A Study About Macao's Industrial Moderate Diversification Based on Single-period Inventory Model

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Abstract

Mini-economies play a important role on the global economy.Many policy makers and researchers focus on their industry selection and expansion.By comparing on the industrial structure of typical mini-economy, it is found that the 'single industrial structure' is not the defect because it is the result of the market choice. Then using the single-period inventory model and time-series to predict the optimal scale of the Macao's gaming industry in the next three years, the result show that the demand will increase slowly in the future, the optimal scale will expand and Macao's capacity will be insufficient in 2019-2021. Based on these, this paper will propose practical and feasible policy suggestions for Macao's industry selection and expansion in Guangdong-Hong Kong-Macao Greater Bay Area.

Keywords

Single-period Inventory Model, Macao, Industrial Moderate Diversification, gaming industry.

1. INTRODUCTION

Macao extremely depends on the single industry, which is reflected in the statistical indicators such as industrial structure and employment structure. The report "Analysis Report on the Moderately Diverse Development of the Macao's Economy" shows that the proportion of the gaming industry (including the gaming intermediary industry) in the total value added calculated by the production method based on the current producer price or basic price is relatively larger than other industries in 2017. The indicators were 63.1%, 58.5%, 48.0%, 46.7% and 49.1% from 2013 to 2017. The statistics of employment structure diversification indicators show that the Macao's residents had the largest number of employees in the gaming industry, accounting for 21.2% of the total employed population in 2017. And the entropy index of the employment has little change from 2002 to 2017.

The indicators show that Macao extremely depends on the gaming industry. But in terms of economy stable, the diversification of the industrial structure is reasonable even if the implement effect is not satisfactory. From the perspective of the Guangdong-Hong Kong-Macao Greater Bay Area, the exploration of the relationship between Macao's industrial structure and the maximization of economic utility has rarely involved. This paper trys to study this aspect. By comparing with the four typical mini-economies' industry structure, summarizing the universality of mini-economies' industry choices by single-cycle inventory model, predicting the optimal size of the gaming industry in the next five years by time series. The paper mainly answers three questions: (1) Is there a regular about the industry choice in mini-economies? (2) How to adjust the scale of Macao's gaming industry to improve economic efficiency? (3) what role should Macao's industry play in the perspective of the construction of the Guangdong-Hong Kong-Macao Greater Bay Area?

The composition of this paper: The second part sorts out relevant research about Macao's gaming industry and industrial diversification strategies; the third part makes the comparison above the industrial structure of mini-economies, then summarizes the natural selection of mini-economies' industry. The fourth part is the calculation and empirical prediction by the single-period inventory model; the last part is the analysis and inspiration about the policy recommendations.

2. REVIEW OF RELATED RESEARCH

There is a wealth of researchs about industry. This section selects representative and reference literature for analysis, mainly including the industrial characteristics of mini-economies, the application of the single-cycle inventory model in the industry, and the mini-economies' choices about industry .

In the relevant studies on the characteristics of the industrial structure of mini-economies, Xiao Song (2004)[2]studied 31 small countries around the world and got the result that all of them have one or more leading industries with extremely high industrial efficiency to support the national economy. Li Yuan (1981) [3] studied the industry structure of Monaco founding that the gaming industry accounts for more than half of the national income, and there are rich entertainment facilities such as hotels, bars, baths, dance halls, theaters to make the gambling industry be more attractive.

So far, the single-cycle inventory model has been used to calculate the optimal scale of the exhibition industry and the hotel industry in Las Vegas . Zheng Gu (2003) [4] used the single-period inventory model to measure the optimal scale of the Las Vegas's casino and hotel industry in the "Analysis of Las Vegas Strip casino hotel capacity: an inventory model for optimization" , it was found that the scale of Las Vegas hotels has changed from overcapacity to undercapacity, and the scale should be adjusted carefully. In 2012, Zheng Gu[5]used the same method to calculate the optimal scale of the Las Vegas exhibition industry in the "Capacity optimization analysis for the MICE industry in Las Vegas",it was found that the convention and exhibition industry market will face serious overcapacity which will lead much more business failures and bankruptcies .

Regarding the selection and expansion of the tourism industry in the mini-economies, Shou-Tsung Wu, Yeong-Shyang Chen (2015)[6]mentioned that the gaming industry is the fastest-growing tourism industry without considering moral, political and religious influences. Therefore, many tourism countries and cities are considering the gaming industry (such as Japan and Vietnam).

Regarding the studies of industrial diversification in the mini-economies, Zeng Zhonglu (2015)[7] proposed that the industry structurein Macao was reflected in the employment distribution and gaming tax. It was believed that the diversification implemented in Macao has increased the dependence on the gaming industry, because Macao's funding for supporting diversified industries comes from the gaming industry. Zeng Zhonglu and Ji Chunli (2018) [8] compared with two similar mini-economies' industries, they mentioned that the policy of diverse industries was feasible in the mini-economies.Such as the international financial services industry and the Internet gambling industry have filled the gaps in the relevant proposals that lack practical value.

From the perspective of regional economic integration, Lin Zhou (2009)[9] pointed out that Macao should be accurately positioned, led by the tourism and gaming industry, and supported by finance, trade, real estate, and transportation information. Modern optical-mechanical-electrical integration technology revolutionizes gaming methods, improves cultural content from a cultural perspective, and enhances the entertainment, fun, and healthy elegance of gaming.

Based on the perspective of the Guangdong-Hong Kong-Macao Greater Bay Area, Liu Chengkun and Chen Zhiyuan (2019) [10]took 11 cities in the Bay Area as the research objects and used the entropy method to evaluate the competitiveness of urban tourism. Optimize the existing casino environment, innovate betting types, consolidate betting projects such as horse racing and dog racing, and make full use of gaming revenue to accelerate the construction of non-gaming elements.

The above studies are discussed from the perspectives of the reasons for the implementation of industrial diversification in Macao, the difficulties and challenges it faces, the regional cooperation, and the positioning and development of Macao from the perspective of the Guangdong-Hong Kong-Macao Greater Bay Area. Few research about the industrial structure of the typical mini-economies and exploring the feasibility of industrial diversification. It can be concluded that there are a lot of papers on the development of the diversified industrial structure in Macao ,and there are few researchs that summarized the trends about the natural selection of mini-economies' industrial structure. Therefore, based on the perspective of the Guangdong-Hong Kong-Macao Greater Bay Area, this paper summarizes the characteristics of the industrial structure of the mini-economiea, then using the single-cycle inventory model and time series to predict the future demands for the Macao's gaming industry.

3. THE PATTERN OF INDUSTRY SELECTION IN MINI-ECONOMY

This section mainly analyzes the industrial selection of the mini-economies. In accordance with the principles of comparability and referability, this paper selected the basic data of five mini-economies for comparison and analysis in 2017, such as Luxembourg, Singapore, Monaco, Malta and Macao (Table 1).

Table 1. Basic information on mini-economies in 2017

	Macao	Luxembourg	Singapore	Monaco	Malta
Area (Square kilometer)	30.5	2586	716	2	316
Population (Ten thousand)	64.5	58	561	3.9	45.3
Population density (People / Square kilometer)	21148	225	7835	19250	1434
GDP per capita (USD)	77596	102831	79697	88939	30202
Change rate of GDP	-2.10%	3.10%	3.60%	3.20%	9%
Unemployment rate	1.80%	-	2.20%	-	1.40%

Source: World Bank.

As we can be seen from the Table 1, the objects are all relatively rich rejions. Except for Malta's economy which is less than half of Macao, the GDP per capita of other three mini-economies are among the highest in the world, and have great growth. Comparing with them, Macao has the highest population density, and the unemployment rate remained at a low level of 1.8% with the negative change of the GDP. It can be seen that the excessive population density is one of the key issues restricting Macao's sustainable development.

A comparison of the industrial structure of Macao, Luxembourg, Monaco and Malta in 2015 (Table 2) shows that the gaming industry in Macao produced nearly half of its GDP. Luxembourg's best-developed financial sector accounts for 46% of GDP. Monaco's gaming and tourism industry and related industries account for 42% of the total output value, and Malta also has several leading industries with a relatively high output.

(A) Luxembourg

Luxembourg is located in the northwestern Europe, adjacent to France, Germany, and Belgium, with a population of 580,000 (statistics in 2015). Due to its small size and many ancient castles, Luxembourg is known as the "Pocket Kingdom" and "Country of One Thousand Castles". Although it is small, Luxembourg is one of the richest countries in the world. Why could Luxembourg develop well?

Agriculture: Luxembourg's food basically relies on imports because of insufficient supply. The agricultural products include wheat, rye, barley and corn which accounts for 0.38% of the 2015 GDP.

Manufacturing industry: In addition to the rich iron ore resources, Luxembourg lacks of natural resources.so the steel industry supplemented by chemical industry, machinery manufacturing, rubber and food industries. In 2015, the mining industry accounted for 0.1% of the total output value, and the manufacturing industry accounted for 8.45% of the total output value.

Finance: Luxembourg has a well-developed financial industry which was consisted of three major industries as banking, investment funds, insurance and reinsurance. It is the largest fund management center in Europe. From the perspective of industrial scale, the largest is the bank, followed by funds and insurance. The financial industry accounted for 45.79% of GDP in 2015.

Transportation and communication industry: Luxembourg's logistics performance index ranks second in the World Bank, and air cargo centers rank sixth in Europe. In 2015, the transportation and communication industry accounted for 10.54% in GDP.

It can be seen that among the industrial structure of Luxembourg, the financial industry has the highest proportion that is close to half of the total output value, and the industrial diversification structure is not obvious.

(B) Monaco

With a population of 39,000 and a land area of 2.02 square kilometers, Monaco is the second smallest country in the world which per capita income ranks first in the world. Monaco is short of natural resources and its agriculture is lagging behind, and gaming tourism supports the national economy. The advantages of the tax exemption policy and the strict legal provisions of the gaming industry have ensured the healthy development of the gaming industry.

Tourism: Monaco's gaming tourism and pleasant climate have attracted a large number of tourists which drives the hotel industry, catering industry and wholesale and retail industries. Table 2 shows that the output of the three major industries of Monaco accounted for 42% of the total output value, and the country's economic development was driven by high value-added and pollution-free industries in 2015.

Financial industry: Driven by the gaming and tourism industry, Monaco's financial industry is developed. Some of the world's largest banks have branches in Monaco, which is convenient for tourists from all over the world. In 2015, the output of the financial industry accounted for 16.1% of the total output value, of which the gaming industry contributed a lot.

(C) Malta

As an island country in the Mediterranean, Malta has the population of 453,000 covers an area of 316 square kilometers and its per capita income is far less than these two small countries. Due to lack of resources, Malta mainly relies on high value-added gaming industry, tourism industry and finance to support the national economy.

Financial industry: Malta's financial industry includes investment funds, insurance, reinsurance and bankingis which at the forefront of the world. In 2015, the financial industry's output value accounted for 5.77% of the total output value.

Internet Gaming Industry: Malta has invested heavily in the internet gambling infrastructure early and it is currently as the foretype. The mature telecommunications joint ventures, data

center joint ventures, lawyers, banks and payment institutions provide the guarantee for the online gaming industry. In 2015, the revenue from the gaming industry and the private service industry accounted for 23.1% of the total output value. In addition to the tourism, hotel, catering, the output of the wholesale, retail industries and other related industries reached 49.25%.

According to the comparison of the industrial structure about Luxembourg, Monaco and Malta, it shows that all of three economies have one or two industries' output exceed 1/5 of GDP (Table 2) and rely on high value-added, pollution-free industry to support the economy. Both Monaco and Malta develop the gaming industry and tourism, which has promoted the development of related industries such as the financial industry, hotels, restaurants, wholesale and retail. And cultive technical labors to develop new gaming projects, coupled with correct policy guidance and strict laws restrictions to ensure the great development of the gaming industry. It is believed that the simple "single industrial structure" should not be regarded as a defect because of the market economy and the specialized division. For example, the "Silicon Valley" in the United States has always maintained a single industrial structure, but it is not a problem affecting development.

Since the implementation of the industrial diversification policy, the development momentum of the Macao's gaming industry has been reduced, and the overall economic level has shown a downward trend. After the implementation of the industrial diversification policy slowed around 2017, the economy gradually picked up. So for now, should Macao's gaming industry continue to develop? The next will use the single-cycle inventory model to calculate the optimal size of the Macao's gaming industry and predict future demand.

Table 2. The Comparison of the Industrial Structure about Macao, Luxembourg, Monaco and Malta in 2015

Unit: %

Industry	Macao	Luxembourg	Monaco	Malta
Primary Industry	0	0.38	0	1.1
Secondary Industry	1.3	9.44	3.9	9.11
Tertiary Industry	98.7	90.18	96.1	89.79

Source: World Bank.

4. CALCULATION OF THE OPTIMAL SCALE OF MACAO'S GAMING INDUSTRY

4.1. Single-period Inventory Model

This section uses the single-cycle inventory model to calculate the scale of Macao's gaming industry. Anderson (2010) mentioned that the single-cycle inventory model is applicable to products and services that involve seasonal or perishable products, because the demand for seasonal or perishable products is uncertain but obeys a probability distribution. The single-period inventory model involves the expected loss which relates to increment of inventory. When ordering at the optimal order quantity $Q*$, the expected loss (EL) of an incremental unit is equal to the expected loss of one less incremental unit, which is EL $(Q*+1)$ = EL $(Q*-1)$. (Over / Under) order expected loss is defined as the corresponding cost times the probability of loss, ie:

$$CoP(demand<Q*)=Cu[1-P(demand<Q*)] \tag{1}$$

$$CuP(demand>Q*)=Co[1-P(demand>Q*)] \tag{2}$$

Important variables in the equation: the unit cost of over-ordering Co (ordering an extra unit and finding a loss that cannot be sold), the cost of under-ordering Cu (the loss of another unit may be sold but not be ordered). P (demand <Q *) is the probability of over-ordering, and P (demand> Q *) is the probability of under-ordering. P equals to the equations (3) and (4).

$$P(demand<Q^*)=Cu/(Cu+Co) \tag{3}$$

$$P(demand>Q^*)=Co/(Cu+Co) \tag{4}$$

Equations (3) and (4) show the general conditions of the optimal order quantity Q * in the single-period inventory model. For example, in equation (3), Cu = Co indicates an equal opportunity for excess and shortage of demand about the optimal capacity Q *. If Cu / (Cu + Co)> 0.5, the loss of Cu is greater than that of ordering an additional unit and found that the loss Co cannot be sold. It is recommended to use more order to reduce the shortage for avoiding the loss of insufficient supply. Conversely, it means that if you do not order another unit and find that it may be sold, the opportunity of the loss Cu is less than the loss Co that you ordered an additional unit but cannot sell. You should reduce the order to reduce the scale. All in all, the single-cycle inventory model tends to guarantee order status at a lower cost.

As for the gaming industry, casinos cannot be resold in the future without guests. The casino equipment is perishable, and guests' demand for gaming is probabilistic rather than deterministic, so the single-period inventory model is available to determine the best capacity of gaming Industry. Comparing the optimal size with the planned available size each year, the extent of excess capacity and insufficient capacity can be determined.

In the paper, the cost of overbooking Co selected the unit fixed cost of operating the gaming industry as the measure, because whether or not there are guests will incur operating expenses. The loss of under-ordering Cu selected the unit profit of the gaming industry as the measure, and selected the cost and income data in the Macao Statistical Yearbook 2004-2016 to calculate equations (3) and (4). Based on the calculated P value, regression estimated future demand and probability distribution. The Macao's gaming industry optimal capacity Q * for each year from 2019 to 2021 is estimated to analyze whether there is excess capacity or insufficient capacity.

The unit cost Co and unit profit Cu of the gaming industry from 2005 to 2016 are shown in Table 3. Among them, the unit profit or under-subscribed cost of the gaming industry Cu was 5.2143 patacas in 2005. And the unit fixed cost of operation Co was 1.8643 Macao Pataca. According to equation (3), the P value is 0.737 which indicats the probability of demand for the gaming industry in 2005 below its optimal scale Q * is 73.7%. According to equation (4), the P value is 0.263 which means the probability of the demand more than its optimal size Q *for the gaming industry in 2005 is 26.3%. In the standard normal distribution, Q * on the right of the mean, and Z-score is 0.6341. Then select the monthly data of betting tax from 2005 to 2016 as the measure of the average gaming industry scale Y. Finally estimate the optimal capacity Q * according to equation (5) (standard deviation s of demand Y = 538.05):

$$Z\text{-}score=(Q^*-Y)/s \tag{5}$$

Table 3. Estimated datas of CU and CO

	CO	CU	P	z	Y	Q*
2005	1.8643	5.2143	0.737	0.6341	17319	17660.18
2006	1.3147	3.0801	0.701	0.5273	20748	21031.71
2007	1.0479	2.4122	0.697	0.5158	30948	31225.53
2008	1.3280	3.5564	0.728	0.6068	41897	42223.49
2009	1.0781	3.2107	0.749	0.6713	44310	44671.19
2010	1.1991	5.4472	0.820	0.9154	68776	69268.53
2011	1.2457	6.9635	0.848	1.0279	99656	100209.06
2012	1.4448	7.7983	0.844	1.0110	113379	113922.97
2013	1.9805	11.1207	0.849	1.0322	134381	134936.38
2014	2.3237	11.0138	0.826	0.9385	136711	137215.96
2015	2.0052	6.5645	0.766	0.7257	89572	89962.46
2016	2.1777	6.7411	0.756	0.6935	84375	84748.14

4.2. ARIMA Forecast

According to the monthly data of Macao gaming tax from 2005 to 2016, the ARIMA product seasonal model (1, 1, 2) * (0, 1, 1) 12 gets the regression results that are shown in Figure 1. As we can see, the results of ar (1), ma (1, 2), sma (1) both passed the significance, and the residuals passed the white noise test (see Figure 2 for details) which indicats the autocorrelation is not in the residuals. Therefore, this model is selected to predict the average demand Y of the Macao's gaming industry in 2019-2021. The results are equations (6) and (7).

$$s12dyt=0.0833s12dyt-1+rt-1.417rt-1+0.65rt-2-0.775rt-12+1.098rt-13-0.504rt-14 \quad (6)$$

$$s12dyt=(Yt-Yt-1)-(Yt-12-Yt-13) \quad (7)$$

In the equations (6) and (7), s12dyt is the first-order 12-step difference result of Y. After substituting equation (7) into equation (6), the demand Y of the gaming industry in the next three years can be predicted. The average Z-score value from 2005 to 2016 is set as the Z-score value for the next three years, and the optimal scale Q * during the period is obtained by formula (5) (see Table 4 for details).

Table 4. The demand and optimal capacity forecast of the Macao's gaming industry in 2019-2021

Unit: MOP million

	2019	2020	2021
Y	127156	134215	141016
Q*	127573	134632	141432

5. RESULTS AND DISCUSSION

According to model calculations, it can be found that the overcapacity cost of the Macao's gaming industry is much higher than the cost of undercapacity. As shown in the Table 4, it is expected that the demand for the gaming industry will slowly increase in the next three years, and the optimal scale will also expand but it is insufficient. Macao will experience a slight shortage of production capacity in 2019-2021.

Based on the above analysis, the following policy recommendations are proposed:

1. On the perspective of the Guangdong-Hong Kong-Macao Greater Bay Area, the various types of advantages should be continuously discovered, explored. As for Macao, the biggest disadvantage of development is insufficient land resources, large population density. At present, it is necessary to strengthen the gaming-tourism industry, integrate optical-mechanical-electrical-mechanical innovations into the traditional gaming industry, and gradually transform into a "Macao brand" modern gaming industry with the characteristics of funny and uniqueness. of course, Macao should work with other cities in the Guangdong-Hong Kong-Macao Greater Bay Area to make up for shortcomings.

2. Comparing with other mini-economies, "single industrial structure" is a general pattern of industrial selection, and Macao should not regard it as a defect. In the short term, the gaming industry should play a leading role to stabilize the position of the "World Tourism and Leisure Center". From a long-term comprehensive perspective, Macao should have moderately diversified industry, but the process of transformation should not be too fast and hurried.

3. From the gaming industry operating models in Monaco and Malta, it can be seen that the cultivation of technical labors plays a very important role. Although the Macao's gaming industry has a leading position in the world currently, the management professionals and other professionals who support the development of industries are still insufficient. Therefore, it is recommended to introduce foreign professionals and cultivate local technical professionals to explore online projects.

In summary, it is not the best choice to blindly pursue industrial diversification for economic stability. The important point is to build a more competitive advantage.

REFERENCES

[1] Macao Government Statistics and Census Bureau: "Analysis Report on the Statistical Indicator System of Moderately Pluralistic Development of the Macao Economy"(2017).

[2] Xiao Song(2004). The Way of Survival of the" Pocket Country. Innovation and Technology, No. 1, p.22.

[3] Li Yuan(1981).European Mini-Country-Monaco.World Knowledge,No.2 p.17-19.

[4] Zheng Gu(2003).Analysis of Las Vegas Strip Casino Hotel Capacity: an Inventory Model for Optimization.Tourism Management,Vol.24,No.3,p. 309-314.

[5] Zheng Gu & LT Yang(2012).Capacity Optimization Analysis for the MICE Industry in Las Vegas. International Journal Of Contemporary Hospitality Management, Vol.24, No.2-3 , p. 335-349.

[6] S.Wu & Chen.Y(2015).The Social, Economic, and Environmental Impacts of Casino Gambling on the Residents of Macau and Singapore.Tourism Management, Vol. 48 , p. 285-298.

[7] Zeng Zhonglu(2015).Feasibility Study on Diversification of Micro-Economy Industry.Hong Kong and Macao Studies, No. 4,p.47-56+95.

[8] Zeng Zhonglu, Ji Chunli(2018).Countermeasures of Macau's Industrial Diversity.Macao Studies,No.2, p.6-18.

[9] Lin Zhou(2009).Macao's Industrial Development Countermeasures from the Perspective of Regional Economic Integration. Special Economic Zone,No.10, 62-63.

[10] Liu Chengkun, Chen Zhiyuan (2019).Empirical Research on Tourism Competitiveness of the Guangdong-Hong Kong-Macao Greater Bay Area. Exploration of Economic Issues" (Kunming) No. 2,p.88-94.