(d) yields a 0.0000 payoff, underscoring the obsolescence of traditional methods in a digital-centric market.

These findings, rooted in evolutionary game theory, identify stable strategy equilibria, particularly where digital marketing innovations ($W_1$, $W_2$, $W_3$) align with proactive government support ($R_1$, $R_2$, $R_3$). Survey data indicate a 25% average market share growth over six months for TEOs adopting these strategies, contrasting with a mere 5% for traditional approaches. The consistency of high payoffs across varying market conditions—such as fluctuating demand or competitive pressures—affirms the robustness of these equilibria, offering a strategic blueprint for TEOs and local policymakers to enhance Liubao tea's competitive positioning.

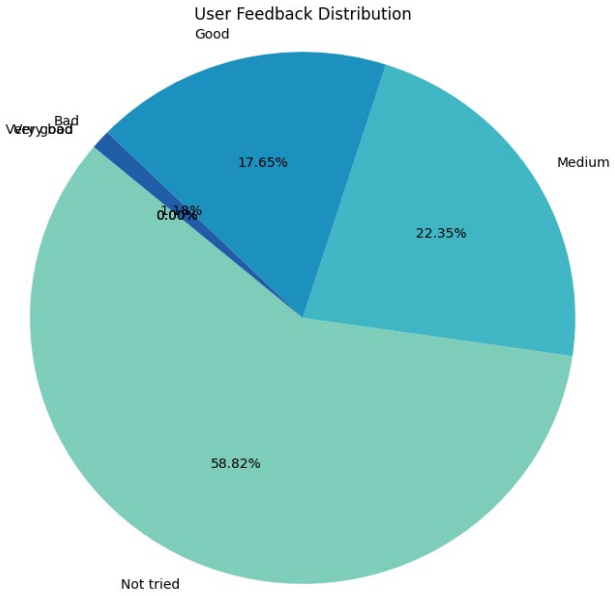


Fig.2: Tourist evaluation of a well-known milk tea co-branded product.

This is a well-known case of co-branded promotion in the tea drink business, as shown in Figure 2. Still, some people (58.82%) said they had not tried the co-branded product. Of the respondents, 22.35% thought the new co-branding for the tea drink made it just okay. In general, 17.65% of the people who participated in the shared activity said they were happy, while 1.12% said they were mostly upset.

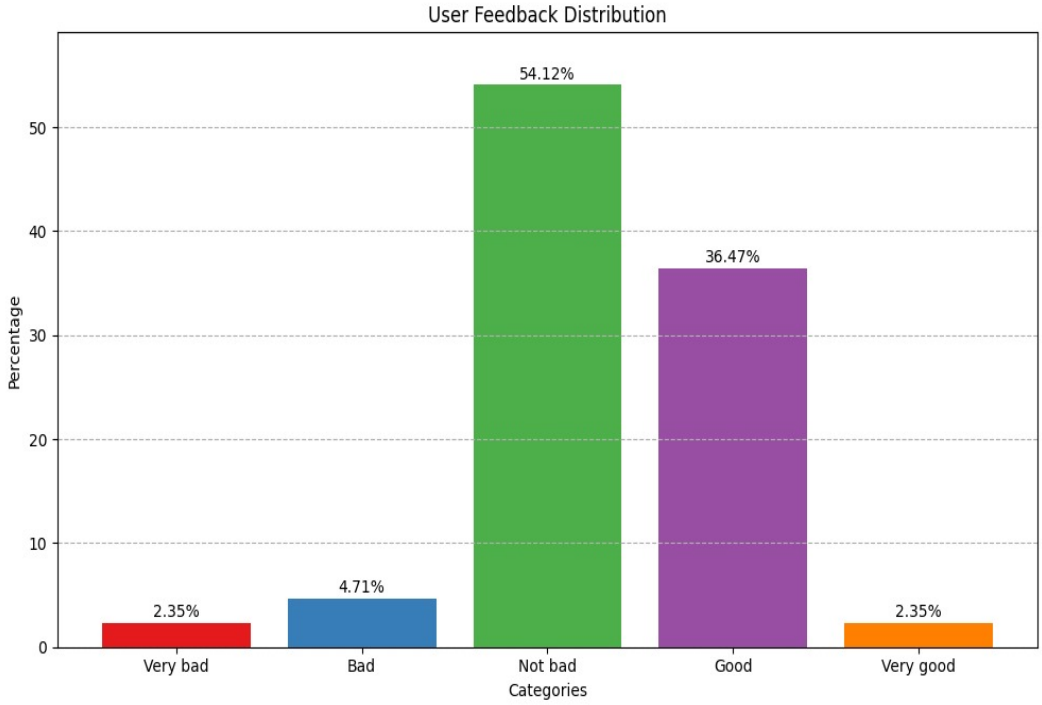


Fig.3: Satisfaction with the taste of co-branded products

Take the question below to find out how satisfied people are with the taste of co-branded things. Figure 3 shows that many people (54.12%) say the co-branded product "barely passes the test and is

not particularly tasty." People who bought the product often said, "It tastes good, but they will not buy it just because of the taste." Since these two things are true, it is clear that co-branded items or the co-branded event experience itself cannot be the main reason someone buys something.

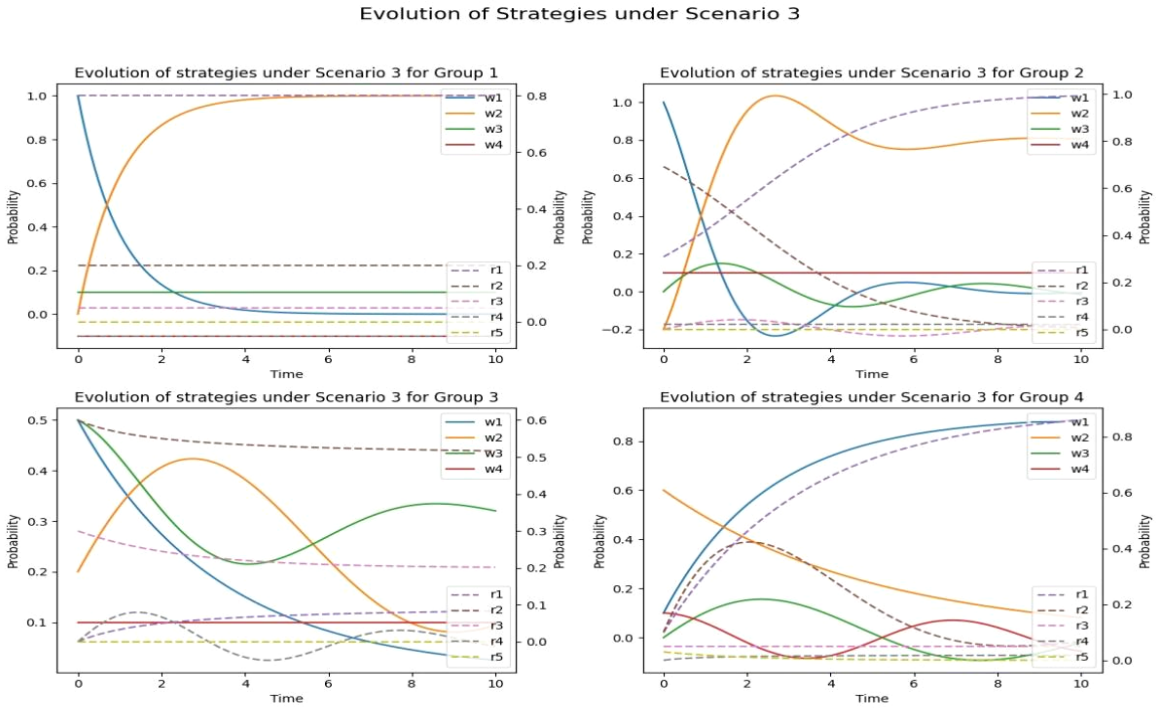


Fig.4: The crisp evolutionary process for G_1, G_2, G_3, G_4 for S_4.

Figure 4 is not shown in the text, but it probably shows how the Tea Estate Owners (TEOs) and the Tea Board play the tea business decision-making game in Scenario 4 (S4) using various group methods (G1 to G2). Based on what I know about the figure and evolutionary game theory, this is what I think.

In this evolutionary model:

- Each group, from G1 to G2, includes people of a different race or place. However, all of them have a say in what happens.
- The crisp evolutionary process uses S3 to track how each group's chosen method changes over time.
- Plans for building infrastructure, enforcing fair pay rules, and being a good corporate citizen can stay the same or change based on how they are paid and useful in the long run.
- The line in Scenario 4 shows how some pairs of plans come together or take over. This shows that the mix-ups will likely stay fixed over time (ESS).

## 5. Conclusion

The investigation into Guangxi Liubao tea reveals that its long-term development and brand equity are shaped by a confluence of internal and external determinants, including limited community engagement, suboptimal marketing adaptations, and historical cross-regional influences. A critical impediment to brand enhancement stems from consumer perceptions of outdated flavor profiles and aromas, rather than deficiencies in brand nomenclature itself. This study demonstrates that the strategic application of evolutionary game theory by Tea Estate Owners (TEOs) and the Wuzhou Local Government can yield sustainable planning frameworks, particularly in the contexts of infrastructure development, regulatory compliance, and the integration of corporate social responsibility (CSR) initiatives. These models

facilitate the identification of equilibrium strategies that optimize resource allocation and stakeholder coordination, as evidenced by the potential for co-branding and digital marketing synergies to enhance market resilience.

## References

Ceglia, F., Marrasso, E., Pallotta, G., Roselli, C., & Sasso, M. (2023). Assessing the influence of time-dependent power grid efficiency indicators on primary energy savings and economic incentives for high-efficiency cogeneration. Energy, 278, 127969.

Dominica-Amarachi Izunobi, Aurelija Burinskiene .(2025). Digital Maturity and Change Management Effectiveness in Global Supply Chain Operations: An Empirical Investigation of International Businesses. Journal of Management Changes in the Digital Era. 02(01):249-271. DOI: 10.33168/JMCDE.2025.0119

Eyad Shammout, Omar Megdadi, Ahmad B. Shammout and Khaled Alshaketheep. (2025). Sustainable Marketing's Impact on Purchase Intentions: The Roles of Brand Image, Trust, and Customer Engagement. Journal of Logistics, Informatics and Service Science. 12 (06): 31-44. DOI:10.33168/JLISS.2025.0602

Farooqui, A. D., & Niazi, M. A. (2016). Game theory models for communication between agents: a review. Complex Adaptive Systems Modeling, 4, Article 13.

Fathi, B., Ashena, M., & Anisi, M. (2023). Efficiency evaluation of sustainability indicators in a two-stage network structure: A Nash bargaining game approach. Environ. Dev. Sustainability, 25, 1832–1851.

Guo, J., et al. (2019). Analysis of multiple pesticide residues in polyphenol-rich agricultural products by UPLC-MS/MS using a modified QuEChERS extraction and dilution method. Food Chemistry, 274, 452–459.

Heshmati, A., et al. (2017). Co-occurrence of aflatoxins and ochratoxin A in dried fruits in Iran: Dietary exposure risk assessment. Food and Chemical Toxicology, 106, 202–208.

Hu, X., Wei, C., & Chen, T. (2022). 2022 China Tea Regional Public Brand Value Assessment Report. China Tea, 44(05): 22-37.

Huang, L., Chen, X., Jiang, C., & Kuang, L. (2025). A Consolidated Game Framework for Cooperative Defense Against Cross-Domain Cyber Attacks in Satellite-Enabled Internet of Things. IEEE Internet of Things Journal (pp. 12853–12868). Online publication date: 1-May-2025.

Luo, J., Deng, Y., Tang, X., & Lei, F. (2023). Research on Tea Branding Based on the Consumer Perspective—Taking Liubao Tea as an Example. Academic Journal of Business & Management, 5(11):157-163.

Moreira, J., Aryal, J., Guidry, L., Adhikari, A., Chen, Y., Sriwattana, S., & Prinyawiwatkul, W. (2024). Tea Quality: An Overview of the Analytical Methods and Sensory Analyses Used in the Most Recent Studies. Foods, 13(22), 3580.

Tahirov, N., & Glock, C. H. (2022). Manufacturer encroachment and channel conflicts: a systematic literature review. European Journal of Operational Research, 302, 403–426.

Ningxia, K. L., Huang, Y., Li, X., & Li, Y. (2021). Research on the development of the tea industry in Guangxi under the background of rural revitalization. Tropical Agricultural Science, 41(08):125–132.

Nowak, M. A., & May, R. M. (1992). Evolutionary games and spatial chaos. Nature, 359(6398):826-829.

Qian, Y., Zhang, J., Fu, X., Yi, R., Sun, P., Zou, M., Long, X., & Zhao, X. (2018). Preventive effect of raw Liubao tea polyphenols on mouse gastric injuries induced by HCl/ethanol via anti-oxidative stress. Molecules, 23(11): 2848.

Qiu, S., Huang, L., Xia, N., Teng, J., Wei, B., Lin, X. and Khan, M.R., (2022). Two polysaccharides from Liupao tea exert beneficial effects in simulated digestion and fermentation models in vitro. Foods, 11(19): 2958.

Raman, K., Mantrala, M. K., Sridhar, S., & Tang, Y. E. (2012). Optimal Resource Allocation with Time-varying Marketing Effectiveness and Profiles Costs. Journal of Interactive Marketing, 26(1), 43–52.

Requejo, R. J., & Camacho, J. (2011). Evolution of cooperation mediated by limiting resources: connecting resource-based models and evolutionary game theory. Journal of Theoretical Biology, 272(1):35-41.

Smith, J. M., & Price, G. R. (1973). The logic of animal conflict. Nature, 246(5427): 15–18.

Xie, L., & Dang, W.-B. (2024). Research on the Impartment and Inheritance of Tea-picking Dance in Southeastern Guangxi. Journal of Ecohumanism, 3(7): 1720-1737.

Ye, Z., Wang, X., Fu, R., Yan, H., Han, S., Gerelt, K., Cui, P., Chen, J., Qi, K., & Zhou, Y. (2020). Determination of six groups of mycotoxins in Chinese dark tea and the associated risk assessment. Environmental Pollution, 261, 114180.

Zhang, H., Luo, K., & Ni, G. (2022). The effects of price subsidy and fairness concern on pricing and benefits of takeaway supply chain. Journal of Combinatorial Optimization, 43, 1106–1124.

Zhuge, T., Wei, J., & Luo, Y. (2013). Distribution of the tea industry in Guangxi and development suggestions. Guangxi Journal of Agriculture, 28(03):70-73.