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Distribution Characteristics of Gaming Industry on the Macau Peninsula and Its Relation to Morphological Transformation

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ABSTRACT

Being the oldest gambling city of the world, Macau has evolved from a traditional fishing village in South China into a world cultural heritage city over the past 450 years. As a result, its urban morphology presents a unique layout pattern, which has aroused the attention of a number of researchers in urban design domains. Indeed, the constant development of gambling industry has contributed considerably to the rapid economic development of the city; however, it has also bought about a number of environmental problems, including traffic congestion, shortage of land uses, contradiction to historic districts and local culture e.g. Therefore, how to balance the spatial relationship between gaming activities and other functions is one of the challenges faced by the Macau Government. In this case, this study represents an attempt to examine the distribution pattern of gambling facilities by embedding them into the overall urban system of the Macau Peninsula. Through using the segment-line analysis suggested by space syntax in combination with POI data, this study analyzes the spatial characteristics of gaming facilities in six historical periods in terms of their location, centrality and accessibility, as well as their relation to other functions, and then identifies their spatial preference and organizational laws. Also, the question of how the development of the gambling industry interacted with the overall morphological evolution is analyzed. It is hoped that the findings can help promote sustainable development of the gambling industry in Macau, as well as providing a basis for decision-making in future spatial planning process.

KEYWORDS

Tempo-spatial Characteristics, Gaming industry, Urban morphology, Macau Peninsula

1 INTRODUCTION

Being the oldest gambling city of the world, Macau has gradually evolved from a traditional fishing village in South China into a world cultural heritage city over the past 450 years. However, the urban development of Macau did not happen by accident, but the result of various socio-economic and cultural factors. Owing to its special historical background and geographical characteristics, Macau has been developed into an international gambling city, with its gaming industry increasingly playing an important role in Macau's society and economy. Indeed, the prosperity of the gambling activity has significantly stimulated the urbanization process, especially on the Macau Peninsula. Consequently, its urban area continued to expand through a series of reclamation projects, leading to the morphology presenting a unique layout pattern, which has aroused the interests of a number of the researchers in the urban design domain. On the one hand, the gaming industry brought huge wealth accumulation to the society as a whole, on the other it has also caused numerous social, economic and environmental problems, including traffic congestions, shortage of developable lands, disordered public space, and disturbance to the daily life of local residents, and so on (Li, 2010). In this case, there is a need for research to study the temporal and spatial characteristics of the gaming functions, and further discuss their relationship to the overall development of the urban morphology. It is believed that results may help us identify the crux of problems and the driving factors behind, subsequently providing valuable reference in future spatial planning process.

In fact, in recent years, the risks from the predominance of gaming industry in Macau has been realized by the Government. To reduce the potential economic crisis in the long run and to achieve moderate economic diversification in future, the Government has been committed to developing non-gaming industries, such as conventions, exhibitions, retails, and entertainments. However, the progress was not so smooth. Some industries still heavily rely on the gaming facilities so that there is still a long way for Macau to transform from 'a gambling city' into 'a world tourism and leisure center' (Gu & Zhuang, 2017). In this sense, this study not only investigates the distribution characteristics of the gaming industry, but also examines its relationship to other land uses and functions. Based on the above discussion, this study aims to answering following questions:

- How has the gaming industry evolved spatially? More specifically, what are the distribution characteristics of the industry in different periods on the Macau Peninsula?
- What is the spatial relationship between the development of gaming industry and the overall urban morphology?
- How does the current gaming industry interact with other land use and functions?

2 LITERATURE REVIEW AND METHODOLOGY

Due to its considerable advantages in stimulating economic development, gambling industry is always deemed an important model and thus widely adopted by many small economies of the world. Therefore, quite some scholars focused on the positive impacts of gaming industry (Aderson, 1996; Cotti, 2008; Gu & Li, 2009; Kearney 2005; Long, 1996), such as significantly increasing government tax revenue, stimulating employment opportunities, or stimulating the development of tourism, Leisure, construction industries, and so on. (Buultjens, 2006; Bazelon, Neels & Seth, 2012; Rose, 1998). Nevertheless, some scholars paid more attention to its negative impacts. For example, some studies have pointed out that gambling industry can bring good economic return in a short term, however, it can also lead to a monotonous and narrow tax base, suppress the development of other industries, and cause labor shortages in the long run (Garrett, 2004; Grinols, 1994; Goodman, 1994; Room, Turner, and Ialomiteanu, 1999). By contrast, there are a number of scholars emphasizing the social impacts of gaming industry by examining its social costs (Walker, 2007), or analyzing its influence on the community (Eadington, 1996; Fong, Fong and Li, 2011), or discussing its relation with crime rates (Grinols and Mustard, 2006; Long 1996; Reece, 2010; Collison 2004; Giacopassi, Nichols and Stitt, 1999).

In the studies associated with the gambling economy of Macau, Vong (2008) pointed out that Macau residents widely believed that the industry has caused a series of environmental problems, including traffic congestion, air pollution, and crowded living environment. Similarly, Sheng & Gu (2018) focusing on the development and influence after the handover, pointed out while the society has benefited greatly from the development of gaming industry, it has also paid some costs, such as the reduction of leisure and entertainment spaces, and the overload of public spaces. Moreover, there are other scholars who invloved the study of gaming industry with other land uses, but they mainly discussed the characteristics of the gaming industry itself. From the above review, it is found that research on the temporal and spatial characteristics of the gaming industry of Macau is relatively lacking, and the studies on its relationship with the overall morphological development are even rarer.

Indeed, as one of the major subjects of urban design, the morphological development of Macau has also aroused the interests of many scholars. Early scholars focused on the planning and development of the Peninsula and its arising problems, but their methods for analysis were relatively macro. For example, Mou and Zhang (2009) analyzed the morphological evolution characteristics of Macau from 1973 to 2004 based on the remote sensing images of seven phases, as well as discussing the driving mechanism behind. Likewise, through sorting out important historical events, Yuan (2011) divided the urban development of Macau into six periods, and then discussed the influencing factors and their spatial characteristics at each period. Chan (2014) , by reviewing the urban development process of Macau in terms of its historical evolution, economic development, urban planning and construction, and cooperation with surrounding cities, concluded that currently the Macau Peninsula is facing many challenges, such as shortage

of resources, a monotonous industrial structure, and incomplete urban planning legal system, and so on.

Since the Macau Peninsula was successfully nominated as the World Heritage City in 2005, its unique local culture, street patterns, and various historic buildings have also attracted the interests of some scholars. They discussed the characteristics of its streets and alleys (Tong & Sheng, 2005), or explored the underlying characteristics of street network from the perspectives of spatial orders, scale, streetscape, and pavements. No doubt, these researches focuse more on local spatial features, and rarely dealt with the inherent structure of the network at different scales.

In recent years, the emergence of various spatial analysis techniques and the availability of network data have led to some changes in the morphological studies of Macau. For example, Feng et.al. (2012) applied space syntax to analyze the configurational transformation on the Macau Peninsula by comparing and analyzing the development characteristics in four historical periods. In comparison with other methods, space syntax can quantitatively analyze the relationship between the local and global spatial structures and their effect on pedestrian and vehicular movements, it therefore can help us predict the functional aggregation and separation in specific urban areas. Therefore, the space syntax related research is deemed relatively scientific and objective, which can make up the deficiencies existing in previous studies.

In this circumstance, this study will use the segment-line analysis provided by space syntax in combination with multivariate data obtained from the network, to investigate the distribution characteristics of the gambling function on the Macau Peninsula and its relation to overall morphological development and other land uses. During the analysis, two major configurational properties are to be measured, they are *integration* and *choice*, which will be devised to identify to-movement and through-movement potential respectively. Considering the spatial layout of the Macau Peninsula, serval radius, including 500m, 1500m, 3000m and 5000m are selected to constrain the analysis. As a result, a number of graphs are generated through Depthmap X , presenting the configurational properties of the Peninsula under different metric radius.
To explore the changes of temporal-spatial characteristics of the gambling industry, this study finally identified six historical periods to carry out the analysis. The six periods include 1789 before the legalization of gambling, 1889 after the legalization of gambling, 1930s the opening of gambling franchise, 1960s the opening of permanent gambling zone, 1990s the autonomy transition period, and 2018 after the opening of independent travel plan and re-opening of gambling rights.

3 MORPHOLOGICAL EVOLUTION AND DISTRIBUTION CHARACTERISTICS OF GAMING FUNCTIONS

It was in 1557 when Macau opened a trade port and the Portuguese were allowed to live in Macau. At the time, the Portuguese mainly lived in the central and western parts of the Peninsula, building their community in Western styles, initially shaping the layout of a Catholic city of Macau. Till 1586 when Macau was allowed to have the autonomy right, the plan layout of the Peninsula began to be transformed into a 'dual cores and three districts' pattern. Since the outbreak of the Opium War in 1840, Macau had entered its colonial period, with its city area constantly being expanded. After the Opium War and till the 1970s, through carrying out a series of land reclamation projects on the south-east and north-east sides of the Peninsula in response to the rapid development of gaming industry, Macau has gradually been developed into a modern city (Fig. 1).

Figure 1: Location of the Macau Peninsula

3.1 The Development Period after the Opening of the Port in 1789

The graphs of 1789 (Fig.2) show that the street network of the Macau Peninsula began to take its original shape. Based on segment-line analysis, it is found that the top 25% integration values were mainly concentrated in the geometric center of the Peninsula. The core run along the main street from northeast to southwest, being connected with several streets. Also, the distribution did not migrate with the change of radius, indicating that the spatial structure of this period was simple, and there was no differentiation among different scales.

Likewise, the 25% high choice values were distributed along the main street and its intersecting north-south streets under the radius of 500m, presenting a cross structure. With the radius increasing, the core shape did not change significantly. In addition, the distributions of integration and choice showed a similar pattern, implying that the street network was not highly developed, and the differentiation between to- and through- movements did not appear. The scattergram (Fig.4) of this period shows a high level of synergy, but this may be due to the incomplete development of the overall layout of the Peninsula.

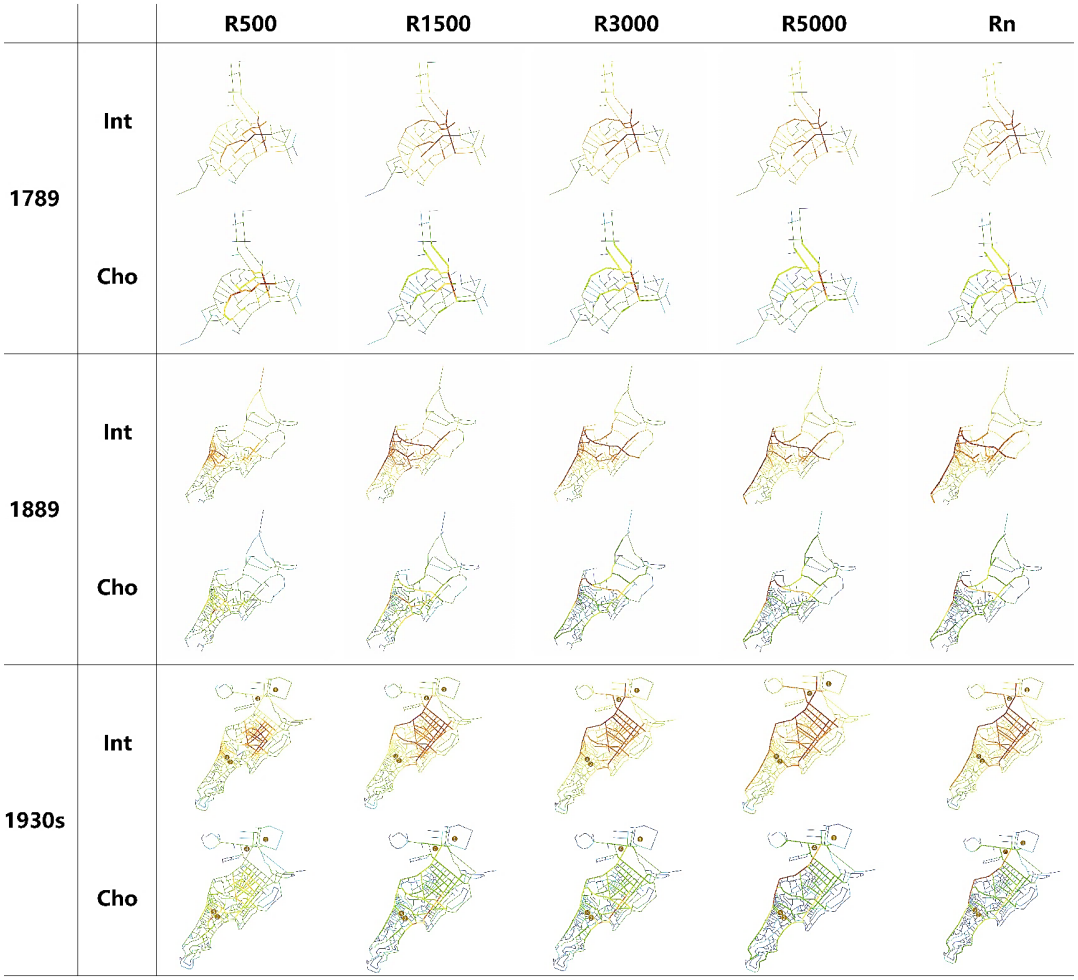

Figure 2: Integration and Choice Analysis in 1789,1889, and the 1930s

3.2 The Period of Colonial Expansion in 1889

As indicated by the analysis of R500m, the top 25% integration values were distributed in patches, forming two local cores. One was located along the Basudar Ancient Street to the east side of the Inner Port, spreading inwards through several radial streets, indicating that the functional center of the Peninsula had migrated to the Inner Port. The other core was located in the area to the northwest side of Songshan, in a tree branch shape. When the radius was increased to 1500m, two cores were connected, gradually forming a ring shape. Under the radius of 3000m and 5000m, their integration cores did not show many differences, forming a herringbone structure, implying that the urban structure did not vary from medium to macro scales. This may be due to that rapid transportation had not been developed yet.

The analysis of choice shows that at the micro-scale (R500m), high values were mainly concentrated along the Inner Port and Kao Di parish, featuring on short segment lines in the old city center. Unlike the integration, the high choice values formed a core only. As the analysis radius increased, the high values clustered towards the long lines, eventually covering most of the main streets of the Peninsula, displaying an irregular grid pattern. The scattergram (Fig.4) shows

that synergy was significantly lower than before, implying that the relationship between the local and global configuration was likely to be segregated, with the spatial fabric of the Peninsula tending to display a fragmented pattern.

When the gambling in Macau was legalized in 1847, various gambling activities began to flourish on the Peninsula. Most of them were operated in the form of street stalls, playing a role in the daily leisure and entertainment of local residents.

3.3 The Franchise Period of Gambling Rights in the 1930s

In 1936, with the conversion of gaming rights to centralized franchise, a number of gaming facilities began to emerge in conjunction with banks and hotels. At this stage, there appeared four casinos, namely the Central Hotel ②and Dafeng Bank③, which were located in the historic center, as well as the Greyhound Club ④ and the Racetrack ① located in the north-eastern part of the Peninsula (Fig.2).

Meanwhile, the urban area of the Peninsula entered a period of breakthrough expansion. The street network was further developed, with the urban morphology gradually displaying a complex pattern. Finally, the analysis of radius 500m shows that two local integration cores were still found. However, the core along the Inner Port was weakened, and the other was expanded in order to cover a wider range of areas, indicating that the local functional center gradually moved from the Inner Port to the Kaodi and Wangde parish, where the colonial Government was situated.

In this period, the Central Hotel ② and the Dafeng Bank ③ were located along the streets whose local integration was much higher than the overall average, reflecting that they intended to serve for the locals, thus being located in the areas sensitive to pedestrian movement at the community level. Since the Greyhound Club ④ and Racetrack ① required large venues, they were unsurprisingly distributed in the outskirt with relatively poor local integration, but with their values still above the average. The analysis of radius 1500m shows that the integration cores had gradually merged into one and mainly concentrated in the areas surrounded by Goldstone Avenue, Meijian Avenue, Dongwangyang Street and Jinghu Avenue. With the radius increasing, the core began to leak westward to the Inner Port, finally forming a loop shape under the radius of 5000m.

Accordingly, the accessibility of the streets surrounding casino ② and ③ was strengthened, further exerting agglomeration effect on the medium and long distance to-movements. The integration of the Greyhound ④ also increased, slightly above the average, but with the Racetrack① remaining lower than the average. From this, we may infer that in the 1930s, the gaming industry tended to be located in the areas with high local integration as possible. This

may be due to the fact that local residents accounted for a large proportion of the gamblers at the time.

The analysis of choice shows that under the five radii, the lines with high values basically covered the entire peninsula. The distribution of high values under radius 500m was characterized by short segment-lines in the central area. With the metric radius increasing, high values gradually moved to the long segments, almost covering all the main streets of the Peninsula in the end. The overlapping analysis shows that casino ② and ③ continued to be located in the areas with high choice values, with the intention to attract both local and global through-movements. By contrast, both ① and ④ performed better in attracting medium and long-distance movements. To sum up, the gaming industry in Macau just began to develop, thus they tended to be distributed near the city center to attract more pedestrian movements with the help of spatial configuration and the catchment effect of other functions.

The scattergram (Fig.4) shows that the synergy of this stage was slightly increased, with R^2=0.512, indicating that a considerable number of streets had high integration values both locally and globally. As a result, the overall urban layout was open in nature, with the local and visitors being able to well interact with each other.

3.4 Establishment of Permanent Gaming Zone in the 1960s

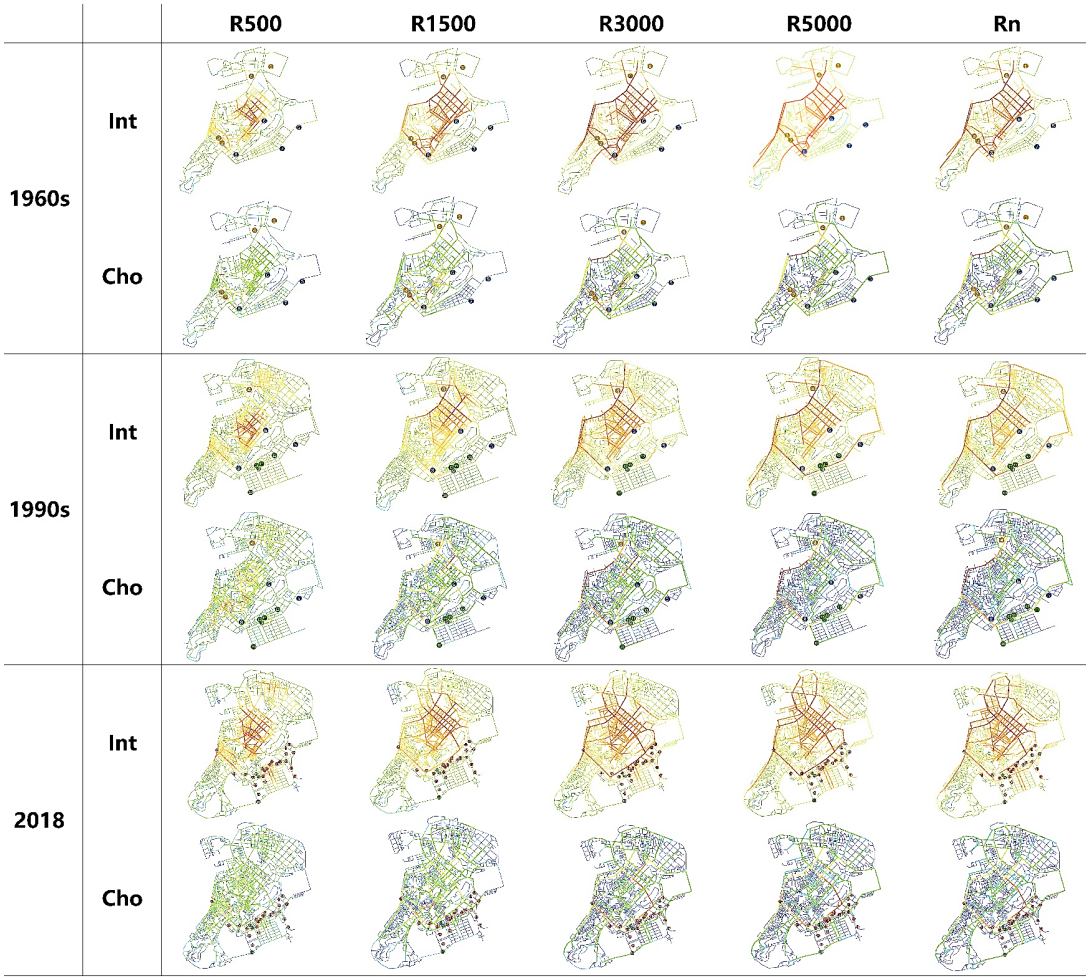

Figure 3: Integration and Choice Analysis in the 1960s,1990s, and 2018

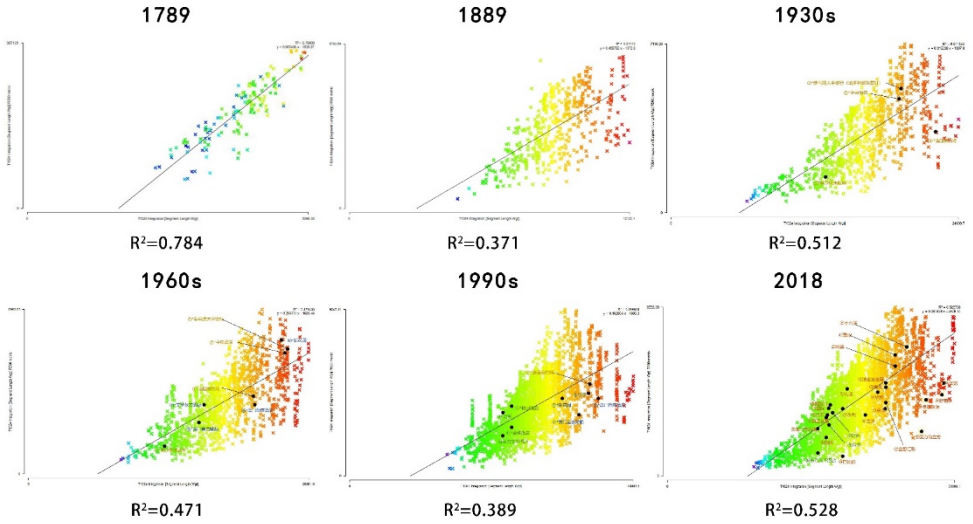

Figure 4: Scattergrams of the Six Historical Periods

In the 1960s, Macau experienced the third stage of the development of the gaming industry. In order to establishing permanent gaming zones and to obtain more lands for urban development,

the Macau-Portugal government carried out a series of reclamation projects in the Outer Port as well as developing new towns in the North Gate bordering with the Mainland.

As a result, the analysis of radius 500m shows that there still appeared two local centers in terms of the distribution of high integration, but they were connected by several segments, presenting a U-shaped. In addition, as the radius increased, the integration core became more implicit, with its coverage being expanded either. Meanwhile, the 25% integration core had covered most of the casinos except for Mandarin Oriental ⑦, which was located in a relatively isolated place (Fig.3). From the 1960s to the 1990s, having the gambling tourism been flourished in Macau, the number of gamblers from other cities increased greatly. As a result, there emerged eight gaming venues on the Peninsula. Four, including the Palace Casino ⑤ ,New Garden⑥, Mandarin Oriental⑦, and Lisboa ⑧, were mainly located in the reclaimed area adjacent to the Outer Port. During this period, casinos were operated by major consortiums, and most of them were developed into multi-functional complexes in combination with hotels or entertainments in order to provide one-stop services for tourists across the world. In other words, their ability to attract tourists had been significantly strengthened.

The configurational analysis shows that from the radius of 1500m to 5000m, the streets connecting with or passing through casino ② ③ ⑥ and ⑧ all showed high integration values, indicating that these facilities could not only attract pedestrian movements at the community level, but also had the potential to accumulate medium- and long-distance to-movement. Comparatively, casino ⑤ and ⑦ were allocated in the area relatively segregated. Morphologically, the connection between the reclaimed area and the old city center tended to be broken, leading to a low integration level in the Outer Port area.

The analysis of choice reveals that casino ② ③ ⑥ and ⑧ continuously demonstrated high choice values in all analytical radii, but with casino ④ ⑤ and ⑦ displaying higher choice values under medium and global scales only. The scattergram (Fig.4) shows that the synergy decreased again, with R^2=0.471. This may be due to the relatively fragmented development of the reclaimed areas. Also, the eight casinos had formed a regression line consistent with the overall plan layout, indicating that the gaming facilities preferred to follow the logic of the whole urban system.

To sum up, the relationship between the gaming industry on the Macau Peninsula and the urban configuration was complementary in nature. Firstly, to gain more developable spaces for expansion, the gaming industry was concentrated in the reclaimed area near the Outer Port. Secondly, through involving other leisure and entertainment functions, the casinos aimed to improve their own attractiveness rather than relying on the configurational effect on pedestrian movement as before. However, their demand for large-scale accessibility and movements still existed. Moreover, the evolution of spatial configuration had been driven by the development of

the industry to a certain degree, with its global structure continuously endeavouring to improve the accessibility of all gaming facilities, but at the same time maintaining high level of local integration in the old city center, so as to reduce the negative impacts on the local social and cultural lives.

3.5 Autonomy Transition Period in the 1990s

Entering into the 1990s, the Macau Peninsula continued to expand, and mainly increased land supply in two areas. One was in the Outer Port through carrying out large-scale reclamation projects to establish the gaming franchise area, with the other being allocated near the North Gate. In this period, there appeared five new casinos, all of which were located in the reclaimed area. Finally, Casino ① ② ③ which were originally located in the old city, were cancelled or relocated. In the end, the number of casinos on the Macau Peninsula remained 9 in total (Fig.3) Under the radius of 500m, there appeared three local integration cores. In addition to previous two cores, there emerged a new local center in the north-eastern part of the Peninsula near the Gate to the Mainland, indicating that the ever-increasing communication between Macau and the Mainland had stimulated the urbanization process of the district. With the increase of the radius, the integration cores moved back to the historical center, forming a circle shape and retaining its accumulating effect on medium-distance to-movement. When the radius was increased to 5000M, the distribution pattern was slightly changed. The core was still located in the historical area, but expanding along the Inner Port, finally covering the main ring roads of the Peninsula. In this way, the gaming franchise area and the North Gate area were effectively connected, with their ability in attracting long-distance to-movement being enhanced (Fig.3).

When examining the spatial characteristics of the casino in the 1990s, it is found that under the radius of 500m and 1500m, almost all casinos were far from the local integration cores, indicating that their distribution was not as sensitive to pedestrian movement at the community level as before. Again, the possible explanation is that the casinos could provide one-stop entertainment, accommodation and catering services, thus their demand for the maturity of the development in surrounding areas was reduced. However, at the radius of 3000m and 5000m, the integration of the casinos was increased, illustrating a strong degree of aggregation effect. From this, it may be inferred that the casinos no longer valued convenient pedestrian movement, high traffic flows, and proximity to commercial centers to support their locational decision. In other words, their dependence on spatial configuration and its effect on movements had been reduced. Similarly, the analysis of choice shows that only the high values at the medium and global scales covered or passed through the gaming facilities, indicating that the global structure of the plan layout was developed to improve the accessibility of the gaming function as a whole.

The scatter plot (Fig.4) shows that the synergy was decreased, with R^2=0.389, and the relationship between the part and the whole was inconsistent again. According to their distribution in the scattergram, the casinos of this stage could be divided into two groups. One

group, including casino ⑩ ⑪ ⑫ ⑬, with a slightly lower global integration, was close to the regression line, showing a state compatible with the overall layout, whereas the other group (including ⑤ ⑥ ⑧ ⑨) tended to be located in the area with both high local and global integrations, displaying higher potential to attract movements at various scales.

The study also revealed that the first group was mainly built after the 1990s, thus being inclined to integrating gambling with hotels, restaurants, shopping and other functions. Since they could provide one-stop services for tourists, they were not necessarily dependent on the accessibility conditioned by the configurational properties. Br contrast, the second group are those which were mainly constructed in the 1930s or the 1960s, thus still demanding for good connectivity with the community as a whole.

3.6 Reopening of Gambling Rights in the 2000s

When Macau returned to China in 1999, the Macau Peninsula experienced another period of rapid urban development. With the reopening of gambling rights in 2002 and the opening of free travel for the Mainland citizens in 2003, the gambling tourism was further prospered. From the map of 2018, it can be seen that the Outer Port area was further expanded, and the connectivity between the reclaimed area and the historical city center was strengthened. By 2012, the number of casinos had increased significantly. Also, almost all casinos were concentrated in the Outer Port to reduce their negative impacts on the historical districts (Fig.3).

Under the analysis of 500m, four integration cores were identified. In addition to the original cores in previous studies, the reclamation area in the Outer Port had formed a new local center. With the analysis radius increasing, the overall syntactic core formed a circular pattern; that is, based on the area in the historical center, ring roads were extended to connect the gaming franchise area. From the configurational analysis, it is found that the development of urban structure and its relationship with the gaming industry tended to be synergized. Through improving the connection at various scales, the accessibility to the gaming franchise area was strengthened, and its potential to gather various movements was also enhanced (Fig.3).
In addition, the analysis of choice shows that the high value at the radius of 500m spread over most of the areas of the Peninsula, indicating that local accessibility was relatively prominent. With the increase of the radius, high values gradually migrated to the long lines, finally covering most of the main roads of the Peninsula, forming an irregular grid pattern. The analysis also found that under all radii, high choice values passed by most of the gaming venues, indicating that the urban structure had increasingly adjusted itself to guarantee the accessibility of entire gambling area so as to attract more through-movements at various scales.

The scattergram (Fig.4) shows that the synergy of the Peninsula rised again, with R^2=0.529, indicating that the relationship of the newly developed areas with the overall layout had been improved. According to the distribution pattern of the casinos, they were naturally divided into

three groups. The first group was consisted of 12 gaming facilities, with their local and global integration values being relatively low, but formed a very steep regression line. The second group was located in the place with both high global and local integration, as well as forming a deeper regression line, indicating that their local and global relationship was better than the Peninsula as a whole. The third group consisting of 4 casinos, had significantly higher global integration than others, with their distribution forming a steep regression line in the scattergram either.

The above analysis shows that under all radii, the integration of most gaming facilities was higher than the average of the Peninsula, but generally with their global integration performing better than the local ones, indicating that they still heavily relied on the global structure and its effect on movements. However, when comparing with the analysis in previous periods, it is found that the gaming industry of this period also strengthened its ability to attract small-scale movements by the establishment of their own local center.

4 THE RELATIONSHIP BETWEEN GAMING INDUSTRY AND OTHER POI FUNCTIONS

In addition to examining the spatial distribution of the gaming industry and its relationship with the transformation of urban configuration, this study also explores the relationship between gaming function and other land uses by using the POI data. Since only current POI data can be collected, this study then superimposes the POI kernel density maps upon the segment-line analysis of 2018 to understand their spatial relationships. For further research purpose, the POI data is classified into 10 categories, including Transportation, Catering, Hotel, Shopping, Tourist Attraction, Residential, Daily Service, Leisure and Entertainment, Office and Enterprise, Culture and Media (Fig.6) .

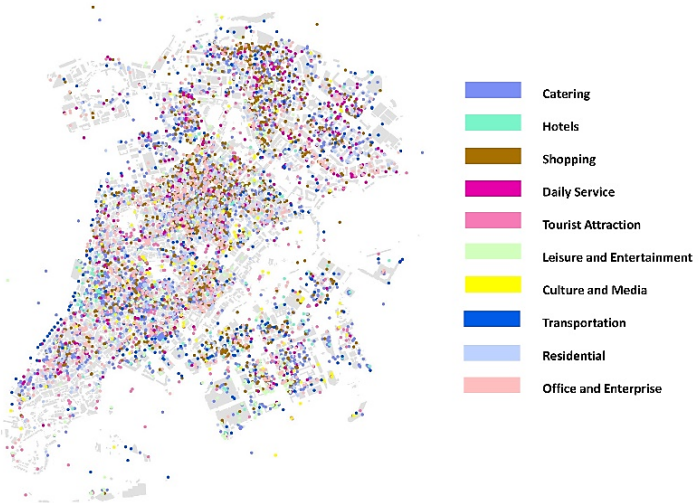

Figure 5: Distribution of POI Points on the Peninsula

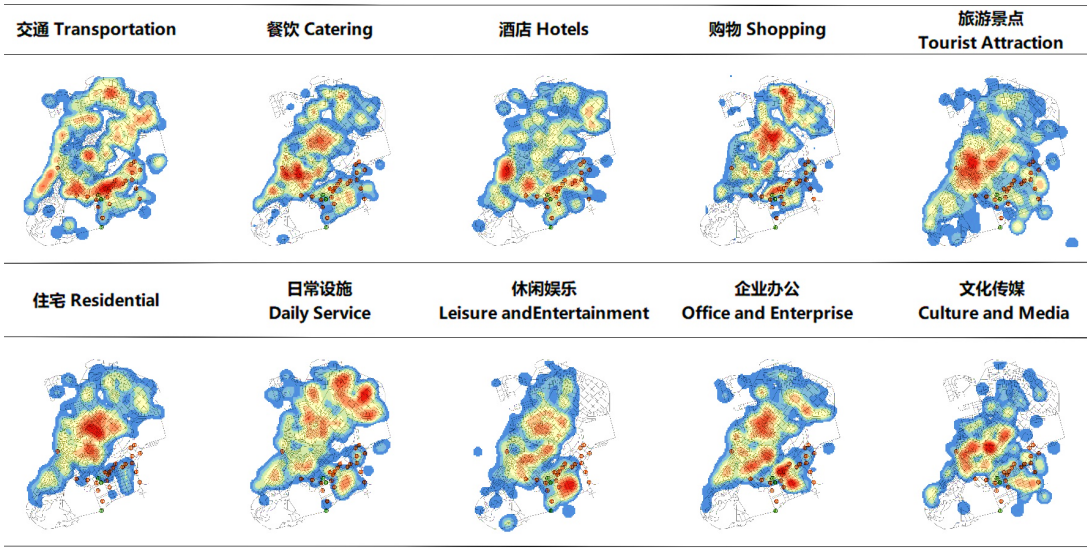

Figure 6: The Relationship of Various POI Functions and the Gambling Facilities

As a result, Figure 5 shows that various functions spread widely over the Macao Peninsula, displaying a high degree of mixing and high utilization efficiency of the urban space. Eexamining the relationship between POI Kernel density and the configurational properties, it is observable that various POI functions are strongly correlated with integration under all radii, indicating that the functional distribution on the Macao Peninsula can make good use of spatial configuration and its effect on to-movements. Also, the analysis of 1500m shows the highest co-efficiency, indicating that the interaction between spatial structure and different functions performs the best at this scale. By contrast, no significant correlation is found between various POI functions and choice values, showing that their response to through-movement is not sensitive. Among all the radii, the analysis of 500m displays a slightly better correlation (Fig. 7).

Figure 7: Correlation between Integration, Choice and POI Density

Transportation:

This study first investigates the distribution of various traffic stops on the Macau Peninsula. As a result, the figure shows that they tend to be evenly distributed throughout the Peninsula, but with evident clustering around the North Gate and the Outer Port where the gaming franchise area is located, forming two local transportation centers. From this, we may speculate that the

distribution of transportation somehow has been driven by the development of the gaming industry. As a result, the tourists, especially those from the Mainland and Hong Kong, can directly reach the gaming area in convenient and rapid ways (Fig. 6).

Catering:

The Kernel density of catering is not evenly distributed. There appear two high-density areas, meaning that catering related facilities tend to be located near the historical city center. On the southeast side of the franchise area, as well as the North Gate and the Lower Ring, there emerge some small-scale catering cores, suggesting that there is no obvious interdependence between the catering and the gaming functions.

Hotel:

Overall, the Kernel density of hotels on the Macau Peninsula is relatively low. Although it is widely distributed over the Peninsula, it only forms one obvious high-density core in the area of Ponte 16 and Xinma Road. In addition, two small-scale gathering points have been found in Lisboa and the New Port, showing their proximity to the gaming facilities. In other areas of the Peninsula, only some small dense areas can be observed in the Black Sand Ring, suggesting that the hotel related facilities are insufficient in number and not diversified enough in profile.

Shopping:

As far as the distribution of shopping centres is concerned, it is found that one high-density core is observed in the area around Goldstein-Xinqiao-Holland Park, indicating that intensive commercial activities are still retained in the historical centre. Another large-scale shopping center appears in the North Gate boring with the Mainland, indicating that the demand for shopping in the northern district is strong. In addition, in the New Port-Lisboa area, there also appear some small dense points, showing a certain degree of dependence on gaming activities. Therefore, it may be fair to infer that the current gaming industry and shopping functions have been mixed to a certain extent.

Tourist Attractions:

As a world heritage city, the Macao Peninsula has rich historical and cultural resources, most of which are located in the central area. Thus, it comes as no surprise that their Kernel density only forms a clear high-density core in the city center, with no overlapping with the gaming franchise area. In this case, we may assume that establishing seperated gaming areas can help alleviate the environmental pressure from tourists on the cultural heritages and historical attractions. However, the differentiation in the tourist profile may occur.

Residential:

In general, the density of residential functions is widely but not evenly distributed. Two distinct high-density cores can be identified in the historical city center. The secondary-density areas are

founded in Fengshun Parish, the North Gate and Black Sand Ring, indicating that the residential function tends to distribute in a hierarchy pattern, with its density decreasing from the center to the peripheral areas. In the gaming franchise area, a very small proportion of residential buildings is configured, implying that the gaming industry has consciously been separated from the residential areas to reduce the negative impact on local residents. In addition, there is a certain degree of overlapping between the residential and tourist attractions, indicating that the social contradiction between local residents and visitors is likely to arise with the booming development of tourism and the increasing number of tourists.

Daily services:

Daily service mainly refers to the facilities serving for the daily life of local citizens. The figure shows that there appear multiple high-density areas, which are located in the areas around North Gate-Black Sand Ring, Goldstone-Xinqiao, Xinma Road and Hahuan. Song Yusheng Park has also formed a gathering area. It is worth noting that in the historical center where residential functions are highly concentrated, no corresponding agglomeration of daily services can be found. This may be due to the high property prices and rents of these areas. Again, there is no overlapping between the daily service and the gaming franchise area.

Leisure and Entertainment:

In addition to gambling activities, the Kernel density of other types of leisure and entertainment facilities exhibits three high-density cores, with one located in the traditional functional center of Holland Park-Xinqiao District, and the second along the west side of Guiyang Mountain to Lisboa. The third core appears in the Song Yusheng Park near the Outer Port, forming an extension of the gaming franchise area. From the Figure 6, it is observable that the overall density of non-gaming leisure and entertainment is not high, their distribution is not widespread, and their integration with the gaming function is insufficient neither.

Office and enterprise:

The Kernel density of office and enterprise is relatively high and widely distributed. Totally, there are three high-density areas, two of which are located near Xinqiao-Korst and Holland Park respectively. The other is located in the Outer Port area, somehow overlapping with the gaming franchise area, implying that with the gaming industry increasing playing an important role in Macau's economy, many companies have been involved in the business associated with gambling.

Culture and Media:

Culture and media industry can play an important role for Macao to build a world tourism and leisure city. However, the density of cultural facilities on the Macau Peninsula is not widely distributed. The most high-density areas are mainly found in the old city center, highly overlapping with traditional tourist attractions. Secondly, the facilities in relation to culture and

media have formed a cluster in the Outer Port, where the Macau Art Museum and the Cultural Center are located. The figure also shows that there is no overlapping between the cultural function and the gaming franchise area. Conversely, the culture and media formats on the Peninsula have been spatially isolated by the gaming area, failing to form a continuous whole. From the above analysis, we may summarize that the gaming industry is highly interdependent with transportation facilities, hotels, and office and enterprises. Secondly, casinos have a certain degree of integration with hotels and shopping malls, indicating that the development model has been changing in recent years, with the aim to providing diversified services for tourists. By contrast, the gaming industry almost has no overlapping with traditional tourist attractions, residential, cultural, catering facilities, etc., indicating that these functions have not yet been well integrated to give full play of their complementary advantages.

The research so far has also found that there is a good correlation between various POI functions except for daily service category, indicating that different types of functions on the Macau Peninsula can coordinate and complement with each other, maximizing their respective benefits for the city.

5 CONCLUSIONS

(1) This study has proven that the development of the gaming industry has played an important role in the urban development of the Macau Peninsula. Firstly, in the 1930s, when Macau's gambling rights were transformed into franchise, the location of casinos was highly dependent on the spatial configuration at various scales, especially at community levels, so as to make full use of to- and through-movements that they generated. In the 1960s, Macau began to set up the permanent gaming areas, isolating the gaming industry from other land use and functions. As a result, the industry tended to reduce its dependence on the micro-scale pedestrian flows through functional diversification, but still had the demands for global movements. After Macau returned P. R. China in 1999, as well as with the re-opening of gaming rights in 2002, the gaming franchise area forms its own local center in addition to strengthening its connection with the traditional city center.

(2) The relationship between the gaming functions and the development of urban morphology varied from different historical periods. To sum up, it can be divided into several stages, from *high dependence*, to *moderate disengagement*, and to *mutual coordination* finally.

(3) By examining the spatial relationship between the gaming industry and different POI functions, it is found that the problem of the over dominance of gaming industry in the economy has not been resolved. The gaming industry and other leisure and entertainment facilities, such as tourist attractions, catering, shopping, cultural and media, etc., have not well integrated and synergized. Also, the number of hotels on the Peninsula is insufficient, and their distribution still have a strong dependence and convergence on the gaming facilities.

(4) Based on the above analysis, it is likely for this study to provide some suggestions. Firstly, Macau should strengthen the development of cultural and entertainment facilities, exploring various ways of combining them with the gaming activities. Secondly, Macau has outstanding tourism resources. In addition to a large number of historical and cultural heritages , its natural landscape features are also prominent. Therefore, Macau's tourism industry should strengthen the development and promotion in this aspect.

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