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Article

Study on the coupled coordination relationship and constraining factors of Macau's gambling-tourism-economic development from the perspective of urban high-quality development

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Abstract: This inquiry endeavors to meticulously examine the intricate dynamics of the symbiotic developmental interplay among the gaming, tourism, and economic sectors in Macau. Utilizing the methodology of deviation standardization, the data undergoes scrupulous processing, invoking the entropy method to ascertain the weights of diverse evaluative indices. The developmental trajectories of Macau's gaming, tourism, and economic domains spanning the years 2011 to 2021 are fastidiously gauged. Subsequently, a sophisticated coupled coordination model is employed to delve into the nuanced systemic interdependencies characterizing their developmental relationships. From 2011 to 2021, the holistic progression of Macao's gaming and tourism sectors has exhibited a discernible ascent over the temporal continuum. Concurrently, the degree of coupling coordination has advanced from a state of near coordination to a commendable level of synchronized development. The overarching system of Macau's gaming and tourism industries has transitioned from a state of disarray to one of ordered harmony, with the correlative impact of Macau's tourism sector being adeptly realized. The supporting role played by Macau's gaming industry in fortifying the tourism sector is conspicuously manifest. The alignment and coordination between Macau's gaming and tourism sectors exhibit fluctuations across distinct developmental stages. During phases of nascent development in both the gaming and tourism domains, a palpable imbalance prevails. Elements such as the proliferation of gaming enterprises, international tourism revenue, aggregate output value of gaming establishments, market share held by gaming enterprises, and the profit margins thereof have, to a certain extent, impinged upon the harmonized evolution of the tripartite subsystems. This study proffers recommendations to foster the optimization and elevation of the industrial structure while championing the integration and advancement of diverse sectors. It advocates for the amplification of the propulsive impetus intrinsic to the gaming industry, coupled with the enrichment of the tourism product portfolio. Furthermore, it espouses the establishment of an effective mechanism for high-quality development, tailored to the exigencies of the contemporary era. This involves the implementation of precise policies, the facilitation of amalgamated progress in gaming and tourism, and an unwavering commitment to sustainable development through the interconnected alignment of gaming, tourism, and the broader economy. The findings of this study furnish a scientific foundation for the strategic industrial planning and developmental initiatives undertaken by relevant departments in Macau.

Keywords: gaming industry; tourism; coupling coordination; comprehensive evaluation; high-quality development; Macao

1. Introduction

Macao plays a pivotal and strategic role within the comprehensive framework of the modernization efforts and the high-quality developmental paradigm of the Guangdong-Hong Kong-Macao Greater Bay Area. The advancement of Macao's integrated economic development carries profound significance in guiding the nation towards high-quality growth and cultivating the establishment of a contemporary economic system (Yang et al., 2021). The economic trajectory of the Guangdong-Hong Kong-Macao Greater Bay Area has evolved into a phase characterized by high-quality development, thereby compelling the imperative integration of Macao's advancements within a comprehensive growth model attuned to elevated pragmatic standards (Yu, 2019; Zhou et al., 2018). The Macau Special Administrative Region (SAR) government has responded to the evolution of diverse industries within the local landscape by delineating precise objectives, primary undertakings, and pivotal initiatives for a period of moderate and diversified economic development spanning from 2024 to 2028. This strategic blueprint aspires to steer the course of social investments and residents' progress, thereby efficaciously augmenting the developmental momentum and overall prowess of Macau's economy. It expedites the trajectory of Macau's economic landscape towards a state of moderate diversification, sustainability, and heightened excellence. It is necessary to promote the diversified development of the comprehensive tourism and leisure industry. Promote the healthy development of the gaming industry in accordance with the law, and accelerate the construction of a comprehensive tourism and leisure destination integrating food, vacation, sightseeing, shopping, entertainment, culture, medical care, sports and other elements through the "tourism +" development model, and continuously enrich Macao's world tourism and leisure central connotation. The all-encompassing sectors of tourism and leisure, traditional Chinese medicine and health, modern finance, high-tech, and the transformative elevation of traditional industries, as well as exhibition, trade, and cultural and sports industries, demand the diligent execution of principal tasks and pivotal projects. Within the confines of a specialized chapter dedicated to protective measures, the plan delineates the distinct roles and implementation responsibilities of key project departments, ensuring the meticulous realization of the outlined objectives.

The discourse surrounding China's paradigm shift towards high-quality development has garnered significant scholarly attention. Indeed, China's economic trajectory has successfully traversed the transition from a phase marked by rapid growth to one characterized by a commitment to high-quality development. The imperative of this evolution encompasses multifaceted dimensions, spanning the realms of economics, society, ecology, and culture. This imperative arises as an urgent demand to address the fundamental societal contradictions prevailing in the contemporary era, concurrently laying the foundation for the establishment of a modern economic edifice (Liu et al., 2021; Yuan and Jang, 2022). As one of the strategic pillar industries, tourism must shoulder the mission entrusted by the new era. Under the development requirements of the new era, China's tourism industry urgently needs to transform from a quantitative development model to a high-quality development model. The Macau Chinese General Chamber of Commerce held the

annual "Macau Industrial and Commercial Forum" on 3 April 2023. President Cui Shichang said that with the strong support of the central government and the guidance of the SAR government, the Macau economy has been promoted to achieve appropriate diversification of "1 + 4" has become an urgent priority. The business community must be good at seizing the opportunity of fully resuming the flow of people from the mainland to Hong Kong and Macao, make full use of the central government's policies that are beneficial to Macao, continuously enhance the development momentum and overall competitiveness of Macao's economy, and provide strong support for the high-quality development of Macao's economy (McCartney, 2021; Pang et al., 2021). Hence, it holds profound significance in the contemporary era to undertake meticulous research into the high-quality development of the gaming industry and tourism.

The "14th Five-Year Plan for National Economic and Social Development of the People's Republic of China and the Outline of Long-term Goals for 2035" explicitly delineates the imperative implementation of new development paradigms, the proactive promotion of high-level development, and the advocacy for the harmonized advancement of diverse regions. By refining the synergistic interplay between the gaming industry and tourism, Macao stands poised to actualize its objectives of industrial upgrading and the pursuit of high-quality development.

Macao's venerable cornerstone, the gaming industry, assumes a pivotal role as a strategic platform for economic development. The gaming industry has a profound role in promoting Macao's economy, and its driving effect is significant in the economic field. Macao's economic development has gone through four different stages since the handover, including fluctuating development from the handover to 2004, slow development from 2005 to 2009, transformational development from 2010 to 2020, and the post-epidemic era since 2020. After the outbreak of the COVID-19 epidemic in 2020, the number of global cross-border tourism dropped significantly, especially the number of tourists in Macau, with the gaming industry as a pillar industry, falling off a cliff (Puah et al., 2022). According to data released by the Macau Gaming Inspection Bureau, the number of tourists in June 2021 dropped by 50% compared with the same period. The decrease in tourist arrivals also means a decrease in tourism income. Macau's gaming revenue in 2021 decreased by 3.91 billion patacas compared to the same period in 2020, with a decline rate of 37.4%. The unstable development of the gaming industry has brought significant economic fluctuations.

In the course of Macao's evolution within a distinctive political and historical milieu, an exclusive gaming tourism sector progressively crystallized, emerging as the fulcrum of the indigenous economy (Law et al., 2019). After the downturn from the mid-1990s to the beginning of this century, Macau's gaming tourism industry, driven by the return of Macau and the liberalization of gambling rights, successfully got rid of the negative impacts of the Asian financial crisis, public security problems and other negative impacts, and achieved steady growth. In 2012, Macau received 28.082 million inbound tourists by sea, land and air, which is equivalent to about 20 times the local population of Macau. Employees in gaming, tourism and related industries account for about one-third of Macau's employed population (Tang et al., 2021). It can be seen that gaming tourism is still the leading industry in Macao's

economic development. However, the growth of Macao's inbound tourism has slowed down, with a slight decline in 2012, and the development of the gaming tourism industry has shown weakness. Against this background, finding new growth points for the gaming tourism industry has become a new challenge facing Macau's economic development.

Although Macau's gaming industry has had a positive impact on promoting the development of tourism, shaping a unique gaming culture, promoting the maturity of construction technology, and promoting economic development, most countries and regions around the world have fully or partially liberalized the gaming tourism industry. Consider it an important means to attract tourists and drive economic growth. As one of the few countries that has not yet opened up gambling tourism, China's long-term policy of banning gambling has not achieved the expected results. As China's era of reform and opening enters a novel phase, amid the intricate challenges within the gaming milieu encapsulated by "internal and external troubles", the imperative lies in orchestrating a sagacious integration of the gaming tourism industry with the nuanced dynamics of supply-side structural reform. Navigating this juncture demands a strategic grasp of the pivotal opportunities embedded within the reformative landscape, thereby propelling the sector toward profound development. The optimization of industrial structure and configuration assumes paramount significance in this endeavor, constituting a strategic response to the formidable pressures arising from the burgeoning overseas gaming tourism landscape. Achieving a state of robust health and sustained growth stands as the foremost objective in this evolving panorama.

2. Literature review

The huge influx of people and funds driven by the tourism gambling industry is also increasing the limited natural and social resources of Macau, while bringing convenience to the development of other industries. So the impact of Macau's tourism and gambling industry on the socio-economic development has always been a focus of research by scholars.

Scholars' research on Macau's tourism and gambling industry mainly focuses on its impact on the overall economy, its relationship with the financial industry, and its impact on other industries. For example, some scholars have explored the ways in which the cultural and creative industries and the gambling industry mutually promote development from the perspective of cultural creativity. That is, the gambling industry provides new development space for the cultural entrepreneurship industry, while the cultural and creative industry enriches the connotation and extension of the gambling industry. Based on the theory of industry interaction and integration, they have proposed strategies for the integration and interaction of the two industries (Chen et al., 2023). Scholars have also studied the impact of gambling tourism on the overall economy of Macau, proposing that the gambling industry in Macau drives rapid GDP growth, provides conditions for creating a low tax environment, provides employment opportunities, and brings about changes in the urban landscape, thus becoming the foundation for the rapid development of Macau's economy (Li et al.,2023). Some scholars, through years of empirical

analysis, have found that the positive impact of casinos on the regional economy is only temporary and will gradually weaken over time. This may be due to the competition between casinos and other legal gambling industries, and the gambling industry's impact on other Cannibalization (in markets and resources) of non-gaming industries (Sheng et al., 2023). In terms of finance, relevant scholars analyzed the relationship between the gaming industry and the financial industry from the three perspectives of gaming industry revenue, operation management, and loans, and proposed that the opening up of the gaming industry will have an impact on the financial industry in terms of business policies, financial environment, and loans to other industries. Impact on business and other aspects. On the basis of analyzing the industrial structure of Macao, which is dominated by the tourism and gaming industry, some scholars also discussed the support of Macao's financial industry to the tourism industry, and finally proposed a strategy for the interactive development of the financial industry and the gaming industry based on this (Liu et al., 2021; Zhou et al., 2022).

In summary, it is evident that the above studies have conducted relevant studies on the tourism and gambling industry in Macau from various perspectives, but they have only had an impact on the economy, finance, and related industries, without elaborating on the relationship between the three from an internal perspective. Therefore, this study adopts the perspective of high-quality urban development and integrates Macau's gambling, tourism, and economic development into a comprehensive framework for research. This comprehensive perspective is expected to provide new insights into the complex interrelationships between different elements in urban development. Overall, the innovation of the article may be reflected in its comprehensive perspective, coupling and coordination relationship research, obstacle factor analysis, and possible regional specificity. These innovative points are expected to provide new theoretical support and practical guidance for the high-quality development of Macau cities.

3. Coupling mechanism for urban high-quality development measurement

Coupling denotes the existence of correlation or interconnectedness between systems, whereas coordination underscores the ordered and harmonious nature of this correlation (Yang et al., 2020b). The phenomenon of coupled coordination occurs between multiple systems, which influence each other and lead to a mutually coordinated state or phenomenon.

The interaction and coordination between the three systems of tourism, gaming and economic development jointly promote the high-quality development of Macao's economy. As the main driving force for high-quality economic development in Macao, the tourism industry and gaming industry have injected vitality into economic development. The coupling mechanism between tourism, gaming and economic development that promotes and complements each other.

Tourism and gaming invariably constitute pivotal components of the economic landscape. The flourishing of these dual industries not only beckons a greater influx of tourists and enthusiasts but also catalyzes the advancement of indigenous

commerce and service sectors. This, in turn, engenders heightened employment opportunities and catalyzes increased business investment, thereby propelling comprehensive economic expansion.

The tourism and gaming industry generally requires a large labor force and includes areas such as hotels, restaurants, entertainment, services and management. This will provide more employment opportunities, improve the livelihoods of local residents and improve their living standards.

Both the tourism and gambling industries can provide considerable tax revenue to the government. These taxes can be used for public services such as infrastructure construction, education, and health care, thereby promoting broader social development (Zhang and Zeng, 2022).

Both tourism and gaming have the potential to constitute integral facets of a region's brand identity. A thriving tourism and gaming sector not only elevates the regional prominence but also acts as a magnet for increased tourism, investment, and a proliferation of business prospects. A reliance solely on a singular industry renders a region more susceptible to economic oscillations, whereas the coexistence of tourism and gaming fosters economic diversity. In this manner, when one industry encounters challenges, the fortitude of others can sustain the regional economy.

The development of tourism and gaming industries may have a profound impact on local society, including cultural exchange, social interaction and identity. These impacts can further promote social development and progress.

4. Overview of the gaming industry in Macao

The Macao Special Administrative Region (English: Macao), referred to as "Macao", is located on the west side of the Pearl River Estuary in southern China. It is the water and land intersection between mainland China and the South China Sea. It is adjacent to Guangdong Province, 60 kilometers away from the Hong Kong Special Administrative Region, and 60 kilometers away from Guangzhou City, Guangdong Province. 145 kilometers (Ian et al., 2023). The Macau Special Administrative Region includes the Macau Peninsula, Taipa, Coloane Islands and Cotai City (Cotai Reclamation Area). The Macau Peninsula only covers an area of 11.6 square kilometers, Taipa Island covers an area of 7.6 square kilometers, and Coloane Island is 3.2 square kilometers, with a total land area of approximately 32.9 square kilometers. As of the end of 2022, the total population of the Macau Special Administrative Region was 672,800, making it one of the most densely populated regions in the world (Wu et al., 2021; Wan and Li, 2013).

Macau is one of the four major gambling cities in the world, and the gaming industry is an important part of Macau's economy (Sheng and Gu, 2018; Liu et al., 2015). In 2019, it achieved a turnover of nearly 300 billion patacas, accounting for more than 50% of GDP. In the same year, Macau received more than 39 million inbound tourists, more than 70% of which were from the mainland. Macau is famous for its fusion of Chinese and Western cultures and is rich in tourism resources, including world cultural heritage buildings, food and shopping. Macau has complete tourism facilities, with more than 120 hotels, and its occupancy rate remains above 80% all year round. The Macau government actively promotes the development of

the convention and exhibition industry and has established the International Convention and Exhibition Center and the Venetian Macao Convention and Exhibition Center. In addition, Macau also hosts a number of large-scale events and festivals, such as the Macau Grand Prix and the Macau Dragon Boat Carnival.

Important components of Macao's economic and social development include the gaming industry and tourism. As of 2021, the GDP of the Macao Special Administrative Region has reached 239.4 billion patacas. The Macao region relies on its unique location conditions to provide a favorable foundation for its economic and social development. The gaming industry and tourism industry are the pillar industries of Macao. The rich gaming cultural resources and tourism resources are the feasibility basis and unique advantages for the coordinated development of the gaming industry and tourism industry.

Contemporary investigations into the interplay between the gambling industry and other systems remain somewhat circumscribed. In an endeavor to redress this lacuna, the present study has opted for an in-depth analysis and assessment of the tourism industry, characterized by similarities in its industrial attributes to gambling. Although the research on the pairwise correlation between tourism, gambling industry and total economic value has achieved some preliminary results, there are still shortcomings. In addition, existing research often only focuses on a short time period and lacks sufficient prediction and in-depth analysis of future relationships. To address this research lacuna, the current study has chosen Macao, a focal point in the trajectory of gaming industry development, as the subject of investigation. The aim is to proffer a valuable reference for the harmonized and enduring development of the triumvirate: tourism, gambling, and the broader economy.

5. Data sources and research methods

5.1. Data sources

Macau gaming industry data and tourism data mainly come from the Macau Yearbook (2011–2021), the Macau Economic Moderately Diversified Development Statistical Indicator System Analysis Report (2011–2021), and are based on the Macau Special Administrative Region Government Tourism Office, Macau Special Administrative Region Government Statistics and Publicly available data released by the Census Bureau serve as necessary supplements. A small amount of data that has not been published on the official website was obtained through interviews and surveys of relevant departments and by searching for the latest information released by WeChat public accounts of government departments at all levels.

5.2. Evaluation index system

In the process of constructing the evaluation index system, we followed the principles of scientificity, rationality and operability. This study takes the tourism and gaming industry in Macao as the research object, refers to the research results in related fields, and establishes a comprehensive evaluation index system that takes into account the coupling relationship between gaming, tourism, and economy (see **Table 1** for details). The comprehensive evaluation index system of the gaming

industry subsystem includes 3 first-level indicators and 9 second-level indicators such as industrial scale, industrial competitiveness and industrial productivity capabilities; the comprehensive evaluation index system of the tourism subsystem includes tourism income, tourism effect, tourism industry scale and other 3 first-level indicators and 7 second-level indicators. The economic subsystem evaluation index system comprises three primary indicators and seven secondary indicators, encompassing metrics such as gross production value, total import and export volume, and asset investment. The establishment of this intricate framework serves to holistically evaluate the nuanced status of Macao's tourism, gaming, and economic development.

Table 1. Weights of Macau gaming, tourism and economic development evaluation indicators.

Industry type	First level indicator	Weights	Secondary indicators	symbol	Weights	Indicator direction
Macau gaming industry evaluation indicators	Industry scale	0.2331	Number of gaming enterprise units (units)	A1	0.0506	+
			Total assets of gambling enterprises (Million MOP)	A2	0.1321	+
			Number of employees in gaming companies (million)	A3	0.0504	+
	Industrial competitiveness	0.4028	Gambling market share (%)	A4	0.1368	+
			Gambling enterprise sales profit margin (%)	A5	0.2274	+
			Average added value of gaming enterprise employees (%)	A6	0.0386	+
	industrial productivity	0.3641	Total output value of gaming industry (Million MOP)	A7	0.1563	+
			Gambling industry added value (Million MOP)	A8	0.1357	+
			Gaming industry return on assets (%)	A9	0.0721	+
Macao tourism industry evaluation indicators	Tourism industry scale	0.2789	Number of star hotels (units)	A10	0.1763	+
			Number of tourist attractions (units)	A11	0.1026	+
	tourism revenue	0.3662	Domestic tourism revenue (Million MOP)	A12	0.1337	+
			Earning foreign exchange from foreign tourism (Million MOP)	A13	0.1268	+
			Total tourism revenue as a proportion of regional GDP (%)	A14	0.1057	+
	tourism effect	0.3549	Number of domestic tourists (million)	A15	0.1913	+
			Number of foreign tourists (million)	A16	0.1636	+
Economic development evaluation indicators	total output value	0.4316	GDP (Million MOP)	A17	0.1508	+
			GDP per capita (Million MOP)	A18	0.1433	+
			GDP share of tertiary industry (Million MOP)	A19	0.1375	+
	Total import and export volume	0.3208	Total imports (Million MOP)	A20	0.1627	−
			Total exports (Million MOP)	A21	0.1581	+
	Asset investment amount	0.2476	Cumulative total investment in the Mainland (Million MOP)	A22	0.1113	+
			Cumulative total overseas investment (Million MOP)	A23	0.1363	+

*Data source: Statistics from the Macao Statistics and Census Service.

5.3. Research methods

5.3.1. Determination of indicator weight

By using the dispersion standardization method to process the data and using the entropy method to determine the weight of each evaluation index, this study adopted a mathematical method to measure the degree of dispersion of a certain index (Bensen et al., 2007; Wu et al., 2023). This method aims to determine the degree of dispersion of the indicator. The greater the degree of dispersion, the more significant the impact of the indicator on the comprehensive evaluation. Therefore, the entropy method can be used to evaluate the dispersion of an indicator. The entropy method can be used to measure the dispersion of an indicator data. When the indicator values are evenly distributed and tend to be stable, the entropy value is low; and when the data are unevenly distributed and show large fluctuations, the entropy value is high. This makes entropy an effective measure of indicator dispersion. It not only provides an objective evaluation of the discreteness of indicators, but also provides a basis for decision-making analysis. By comparing the entropy values of different indicators, decision makers can better understand the distribution of data, which helps to formulate more scientific decision-making plans.

$$P_{ij} = \frac{X_{ij}}{\sum_{i=1}^{n} X_{ij}} \tag{1}$$

P_{ij} represents the proportion of the j-th indicator in the i-th year, where i is the year order (i = 1, 2, …, n), and j is the indicator order (j = 1, 2, …, m).

After calculation, the weight of Macau gaming industry evaluation index and the weight of tourism industry evaluation index are obtained, as shown in **Table 1**.

5.3.2. Comprehensive evaluation method

The Linear Weighting Method is a simple multi-index evaluation method. In this study, we used the Linear Weighting Method to measure the comprehensive development level (Chen et al., 2008; Pamucar and Ecer, 2020). The comprehensive evaluation functions for gaming, tourism and economic development are represented as U1, U2 and U3 respectively. as follows:

$$U_1 = \sum_{j=1}^{p} w_j \, r_{ij} \tag{2}$$

$$U_2 = \sum_{j=1}^{p} w_j \, r_{ij} \tag{3}$$

$$U_3 = \sum_{j=1}^{p} w_j \, r_{ij} \tag{4}$$

In the above formula, j represents the number of indicators of a certain subsystem, w_j is the indicator weight calculated by the entropy method, and r_{ij} represents the dimensionless value of the jth indicator of a certain system in the i-th year. Specifically, U1 represents the comprehensive evaluation index of the tourism industry, U2 represents the comprehensive evaluation index of the gaming industry, and U3 represents the comprehensive evaluation index of the economic aggregate. In the time frame from 2011 to 2021, the value of the comprehensive evaluation index U1 of the

tourism industry fluctuates between 0.15 and 0.84, the value of the comprehensive evaluation index U2 of the gaming industry fluctuates between 0.16 and 0.83, and the total economic volume The value of the comprehensive evaluation index U3 varies between 0.17 and 0.86 (**Table 2**).

Table 2. Comprehensive development level and coupling coordination degree of gaming, tourism and economic development in Macao.

Years	U1	U2	U3	T	C	D	Coupling coordination level
2011	0.1531	0.3654	0.1726	0.2326	0.9503	0.4709	On the verge of disorder
2012	0.1943	0.1631	0.1768	0.1691	0.9997	0.4252	On the verge of disorder
2013	0.2806	0.2564	0.2907	0.2663	0.9983	0.4863	On the verge of coordination
2014	0.3191	0.4581	0.3163	0.3668	0.9881	0.6032	Junior coordination
2015	0.4595	0.5889	0.4617	0.5203	0.9936	0.7368	Intermediate level coordination
2016	0.4553	0.6134	0.4636	0.5356	0.9893	0.7243	Intermediate level coordination
2017	0.4516	0.8329	0.5061	0.6437	0.9651	0.7746	Intermediate level coordination
2018	0.7317	0.7271	0.7567	0.7283	0.9993	0.8365	great coordination
2019	0.8423	0.5306	0.8621	0.6293	0.9726	0.7928	great coordination
2020	0.3126	0.5632	0.4103	0.4316	0.9643	0.6439	Junior coordination
2021	0.7392	0.7151	0.8016	0.7428	0.9361	0.8263	great coordination

5.3.3. Coupling coordination model

The coupling correlation degree C and coupling coordination degree D of Macau's gaming, tourism and economic development can be estimated using Equations (6) and (7) respectively.

$$C = 3[\frac{U_1 \times U_2 \times U_3}{(U_1 + U_2 + U_3)^3}]^{\frac{1}{3}} \quad (5)$$

$$D = \sqrt{C \times T} \quad (6)$$

$$T = \alpha \times U_1 + \beta \times U_2 + \delta \times U_3 \quad (7)$$

In the formula, C represents the coupling correlation between gambling, tourism and economy. As shown in **Table 3**, when $C = 0$, it indicates that there is no coupling relationship between gaming, tourism and economy; when $0 < C \leq 0.3$, it indicates that there is a low coupling relationship; when $0.3 < C \leq 0.7$, it indicates that there is a moderate coupling relationship. degree coupling relationship; when $0.7 < C < 1$, it indicates a high coupling relationship; when $C = 1$, it indicates complete coupling. After calculation, the C value of the coupling correlation between Macao's gaming, tourism and economy from 2011 to 2021 ranges from 0.93 to 1 (**Table 2**).

In the formula, T is the coupling coordination index that reflects the overall synergy between gaming, tourism and economy. $T = \alpha \times U1 + \beta \times U2 + \delta \times U3$, where $\alpha + \beta + \delta = 1$, α represents the weight of the Macao tourism subsystem, β represents the weight of the Macao gaming subsystem, and δ represents the Macao economic development subsystem. the weight of. This study uses the expert consultation method, setting α to 0.33, β to 0.33, and δ to 0.33. The T value of the coupling coordination index between Macao's gaming, tourism and economy from 2011 to 2021 ranges from 0.23 to 0.75.

D is the coupling coordination degree between gaming, tourism and economic development. According to the coupling coordination degree, the coupling level of gaming, tourism and economic development can be divided into 10 levels: extreme imbalance, severe imbalance, moderate imbalance, mild imbalance Dissonance, on the verge of dissonance, barely coordinated, primary coordination, intermediate coordination, good coordination, high quality coordination (Puttnam et al., 2021; Yang et al., 2020a; Chanu and Sonkar, 2023). The D value of the coupling coordination degree between Macao's gaming, tourism and economy from 2011 to 2021 ranges from 0.42 to 0.84.

Table 3. Coupling coordination level classification criteria.

Coupling coordination degree (D)	Grade	Coupling coordination degree (D)	Grade
$0.0 \leq D \leq 0.1$	Extremely out of level	$0.5 < D \leq 0.6$	Barely coordinated
$0.1 < D \leq 0.2$	severe disorder	$0.6 < D \leq 0.7$	Junior Coordinator
$0.2 < D \leq 0.3$	Moderate imbalance	$0.7 < D \leq 0.8$	Intermediate level coordination
$0.3 < D \leq 0.4$	mild disorder	$0.8 < D \leq 0.9$	good coordination
$0.4 < D \leq 0.5$	On the verge of disorder	$0.9 < D \leq 1.0$	High quality coordination

5.3.4. Obstacle degree model

This study refers to relevant data and uses three indicators for calculation, namely factor contribution (F_j), indicator deviation (V_j), and obstacle degree (M_j and B_i) (Wang et al., 2021; Lindqvist et al., 2020). By introducing the obstacle degree model, we analyze and diagnose the relevant influencing factors that hinder the coordinated development of Macao's tourism-gaming-economy coupling. The calculation steps are:

$$F_j = W_i \times P_{ij} \tag{8}$$

$$V_j = 1 - X_j \tag{9}$$

$$M_j = \frac{(W_i \times P_{ij}) \times (1 - X_j)}{\sum_{j=1}^{23} (W_j \times P_{ij}) \times (1 - X_j)} \times 100\% \tag{10}$$

$$B_i = M_{ij} \tag{11}$$

In the formula, M_j represents the obstacle degree of each indicator *j*; B_i represents the obstacle degree of system *i*; W_i represents the weight of the *i*-th system; *Pij* represents the weight of the *j*-th indicator in the *i*-th system; X_j represents the standardization of each indicator. value.

6. Results and analysis

6.1. Time series analysis of comprehensive development level

During the period from 2011 to 2021, the development of Macau's gaming industry was relatively unstable, but generally showed an upward trend. The comprehensive evaluation index increased from 0.16 to 0.62. However, due to the impact of the COVID-19 epidemic, the gaming industry experienced a trough in 2020, with the composite index falling to 0.56. In 2021, Macau's gaming industry has rebounded, with the comprehensive evaluation index rising to 0.72 (**Figure 1**).

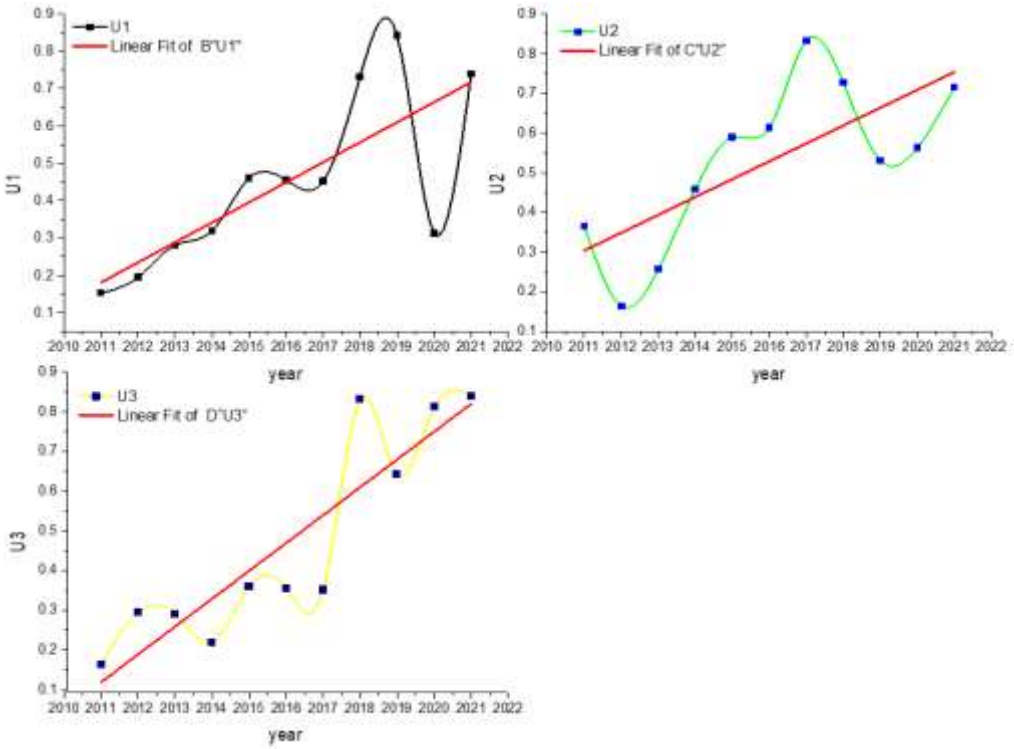

Figure 1. Time series chart of the comprehensive evaluation index of Macau's gaming industry and tourism industry.

In the 10 years from 2011 to 2021, Macao's tourism development has generally shown an upward trend. The comprehensive evaluation index of development level increased from 0.15 to 0.85. However, like the gaming industry, the tourism industry was also affected by the COVID-19 epidemic in 2020, leading to a cliff-like decline in development levels. Generally speaking, the comprehensive development level of Macau's gaming industry is higher than that of the tourism industry.

There are many reasons why Macau's gaming industry has experienced a series of changes over the past 10 years. First of all, the gaming industry itself is affected by many factors such as market, economy, and policies, so it is normal for its development to be unstable. Secondly, Macau may have been affected by global economic fluctuations and the development of the tourism industry, which may also lead to fluctuations in the gaming industry. In 2020, the outbreak of the COVID-19 epidemic had a huge impact on the global tourism and gaming industries, which was one of the main reasons for the trough of the gaming industry. The recovery in 2021 may be related to the gradual control of the global epidemic and the gradual recovery of the tourism industry. Policy adjustments, market demand fluctuations and other factors may also have played an important role in this process. Therefore, the reasons why the development of Macau's gaming industry is not stable but is generally on an upward trend are multifaceted and are affected by multiple factors.

The reverberations of the COVID-19 pandemic on Macau's gaming industry are both profound and intricate. Recognized for its opulent casinos, Macau has witnessed a substantial downturn amidst the imposition of global travel restrictions and pervasive lockdowns. The foremost and conspicuous consequence manifests in a precipitous reduction in tourist influx, a direct result of stringent public health

measures curtailing both international and domestic travel. Macau, heavily dependent on tourism from mainland China, has experienced a discernible contraction in casino revenue owing to the decline in high-volume clientele.

The upheaval induced by the pandemic has, in turn, compelled the gaming industry to undergo a meticulous reassessment of its operational strategies. Constrained by social distancing imperatives and augmented sanitation protocols, casinos have ingeniously incorporated avant-garde technological solutions to conform to the exigencies of the new normal. The advent of virtual gaming experiences, online platforms, and contactless payment systems signifies a palpable paradigm shift in the industry's modus operandi.

As Macau grapples with these challenges, collaborative efforts between the local government and gaming operators have come to the forefront, delineating a series of measures aimed at mitigating the impact. Emphasis has been placed on diversification endeavors and the exploration of non-gaming revenue sources. The advocacy for cultural and entertainment ventures, along with the promotion of conventions and exhibitions, is oriented towards the creation of a more adaptable and equitable economic paradigm for Macau's future.

In summation, the COVID-19 pandemic has precipitated a profound paradigm shift in Macau's illustrious gaming industry, catalyzing a thorough reevaluation of reliance on conventional revenue streams and a quest for innovative strategies to navigate the evolving global landscape.

Macau's economic development process is supported by the tourism and gaming industries. Its rise in the gaming industry has made it one of the largest gaming centers in the world, attracting a large number of international tourists. Distinguished gaming establishments, exemplified by the Venetian and Wynn, have evolved into globally celebrated hubs of entertainment. The gaming industry bestows upon Macau substantial fiscal revenue, furnishing the government with ample funds for infrastructure construction, social welfare, and other sectors, thereby fostering the comprehensive economic progress of Macau. Concurrently, the evolution of tourism has diversified Macau's economic portfolio, mitigating its excessive dependence on the gaming sector and augmenting its economic resilience Due to the epidemic, Macau's tourism industry has been restricted, resulting in a sharp decline in the number of tourists. Especially from 2019 to 2020, due to the impact of the epidemic, the comprehensive evaluation index showed a downward trend (**Figure 2**).

The advent of the COVID-19 pandemic has inflicted profound economic ramifications upon Macau's gaming, hospitality, and affiliated service sectors. The imposition of stringent social distancing and epidemic prevention protocols has cast a pall over service industries encompassing tourism, gastronomy, entertainment, and retail. Consequently, a deleterious impact on revenue has been witnessed among select tourism and gaming enterprises.

6.2. Coupling coordination degree horizontal timing analysis

Throughout the interval encompassing 2011 to 2019, the convergence of Macao's gaming, tourism, and economic development has transcended from the brink of mere coordination to the echelons of commendable and harmonious advancement. The

indices of coupling degree, coupling coordination degree, and coordination index portray a sustained upward trajectory, achieving elevated magnitudes and thereby accentuating the conjoined impact (see **Figure 2**). However, the advent of the COVID-19 pandemic in 2020 precipitated a regression, causing the coupling coordination degree to descend to a preliminary stage of coordination.

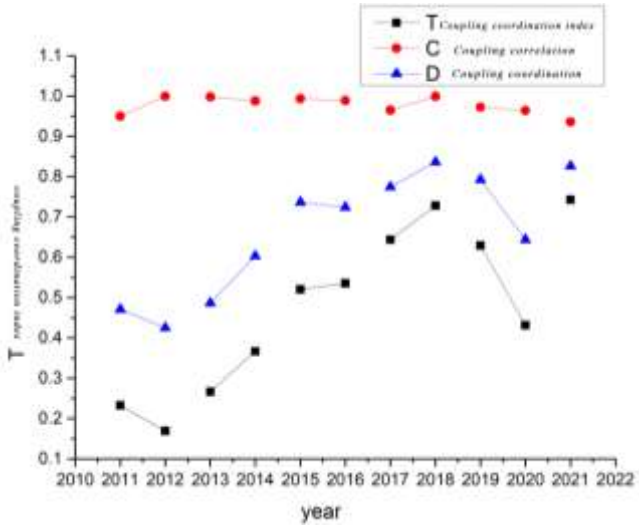

Figure 2. Dynamic evolution of coupling correlation, coordination degree and coordination index between gaming, tourism and economic development in Macau.

6.3. Diagnosis of coupling and coordination development disorder factors

In order to further study the core obstacle factors that affect the coordinated development of Macao's tourism-gaming-economy coupling, this study measured the obstacle degrees of each individual indicator of the three major subsystems from 2011 to 2021. Because there are a large number of individual indicators at the indicator layer, this study uses the obstacle degree Size lists the top 5 factors ranked by obstacle value, see **Table 4**.

Table 4. Ranking of indicators and degree of obstacles to the coordinated development of tourism-gaming-economy coupling in Macao from 2011 to 2021.

Years	Project	Indicator sorting				
		1	2	3	4	5
2011	Obstacle factors	A1	A19	A13	A15	A7
	Obstacle degree	14.51	9.03	5.70	4.41	4.40
2012	Obstacle factors	A1	A19	A15	A13	A7
	Obstacle degree	15.03	9.58	6.24	5.50	4.16
2013	Obstacle factors	A1	A19	A15	A13	A7
	Obstacle degree	17.36	11.84	6.81	5.35	4.31
2014	Obstacle factors	A1	A19	A15	A7	A5
	Obstacle degree	20.63	14.17	6.73	4.31	4.11
2015	Obstacle factors	A1	A19	A15	A5	A7
	Obstacle degree	21.89	15.04	8.14	6.33	4.58

Table 4. (*Continued*).

Years	Project	Indicator sorting				
		1	**2**	**3**	**4**	**5**
2016	Obstacle factors	A1	A19	A15	A5	A18
	Obstacle degree	22.65	13.33	7.36	6.59	5.49
2017	Obstacle factors	A1	A19	A15	A4	A18
	Obstacle degree	23.37	11.47	9.30	8.05	5.81
2018	Obstacle factors	A13	A4	A10	A15	A22
	Obstacle degree	12.32	9.44	7.30	6.83	5.81
2019	Obstacle factors	A13	A4	A10	A15	A22
	Obstacle degree	14.01	10.94	9.78	9.31	6.91
2020	Obstacle factors	A13	A4	A15	A10	A21
	Obstacle degree	16.01	11.94	10.08	9.52	7.66
2021	Obstacle factors	A13	A4	A21	A10	A21
	Obstacle degree	18.06	12.36	11.67	9.96	9.33

It can be seen from **Table 4** that from 2011 to 2021, the number of gaming enterprises (A1) was the largest single indicator obstacle factor affecting the coupled and coordinated development of Macao's three major subsystems. However, after 2017 as of 2020, the number of gaming enterprises ranked second in the ranking of obstacles. The ranking is no longer in the top 5. The reason is that government supervision and regulations on the gaming industry are key factors that affect the number of gaming enterprise units. Strict regulations can make it difficult for gambling companies to enter the market, limiting the number of new players. The gaming industry is a highly competitive sector and new businesses may face strong competition from existing giants. This can make it difficult for new businesses to establish their market share. Since 2011, there has been no new number of gaming companies in Macau for many years, and government supervision and regulations on the gaming industry are key factors that affect the number of gaming companies. Strict regulation can make it difficult for gambling companies to enter the market, limiting the number of new players. The gaming industry is a highly competitive market, with multiple gaming companies competing for limited customer resources. Increasing market competition may lead to price wars and lower sales profit margins. As a result, handicap levels continued to increase and peaked in 2016. Macau's core casino area is gradually shifting from the Macau Peninsula to Cotai. The Macau Peninsula was the core casino area of Macau in the last century and the beginning of this century. It attracted a large number of gamblers through convenient transportation and was lined with many casinos. However, due to the small geographical area, the scale of casinos in the peninsula is usually small. Therefore, at the beginning of this century, the Macau government and various gaming companies gradually shifted the casino center from the Macau peninsula to the Cotai area with a wider geographical space and more hotel rooms, richer non-gaming facilities can encourage more consumers to consume.

The COVID-19 pandemic that broke out in late 2019 and early 2020 had a huge impact on the global tourism industry. As a region that relies on international tourism, Macau has been severely affected by the epidemic. The number of tourists has

dropped sharply and the gaming industry has been affected. The gaming industry is a highly competitive market, with multiple gaming companies competing for limited customer resources. Increasing market competition may lead to price wars and lower sales profit margins.

From 2016 to 2018, international tourism revenue (A13) rose to the first place in terms of barriers, and its barrier index increased from 12.32% in 2016 to 18.06% in 2018, which is a rapid increase. The reason for this phenomenon is that in 2015, Macao's international tourism revenue accounted for 4% of the total annual tourism revenue, but it quickly dropped to 3.6% in 2016, 3.5% in 2017 and 3.5% in 2018. 3%, it can be seen that the proportion of Macao's international tourism revenue is in a declining trend, and the global economic downturn may lead to a reduction in people's expenditure on tourism. In this case, Macau may face the challenge of fewer tourists and lower tourism expenditure. Therefore, its obstacles to the three major subsystems are constantly increasing and tend to be aggravated.

During the study period, the proportion of the tertiary industry (A19) and the number of domestic tourists (A15) were among the top 5 obstacles more frequently, which shows that they have a strong restrictive effect on the three major subsystems. Because the tourism industry itself is an important part of the tertiary industry, fluctuations in the tertiary industry will also affect the development of the tourism industry. As the number of domestic tourists increases, Macau may welcome more tourists from the mainland. This will help increase the overall passenger flow of Macau's tourism industry, increase hotel occupancy rates, shopping consumption, etc. In addition, the top five obstacles include total output value of gaming companies (A7), market share of gaming companies (A4), sales profits of gaming companies (A5), number of star hotels (A10), and total tourism revenue. The proportion of regional GDP (A14) appears more than three times in the top five. It can be seen that these indicators have interfered with the coupled and coordinated development of the three major subsystems to a certain extent, and their restrictive capabilities cannot be ignored. Other obstacle factors appear less frequently and have limited impact on the coupled and coordinated development of the three major subsystems.

In its entirety, the progression of Macau's gaming tourism economy intricately intertwines with the inflow of international tourism revenue. Vicissitudes in the realms of politics, economics, environment, and health can wield a substantial influence on global tourism dynamics, consequently resonating in the trajectory of Macau's gaming industry. Hence, it behooves Macau to judiciously contemplate and align with these extrinsic factors when delineating its economic development strategies.

7. Conclusion and discussion

7.1. Conclusion

Over the decade spanning from 2011 to 2021, the holistic developmental trajectory of Macao's gaming, tourism, and economic facets has manifested a discernible ascent. Concurrently, the level of coupling coordination has transcended the precipice of mere coordination to attain a commendable and well-coordinated developmental echelon. However, the inexorable impact of the 2020 pandemic precipitated a regression in the degree of coupling coordination, reverting it to a

rudimentary state. Throughout the temporal expanse from 2011 to 2021, the paradigm of Macau's gaming and tourism systems has undergone a transformative shift from disarray to a state of orchestrated coherence. The correlative dynamics within Macau's tourism sector have exhibited commendable prowess, underscored by the conspicuous reinforcing synergy emanating from the gaming industry. The reciprocal synergy between the gaming sector and tourism not only fosters mutual promotion but also serves as a catalyst for economic advancement, engendering a virtuous cycle of symbiosis.

In the chronological expanse spanning 2011 to 2021, the overarching interplay and synchronization of Macao's gaming, tourism, and economic domains delineated a gradual ascent, exhibiting varied coupling dynamics across distinct temporal junctures. Between 2011 and 2013, an evident state of imbalance prevailed. However, with the meteoric surge in Macau's gaming and tourism sectors post-2013, the initial dis-equilibrium underwent a transformative evolution, culminating in a state of harmonious coordination. It wasn't until the tumultuous onset of the COVID-19 pandemic in 2019 that the degree of coupling coordination regressed once more, descending to the rudimentary realms of primary coordination. Across the temporal span of 2011 to 2021, the preeminent impediment thwarting the interlaced and coordinated advancement of Macau's three principal subsystems lay in the tally of gaming enterprises (A1). Between 2016 and 2018, international tourism revenue (A13) ascended to the zenith of the obstacle hierarchy, its impediment index surging from 12.32% in 2016 to an accelerated 18.06% in 2018. Noteworthy among the top five hurdles are the aggregate output value of gaming entities (A7), market share wielded by gaming enterprises (A4), sales profits accrued by gaming entities (A5), the number of star hotels (A10), and overall tourism revenue. The proportion of regional GDP (A14) appears recurrently, exceeding threefold within the top five. It is discernible that these metrics have exerted a discernible influence on the coupled and coordinated development of the three major subsystems, attesting to their formidable constraining prowess. Other impediment factors exhibit sporadic prevalence, exerting a marginal impact on the interlaced and coordinated advancement of the three major subsystems.

7.2. Recommendations

(1) Promote the optimization and upgrading of the industrial structure, promote the integrated development of multiple industries, and promote the high-quality development of Macao's economy.

Optimizing the industrial structure is an important way to improve Macao's economic development level (Zhao et al., 2022; Dong et al., 2020). On the one hand, we actively implement a diversified development strategy, promote the integrated development of new generation Internet technologies such as 5G, cloud computing, and artificial intelligence with traditional service industries, and use new technologies, new business formats, and new models to transform traditional industries and low value-added links, promote the service industry to upgrade to high-tech, high-value-added links, and help optimize and upgrade the industrial structure. On the other hand, we can deepen the implementation of innovation-driven development strategies. For example, establish an ecosystem that supports innovation, including

setting up innovation bases, technology parks and incubators to attract and support innovative enterprises and promote innovation in technology and services. Encourage cross-border cooperation between industries such as gaming, tourism, exhibitions, and finance, and promote collaborative innovation in the upstream and downstream of the industrial chain through the sharing of resources, information, and technology to form closer industrial integration. Increase investment in technology research and development and digital transformation, and promote the introduction of cutting-edge technologies in the industry, such as artificial intelligence, big data and blockchain, to improve service levels and business efficiency. Strengthen talent training and cultivate professionals with cross-field knowledge and skills in response to the needs of industries such as gaming, tourism, exhibitions, and finance to promote integrated development of industries. Promote innovation in the financial industry, including developing digital currency and promoting the application of financial technology to provide more flexible and efficient financial services and promote capital flows among various industries. Establish a cross-industry innovation platform to provide opportunities for exchanges and cooperation among various industries, promote innovative cooperation and project incubation among enterprises, and promote industrial innovation and development.

Through these specific measures, we can promote more active industrial integration in the fields of gaming, tourism, exhibitions, and finance, form a new diversified, multi-level, and multi-form industrial integration development model, and lay a solid foundation for high-quality economic development. Base.

(2) Give full play to the driving effect of the gaming industry and enrich tourism products.

Tourism projects with gaming industry characteristics can be developed, such as casino-themed hotels, gaming experience projects, etc. Integrate gaming and tourism resources and launch comprehensive tourism consumer products (Du Cros and Kong, 2020). For example, building a gaming resort provides one-stop services for casino gaming, accommodation, catering, entertainment, and shopping. Strengthen the organization and coordination between gaming venues and surrounding areas to open up the last mile of gaming and tourism. Improve surrounding hotels, restaurants, and transportation facilities, and improve supporting service levels. Relying on the brand effect of the gaming industry, special cultural activities will be held to enrich the connotation of tourism. For example, with the theme of casino culture, we can create special activities such as New Year's fireworks displays and art festivals. Strengthen the digital linkage between the gaming industry and other tourism elements. Build a smart tourism platform to achieve integrated management of attractions, hotels, restaurants, shopping, and entertainment. The integrated development of the gaming industry and tourism requires the joint efforts of all parties to achieve high-quality development.

(3) Implement precise policies in accordance with the times and circumstances to promote the integrated development of gaming and tourism.

Enhance the depth of market research and acumen to precisely apprehend the nuances in the demand dynamics of the tourism sector. Institute a comprehensive framework for market surveillance and analysis, elevating the swiftness of policy responsiveness.(Gallego and Font, 2021). Optimize the structure of tourism products

and develop new cultural tourism products with Macao characteristics. Such as exhibition tourism, sports event tourism, cultural performance tourism, etc.

Energetically nurture innovative reservoirs within the market domain and reconfigure the composition of both domestic and international clientele. Craft bespoke marketing stratagems, intricately tailored for diverse market segments. Employ digital methodologies to forge an intelligent tourism ecosystem, facilitating seamless integration of information across scenic locales, hospitality establishments, culinary venues, retail enclaves, and entertainment realms. Enhance the acumen of our service industry personnel through comprehensive human resources training, thereby elevating the overall professionalism of our workforce(Sinambela et al., 2020; Ichsan et al., 2022). Furnish a cadre of proficient individuals indispensable for the symbiotic evolution of the gaming and tourism spheres. Augment the tourism security apparatus to instill a heightened sense of safety among incoming visitors. Establish and refine multi-tiered safeguarding mechanisms, encompassing measures for epidemic prevention, medical assistance, and insurance coverage. Streamline governmental operations and enhance the efficacy of policy responsiveness. Institute and refine a policy framework for oversight and facilitation conducive to the harmonious development of gaming and tourism. Strengthen collaborative endeavors at the regional level, thereby expanding the horizons for novel developmental prospects. Capitalize on Macao's strategic positioning within the precincts of the Guangdong-Hong Kong-Macao Greater Bay Area.

7.3. Shortcomings and prospects

Previous research may have focused too much on economic growth and ignored the comprehensive perspective of high-quality urban development. This study explicitly adopts the perspective of high-quality urban development, emphasizing the synergy of gaming, tourism and economic development, aiming to provide a more sustainable and comprehensive solution for Macau's comprehensive development.

In summary, this study has made breakthroughs in method and perspective compared with previous studies. It has more comprehensively explored the relationship between gaming, tourism and economic development in Macau, which will help provide a more in-depth understanding of the high-quality development of the city. Comprehension and practical advice.

This inquiry adopts a meticulous evaluative approach to undertake a qualitative and quantitative exploration of the interconnection and synchronization between Macau's gaming and tourism sectors, thereby furnishing a scholarly foundation for the prospective advancement of both industries. Nevertheless, discernible deficiencies persist within the study. The nuanced facets of high-quality development remain inadequately probed in a profound and exhaustive manner. Furthermore, the formulation of the coupling coordination model concerning Macau's gaming and tourism industries demands further refinement. There exists a dearth of comprehensive analysis conducive to the anticipation or assessment of model application. The policy recommendations, though formulated with specificity, may lack practical implementability.

Through the construction of a comprehensive evaluation system encapsulating the triad of tourism, gaming, and economic development, along with the establishment of a coupling coordination degree development model, this study delves into the intricate fabric of Macao's developmental landscape. The exploration of Macao's holistic development, within the context of coupling coordination, assumes profound significance as a touchstone for guiding the trajectory of economic and touristic excellence in both the Pearl River Basin and the expansive Guangdong-Hong Kong-Macao Greater Bay Area.

While the article astutely discerns the impediments hindering the harmonized development of Macao's tripartite systems, a conspicuous gap emerges in its omission to expound upon strategies for fortifying interregional coordinated development within the broader canvas of the Pearl River Basin or the Guangdong-Hong Kong-Macao Greater Bay Area. Subsequent scholarly endeavors should orient themselves towards unraveling the intricacies of urban agglomeration emanating from the Guangdong-Hong Kong-Macao Greater Bay Area and the Pearl River Basin.

Subsequent research endeavors shall witness an elevation in the theoretical underpinning of the coupled coordination model, enhancing its explanatory prowess. Engaging in predictive analyses or scenario simulations rooted in the model's framework will burgeon as a pivotal avenue for exploration. The formulation of more nuanced, quantifiable policy recommendations is imperative for navigating the complex terrain of sustainable development. Rigorous collection of firsthand data will not only bolster the robustness of our conclusions but also contribute to the compelling narrative of this study.

Furthermore, a meticulous comparative analysis with extant research shall serve to underscore the innovative dimensions inherent in this investigation. It is our fervent aspiration that these scholarly pursuits will augur well for future endeavors dedicated to fostering the robust and sustainable evolution of Macau's gaming and tourism industry.

Future research could delve into the impact of digitalization on gaming, tourism, and economic development. Explore how new technologies are changing the industry landscape and the potential role of digitalization in improving service quality and efficiency. Further understand the impact of gaming, tourism and economic development on society, including employment, culture, social equity, etc. Research can help formulate more comprehensive policies to ensure that all segments of society benefit from development. Conduct comparative studies with other cities or regions to understand the advantages and disadvantages of different local development models. This will help extract successful experiences and provide reference for Macau to formulate more scientific strategies in gaming, tourism and economic development.

In general, future research should emphasize sustainable development, cross-disciplinary cooperation and the response to new challenges, while at the same time in-depth research on digital transformation and social impact, and gain a more overall understanding through comparative research, so as to provide Macao with high quality in the city. Provide more forward-looking and practical suggestions for development.

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