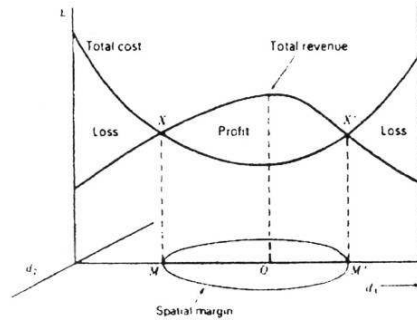# Study on Spatial Distribution of Industries in Chinese Cities During Transitional Period: A Case Study on City of Nanning

The study on spatial distribution of industries can trace as early as back to the Industrial Location Theory (Weber, 1909, 1914) of Weber, a German economist. In the 1950s, Francois Perroux, a French economist, put forward the concepts of "Propulsive Unit" and "Growth Pole". Boudeville developed the theory of Growth Pole, defining it as "a group of constantly developing industries located in the urban area which induce the further concentration of industrial via their influence on the surroundings (Boudeville JR, 1996). The neoclassical approach emphasized the spatial features of economic behaviors, introduced the spatial variable (the transportation cost caused by the spatial distance), and explored the locational equilibrium process under the circumstances of competition in the ideally free market economy from the perspective of the least-cost location. In terms of the optimal location of enterprises, not only the other cost factors but also the revenue factor were considered, thus forming the spatial margin to profitability which is composed of the total cost curve and the total revenue curve (Smith, 1966, 1971). Representing the regional scope in space where the enterprises can make profits, the spatial margin to profitability can be used as the foundation for enterprises to select locations (see Fig. 1). Based on the microcosmic Transaction Cost Theory, Scott put forward the concept of "industrial complex", i.e., the industrial concentration was formed by the connection of various transaction networks. The mode of industrial concentration and the relation between industries were determined by the cost. The more the transaction cost, the higher the concentration degree. Once the industrial complex was established, the concentrated economic benefits could be formed spatially and some unrelated industries could also be attracted to join the complex (Scott, 1985, 1988). Recently, P. Krugman et al. paid attention to the influence of history and haphazard in deciding the location of economic activities. Krugman insisted that the industrial concentration was caused by the interaction of the increased scale merits of enterprises, the transportation cost, and the flow of production factors via market conduction. He stressed that the close economic relations instead of comparative advantages lead to concentration, and also held that the technological outflow is a secondary factor for the concentration because the low-technology industries can also concentrate (Krugman, 1991b). Theoretically, this proved the general tendency that industrial activities tend to concentrate spacially. Krugman ascribed the original industrial concentration to a kind of historical haphazard, and he argued that the initial advantages were amplified owing to the "path dependence", which resulted in the "lock-in" effect. As a result, both the concentrated industries and locations have the nature of "historical dependence". In this paper, Nanning is selected as the case study.
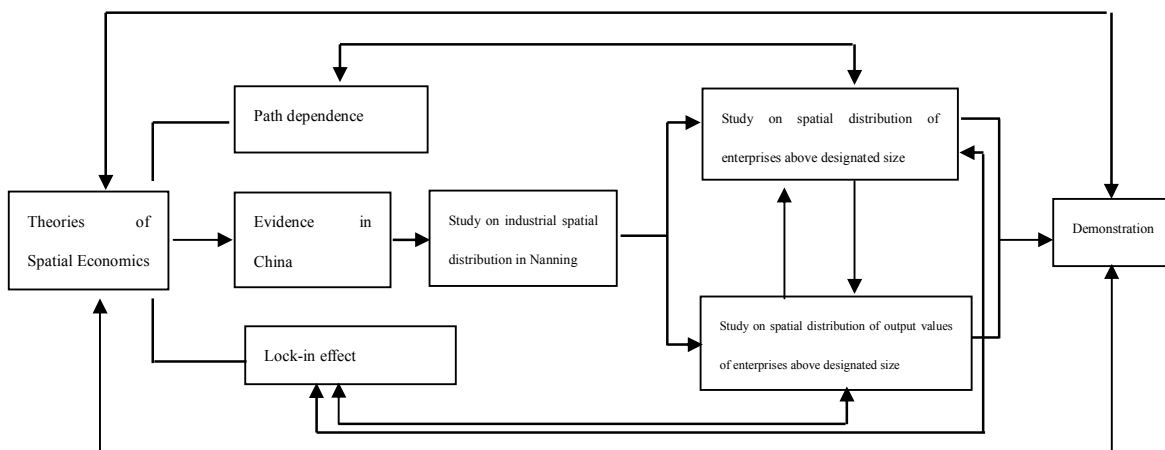
Fig. 1 The spatial margin to profitability

Source: Lever (1987), pp. 30.

1. The theoretical assumption

Spatial Economics emphasizes the influence of specific historical events on the forming process of industrial areas. The initial advantages are magnified due to "path dependence", thus resulting in the "lock-in" effect. Therefore, by studying the spatial distribution of the enterprises above designated size[①] of Nanning and the distribution features of industrial output values of the enterprises above designated size, this paper attempts to validate the influence of "path dependence" and "lock-in" effect in practice, thus demonstrating the applicability of Spatial Economics Theory in China (see Fig 2).

Fig. 2 Study framework

2. The case study of Nanning City

In 2000, the industrial land in the urban area of Nanning occupied an area of 17 km^2, where

772 enterprises were located. These enterprises were mainly distributed in the four industrial zones of Jiangnan, Beihu, Xijiao, and Hantang which have been constructed in succession during the period of planned economy since 1958. The light industry which takes agro-forestry products as material and the traditional processing and manufacturing account for a large amount, with a total industrial value of 11,748,045,000 yuan (RMB). The state-level Nanning High-tech Industrial Development Zone and the state-level Nanning Economic and Technological Development Zone are the new zones where industries concentrate and the bio-engineering and pharmacy industry as well as the technology-intensive industries like electronic communication take a large proportion. The industries mainly distributed in the central urban area are developed, while those in the suburbs and surrounding towns and villages are underdeveloped (see Table 1).

Tab.1 Summary of industry area in the central area of Nanning city

Name of industrial zones	Location	Industrial types	Major enterprises
Jiangnan Indus-trial Zone	South of Wuyi East Road, next to Nanning Economic and Technological Development Zone in the south	sugar-making, chemical industry, aluminium fabrication, and paper manufacturing	Nanning Sugar Co. Ltd., Nanning Chemical Industry Inc., Alnan Aluminum Co., Ltd., Nanning Power Supply Company, Guangxi Guiyuan Lysine Co. Ltd., etc.
Beihu Industrial zones	Along Beihu Road	machinery, construction material, and food	Nanning Heavy Machinery Plant, Nanning Wuling-Guihua Vehicle Co., Ltd, Nanning Hehua Gourmet Powder, Nanning Citric Acid Co. Ltd., Nanning Yinsha Wire & Cable Co. Ltd., Construction Machinery Manufacturing Co. Ltd of Guangxi International Construction Engineering Group, and Nanning Jiatai Cement Products Co. Ltd., etc.
Xijiao Industiral Zone	From Daxue East Road to Beida Road	machinery, rubber, pharmacy, and food	Nanning Machinery Plant, Nanning Decelerator Factory, Nanning Zhuangjin Rubber Co. Ltd., Nanning Baihui Pharmaceutical Co. Ltd., Wantong Pharmacy Co. Ltd., Nanning Wantai Beer Co. Ltd., Nanning Meat Packing Plant, Nanning Canned Food Factory, etc.
Hantang Industrial Zone	West of Jiangnan Industrial Zone	Construction material, machinery, and	Naning Float Glass Co. Ltd., Nanning Generating Equipment General Works, and the feedstuff factories such as

		feedstuff industries	Daguijia, Jingui, Fengyu, etc.
High-tech industrial development zone	On the south of Daxue Road	Industrial system led by biological engineering and pharmacy, mechatronics, electronic information, new material, modern agriculture, etc.	Guangxi Nanning Dikai Sci & Tech Co., Ltd., Guangxi Juxing Sci & Tech Co., Ltd., Nanning Coca Cola Beverage Co.,Ltd., Nanning Asian Olympic Digital Co., Ltd., Nanning Pingsoft New Technology Co. Ltd., Guangxi Deyi Digital Co. Ltd., Nanning Huige Techonology Co. Ltd., Nanning Baling Techonology Co. Ltd., Guangxi plant tissue culture Co. Ltd., Guangxi Kanghua Pharmaceutical Co. Ltd., etc.
Economic and technological development zone	Located to the south of Jiangnan Industrial Zone	Industries such as fine chemicals, automobile parts, aluminium fabrication, sugar, paper manufacturing, biomedicine, electronics, and food	Guangxi Qiaowang Pulp Packing Products Co. Ltd., Guangxi Nanning Phoenix Paper Co. Ltd., Guangxi Quantong Wood Industry Co. Ltd., Guangxi Nanning Chemical Pharmaceutical Co. Ltd., Nanning Jingwei Branch of Foshan Plastics Group Co. Ltd., Guangxi Yuli Real Estate Co. Ltd.

The selection of study area

Since the industrial development layout is concentrated in the central urban area of Nanning, all the industrial zones (Jiangnan, Beihu, Xijiao, and Hantang Industrial Zones) in the central urban area and development zones (Nanning High-tech Industrial Development Zone and Nanning Economic and Technological Development Zone) are taken as the study area (see Fig. 3), with the enterprises above designated size as the study target.

Fig.3 Distribution of industry area in the central area of Nanning city

(Legend: 1 Beihu Industrial Zone;

2 Xijiao Industrial Zone;

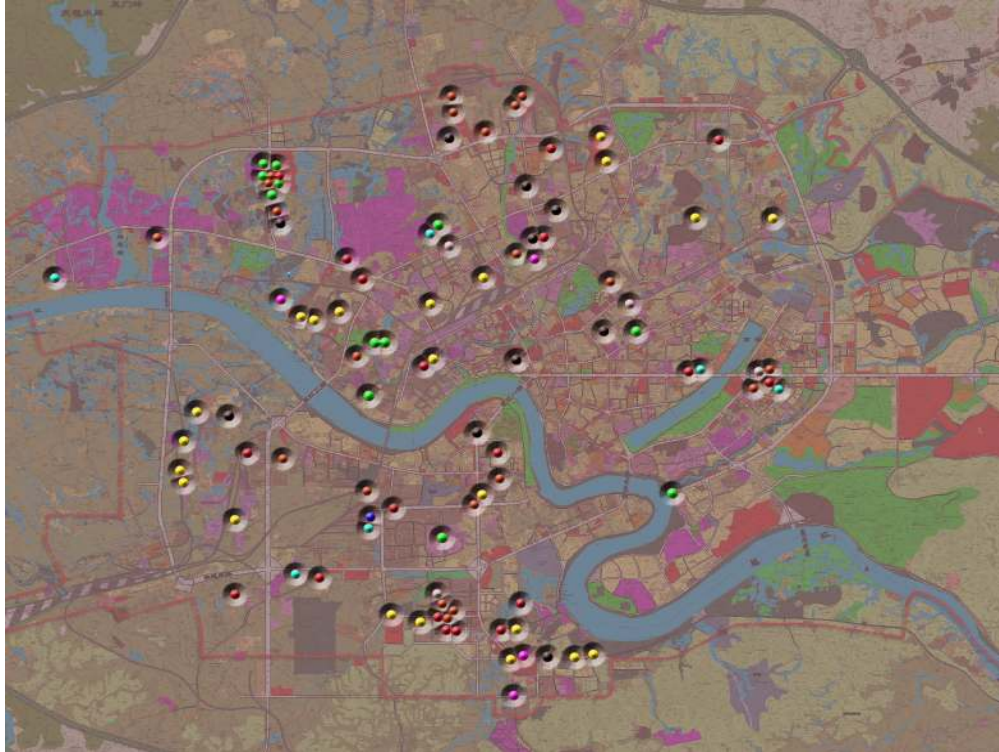**3 High-tech industrial development zone;**

4 Hantang Industrial Zone;

5 Jiangnan Industrial Zone;

6 Economic and technological development zone)

The study methods

Suppose the crossing of Renming Road and Chaoyang Road (near Minsheng Block Office) as the center of Inner City. Take it as the origin, measure the vertical and horizontal coordinate for each enterprise above designated size, calculate their distance from the urban center, and then analyze the relationship between the distance and the number of enterprises above designated size as well as their output values by using the statistical software of Excel and Spass (see Fig. 4).

Fig.4 Spatial distribution of enterprises above designated size in Nanning City
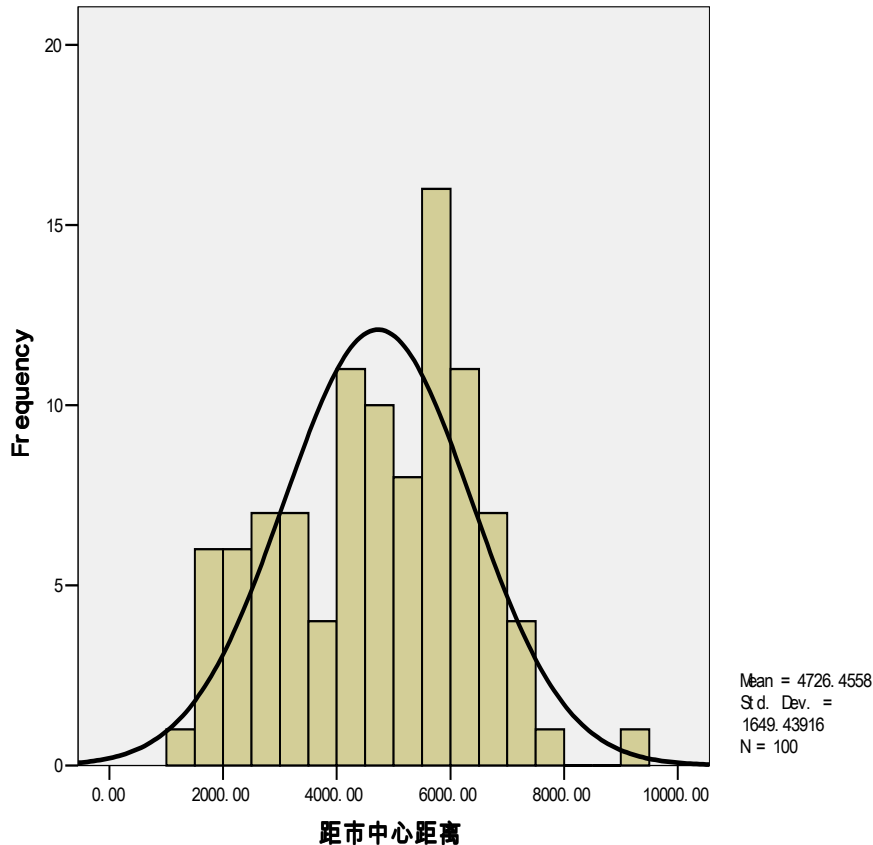 **Source of date**

The statistical indicators of 153 enterprises above designated size in 2003, which is provided by the Investment Department of Economic Committee of Nanning City, are adopted, of which the output value and the number of employees are included. After eliminating the enterprises which are not distributed in the central urban area of Nanning and those whose data are incomplete, 100 samples are collected as study targets.

2.4 Preliminary analysis

2.4.1 Analysis on the number of large-scaled enterprises and their distance from the urban center

According to Fig. 5, with the increase of the distance from the city center, the appearance frequency of large-scaled enterprises gradually rises, which reaches the climax at a distance of 6 to 7 km away from the city center. Afterwards, it gradually vanishes at a distance of 10 km away from the city center. The distribution is similar to the skewed normal distribution.

距市中心距离

Fig.5 Analysis of the distance from the city center and the number of enterprises above designated size (1)

The explanation for each quadrant is as follows (see Fig. 6):

The first quadrant (northeast): the enterprises above designated size are mainly distributed at a distance of 2 to 6 km away from the city center, which is divided into two parts at the distance of 4 km.
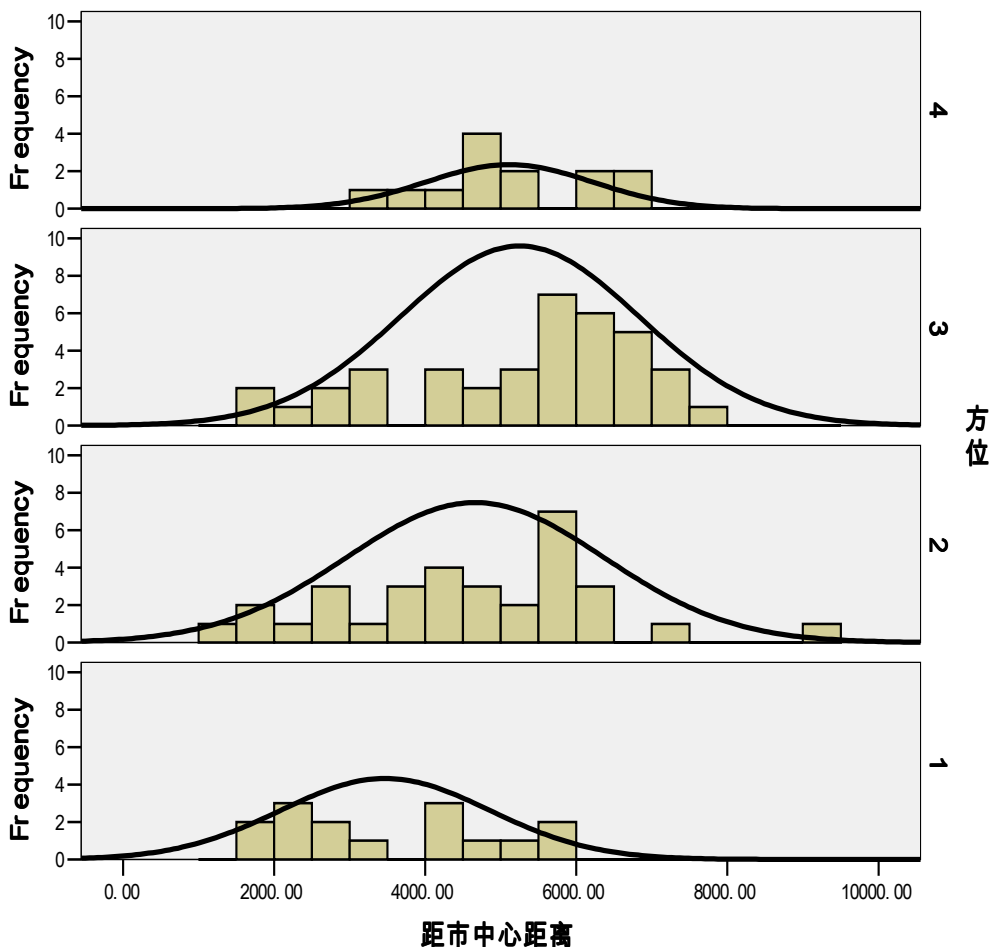
The second quadrant (northwest): the enterprises above designated size are mainly distributed at a distance of 2 to 7 km away from the city center; the frequency rises at the distance of 2 to 6 km, which reaches the highest at the distance of 6 km and falls afterwards.

The third quadrant (southwest): the enterprises above designated size are mainly distributed at a distance of 2 to 8 km away from the city center, and the frequency is the highest at the distance of 6 to 7 km.

The fourth quadrant (southeast): the appearance frequency of enterprises at designated size is relatively low, and a certain number of enterprises are distributed at a distance of 3 to 7 km away from the city center.
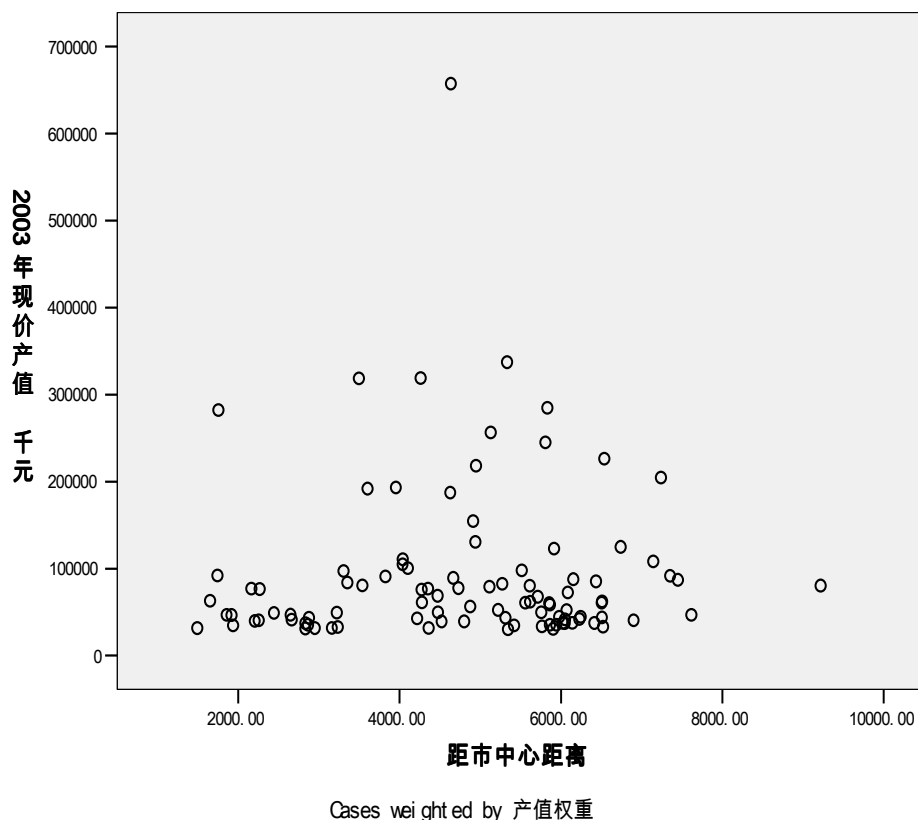
According to the analysis on each quadrant, we can conclude that the appearance frequencies of enterprises above designated size in the second and third quadrants are higher than those in the first and fourth quadrants. The Jiangnan Industrial Zone in the third quadrant is distributed at a distance of 6 km from the city center, where the appearance frequency of enterprises above designated size is high; the Beihu Industrial Zone in the north of the second quadrant and the Xijiao Industrial Zone in the west of the second quadrant are distributed at a distance of 6 km from the city center, where a large number of enterprises above designated size are located and the appearance frequency is high; the Nanning High-tech Industrial Development Zone in the second quadrant is distributed at a distance of 2 km from the city center, where the appearance frequency of enterprises above designated size is relatively low; the Nanning Economic and Technological Development Zone in the third quadrant is located at a distance larger than 7 km from the city center, where the appearance frequency of enterprises above designated size is also low. These two development zones are both built in the market economy, where the development is slow and the number of enterprises above designated size is small.

In summary, the spatial distribution of industries in cities in West China is more influenced by the historical inertia of the planned economy while the influence of market economy is rather small, and the path dependence is the major factor that affects the distribution of enterprises.
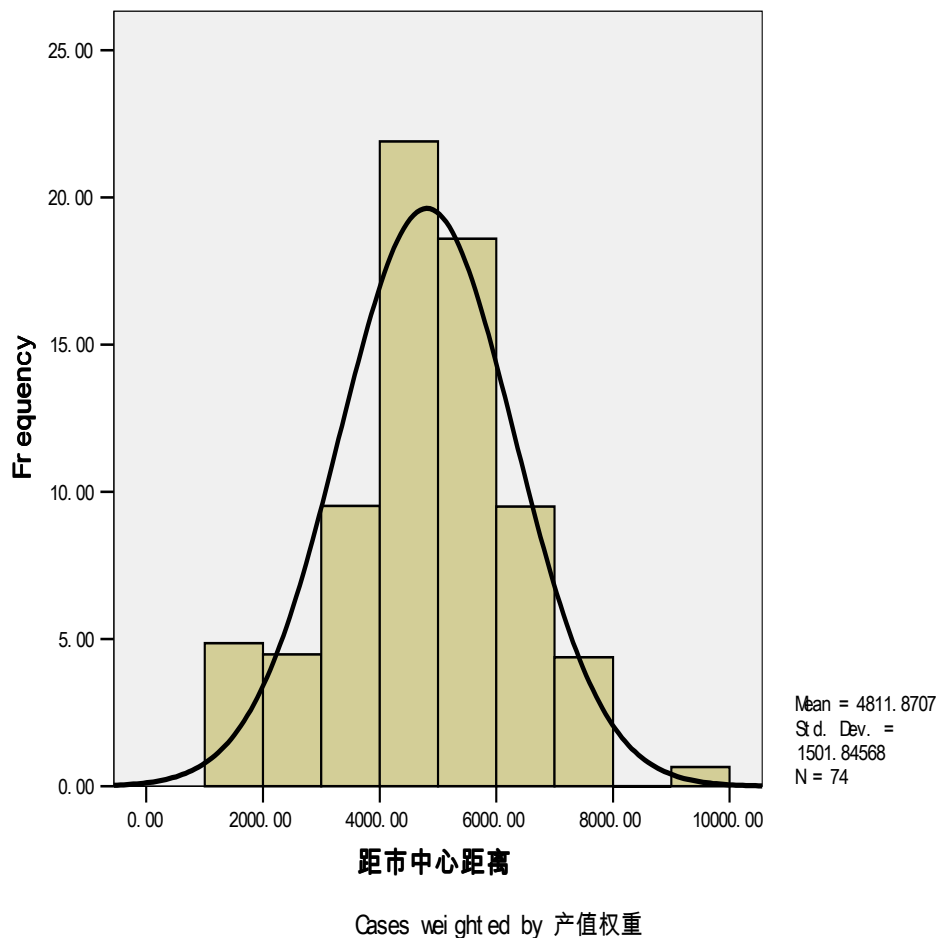
Fig.6 Analysis of the distance from the city center and the number of enterprises above designated size (2)

距市中心距离

Cases weighted by 产值权重

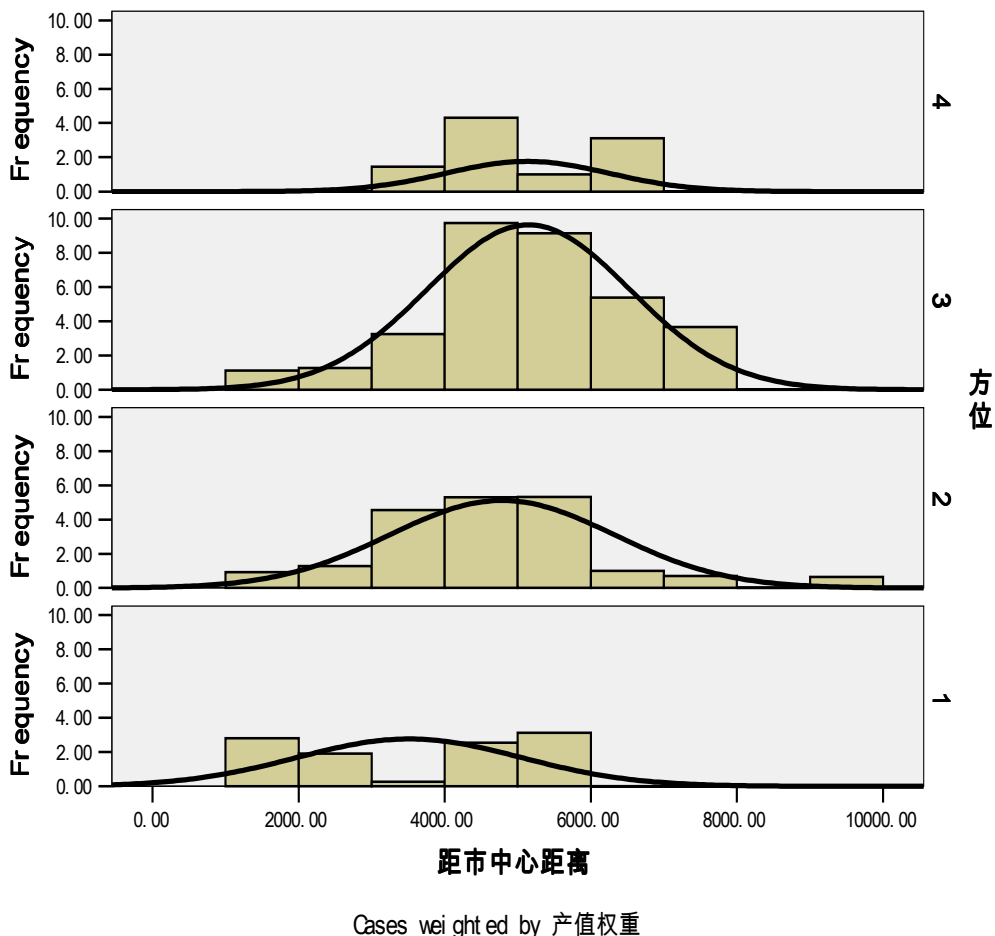**Fig.7 Analysis of the distance from the city center and the output value of enterprises above designated size (1)**

2.4.2 Analysis on the output value of enterprises above designated size and the distance from the city center

In Fig. 7, after the two special points are removed, the output values of enterprises are gradually increasing along with the increase of the distance from the city center, which are relatively large when the distance is 4 to 7 km from the city center, reach the climax when the distance is 6 km, and then falls afterwards.

Fig.8 Analysis of the distance from the city center and the output value of enterprises above designated size (2)

In Fig. 8, after the two special points (Nanning Cigarette Factory and Nanning Sugar Co. Ltd.) are removed, it can be seen that the output values of enterprises above designated size tend to distribute normally surrounding the city center.

Fig.9 Analysis of the distance from the city center and the output value of enterprises above designated size (3)

The explanation for each quadrant is as follows:

The first quadrant (northeast): the output values of enterprises above designated size are mainly distributed at a distance of 1 to 6 km from the city center, and there is a low point at the distance of 3 to 4 km.

The second quadrant (northwest): the distribution of output value ranks the second, a little lower than that in the third quadrant. The output values of enterprises above designated size are the largest when the distance is 4 to 6 km from the city center. The output value distribution in other areas is relatively balanced, but it is far lower than the peak value, demonstrating the feature of normal distribution. The Beihu Industrial Zone in the north and the Xijiao Industrial Zone in the west have a greater contribution, while the Nanning High-tech Industrial Development Zone which is located at a distance of 2 km from the city center has a smaller contribution.

The third quadrant (southwest): the distribution of output values is higher than the other quadrants. The output values of enterprises above designated size are mainly distributed normally at a distance of 2 to 8 km from the city center. It shows that the economic effect of

Jiangnan Industrial Zone is much higher than the other industrial zones, and that the Nanning Economic and Technological Development Zone which is located 7 km away from the city center has a limited contribution.

The fourth quadrant (southeast): there are a certain number of output values of enterprises above designated size distributed at a distance of 3 to 7 km from the city center, while there is almost no output value in the other areas.
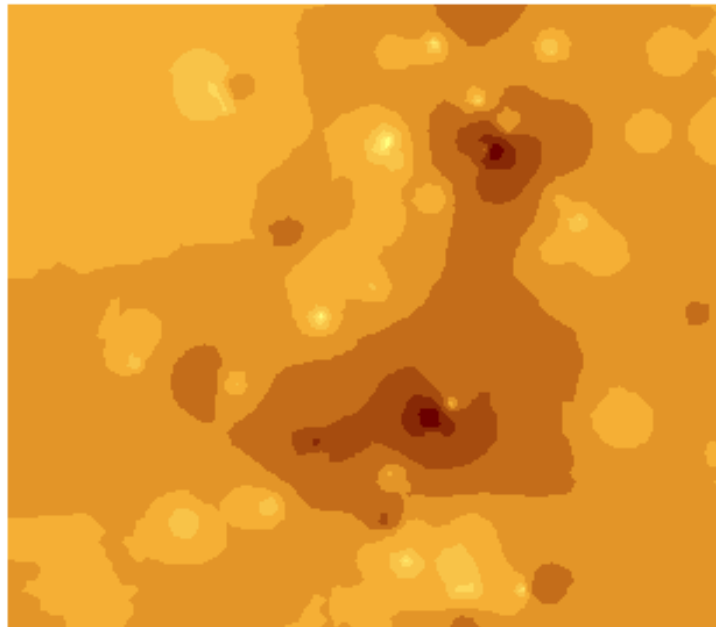

2.4.3 Study on spatial distribution pattern of output values of enterprises above designated size in Nanning City

The statistical processing is conducted by using the software of ArcGIS9.0 and Golden Software Surfer 8.0.

There are 153 enterprises above designated size in Nanning in 2003. After the enterprises which are not distributed in the municipal territory or whose data are incomplete are removed, 100 samples are finally collected. With the city center as the coordinate origin, the horizontal and vertical coordinate of each enterprise is measured, and the Z value is consequently got which refer to the output value of each enterprise.

After the data of the above-mentioned sample points are inputted in the software of ArcGIS, the spatial model for the distribution of output values of enterprises above designated size in Nanning is thus established.

Since the distribution of these enterprises is not balanced, the method of Inverse Distance Weighting (IDW for short) is first adopted to produce gridded data by interpolation. And the spatial distribution of output values of enterprises above designated size is then calculated

based on the data of these sample points[③].

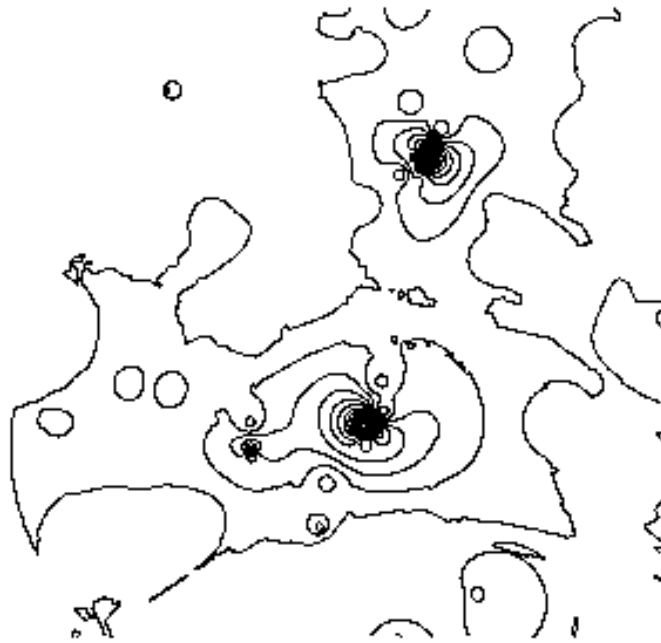**Fig.10   The outcome is as follows (see Fig. 10):**

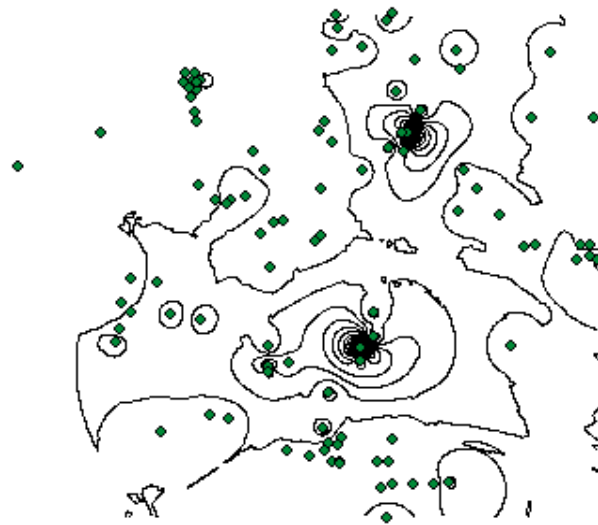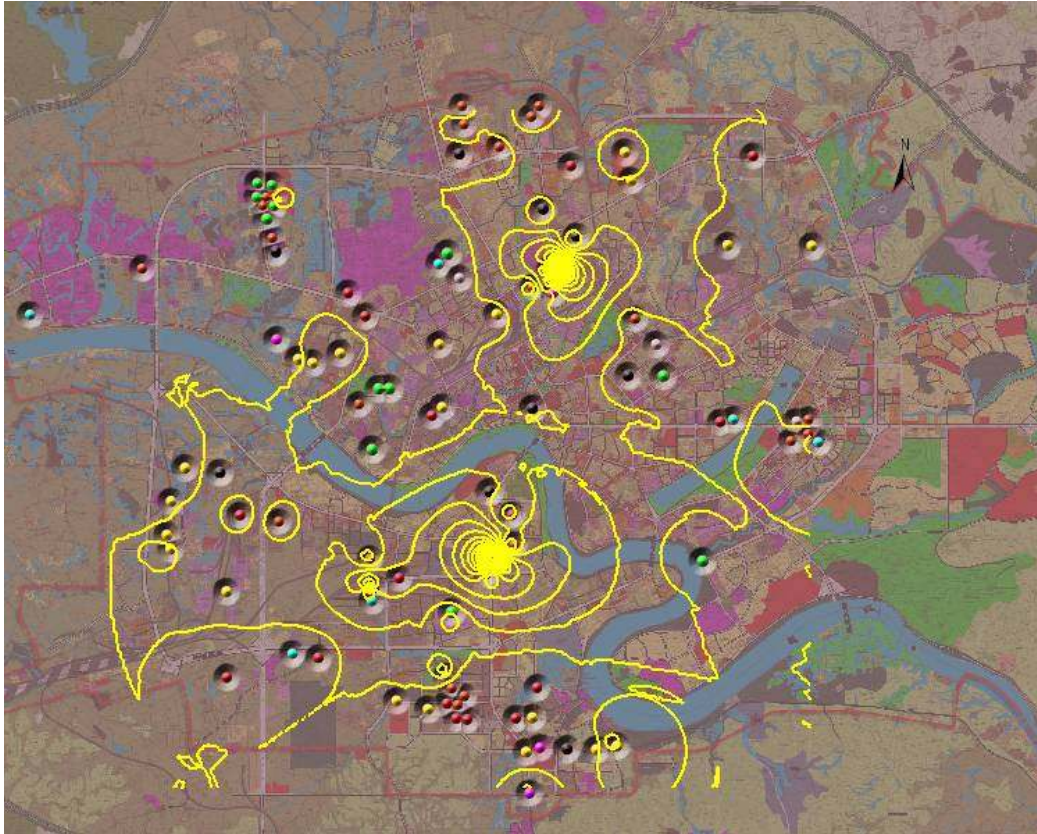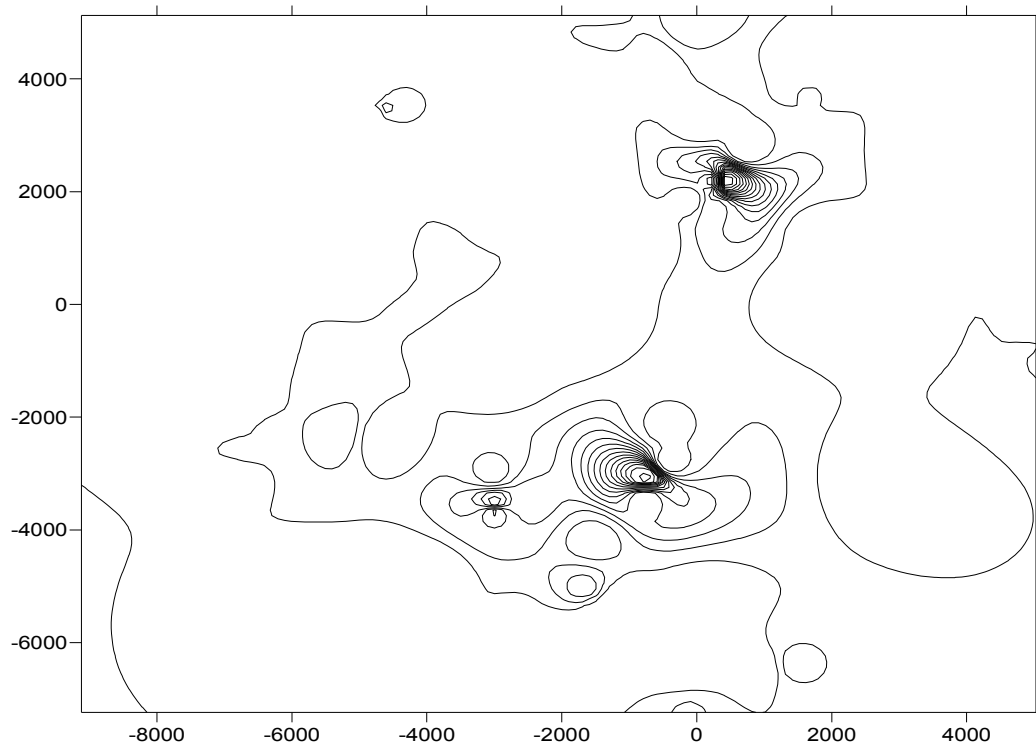**Fig. 11   The two-dimensional contour map (see Fig. 11):**

Fig.12   The relationship corresponding to the sample points (see Fig. 12):

Fig.13   After superposing to the map of Nanning City (see Fig. 13):

In Surfer 8.0, the method of IDW is also adopted to produce gridded data by interpolation,

thus getting the netting data⊕. According to the acquired data, the two-dimensional contour

map is then obtained (see Fig. 14), based on which the three-dimensional simulation map for the distribution pattern of output values of enterprises above designated size in Nanning is produced (see Fig. 18).
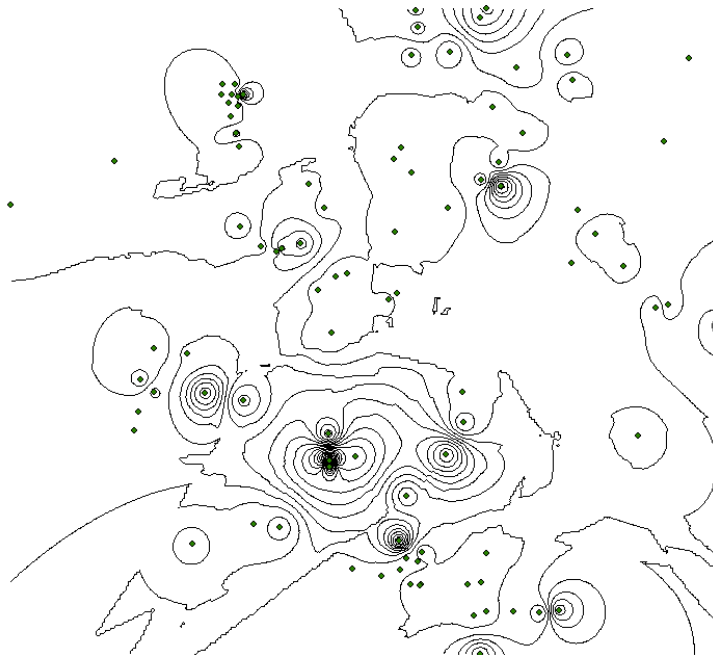
Fig.14

The analysis on the model is as follows:

In general, the spatial distribution of output values of enterprises above designated size is

rather imbalanced[⑤]. The main peak area of output values is concentrated in a reversed

L-shaped belt which runs from south-north to east-west. This belt is located in a range with the radius being 5 to 6 km from the city center. At the both south and north ends of this belt, two main peak areas are formed respectively at the distance of about 2 km north from the city center and 3 km south from the city center, with one being the Nanning Cigarette Factory and the other being Nanning Sugar Co. Ltd.. They are much higher than the other areas. The situation can also demonstrate the nature and feature of the leading industrial enterprises, i.e., the light industry which takes agro-forestry products as its material predominates in Nanning. There is a saddle-shaped valley between the two peak values, where the commercial center of the Old City is located. The other areas in the reversed L-shaped belt, the fluctuation of output values is comparatively stable and slow. Therefore, according to the spatial analysis, the Jiangnan and Beihu Industrial Zones which are formed historically still have strong vitality. The output values of enterprises above designated size, which are located in the state-level high-tech industrial development zone established in the north of the city in the 1990s and the state-level economic and technological development zone in the south of the city built in the same period, are not distributed in the peak area of the reversed L-shaped belt. It shows that these two development zones are still immature and that the high-tech industry is not in the leading status in the industrial structure of Nanning City.

Krugman ascribed the industrial concentration to a kind of historical haphazard. He held that the initial advantages were amplified due to "path dependence", which resulted in the "lock-in" effect; therefore, both the concentrated industries and the concentration locations possessed

the nature of "historical dependence". This placed the tradition comparative advantages in the subordinate position, i.e., the concentration of some industries in a certain area was not caused by the intrinsic advantages of the factors in this area. The close economic relationship instead of comparative advantages led to the concentration; while the technological outflow was the secondary factor for the concentration, because low-technology industries could also cause the concentration. In the areas where the initial conditions were similar, the distribution of economic flow was rather imbalanced, which was proved by the spatial distribution of enterprises' output values in Nanning City.
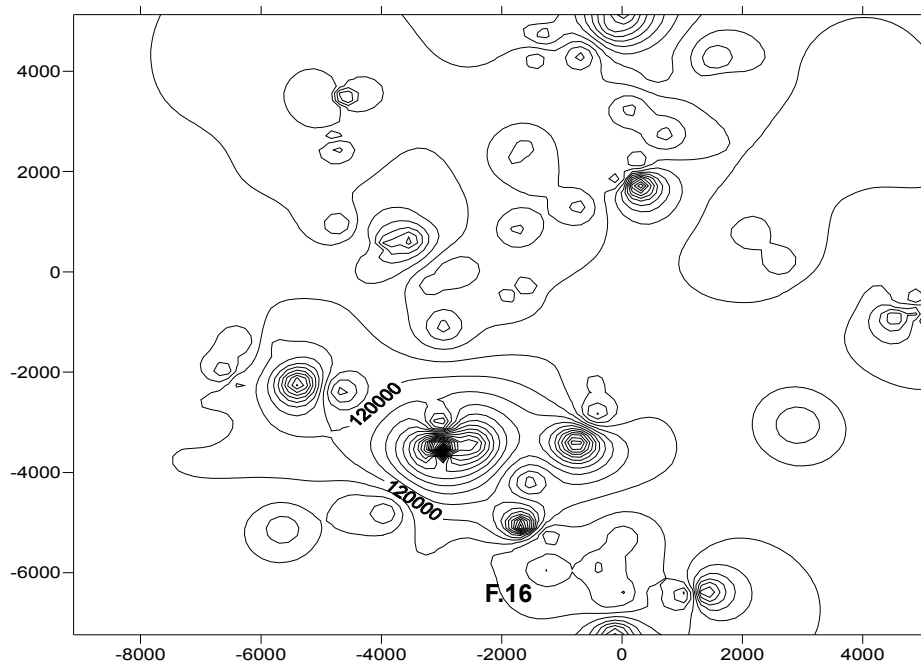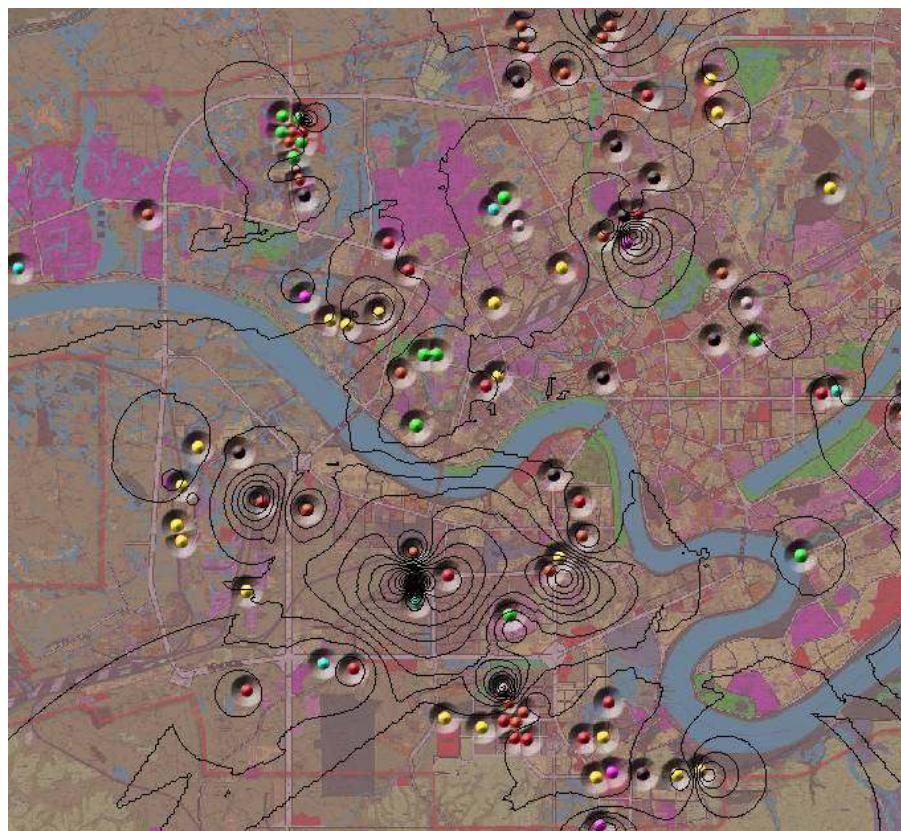

Fig.15

Fig.16

F.17

After the two main peak values are removed which are Nanning Cigarette Factory and Nanning Sugar Co. Ltd., the contour map of output values (see Figs. 13 – 17) and the three-dimensional map (see Fig. 19) are produced. It can be seen that regarding the spatial distribution of output values of enterprises above designated size in Nanning in the year 2003, except a peak in the north, the output values of enterprises are mainly concentrated in the Jiangnan Industrial Zone in the south, forming a peak value area surrounding which other small peak value areas are distributed. When the population flow is taken into consideration, it is clear that the concentration area of enterprises' output values is just where the inflow

intensity of workers is great©(NIU Xiong, 2005). It demonstrates that the spatial distribution of

output values is closely related to the inflow and outflow of population which is attracted by the employment opportunities. The concentration of industrial population is combined with the concentration of industries, which accumulates as the circulation goes. As a contrast, the output values of enterprises above designated size which are located in the state-level high-tech industrial development zone in the north and the state-level economic and technological development zone in the south of Nanning are not prominent in the three-dimensional map, and the high-tech industries have not formed the scale merit there. The above analysis proves that the selection of location in the planning at that time was improper and there lacked the theoretical guidance.
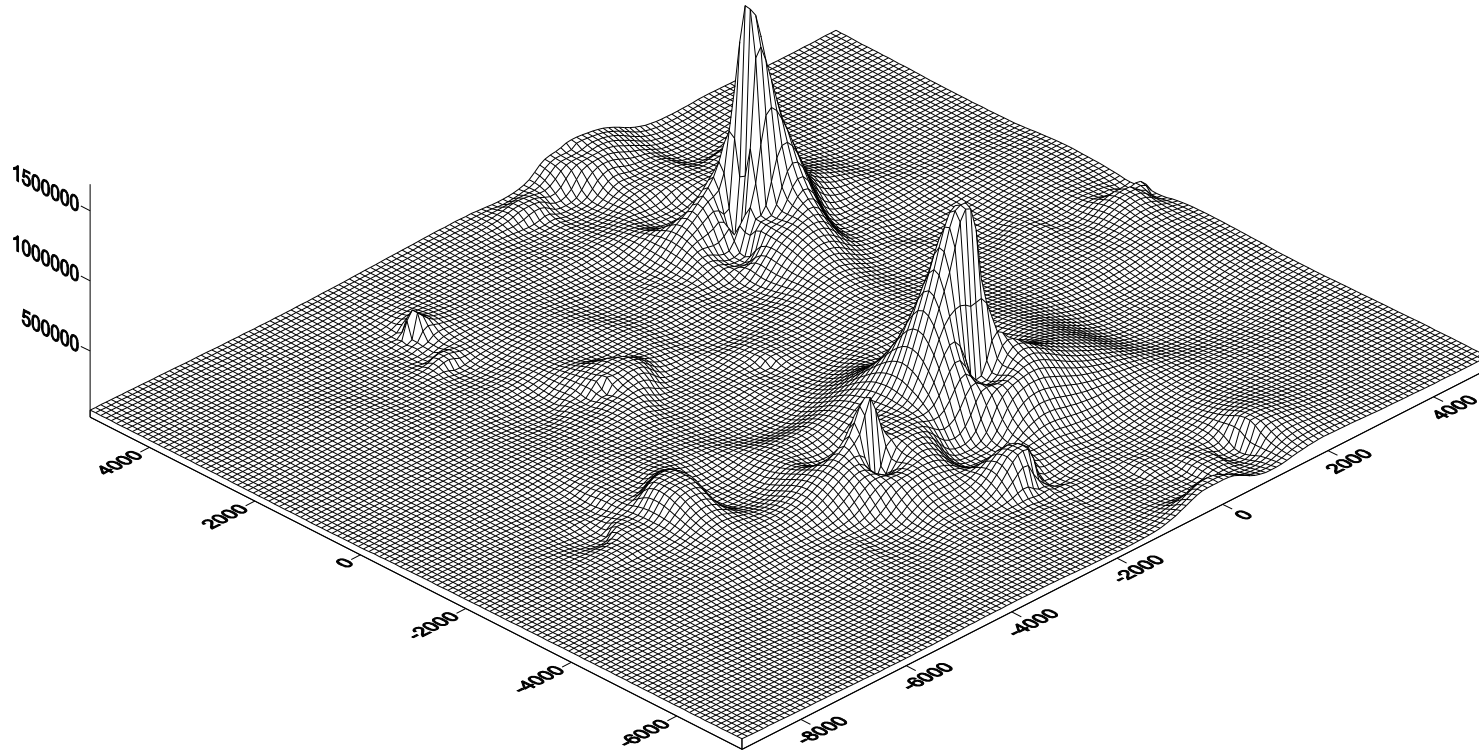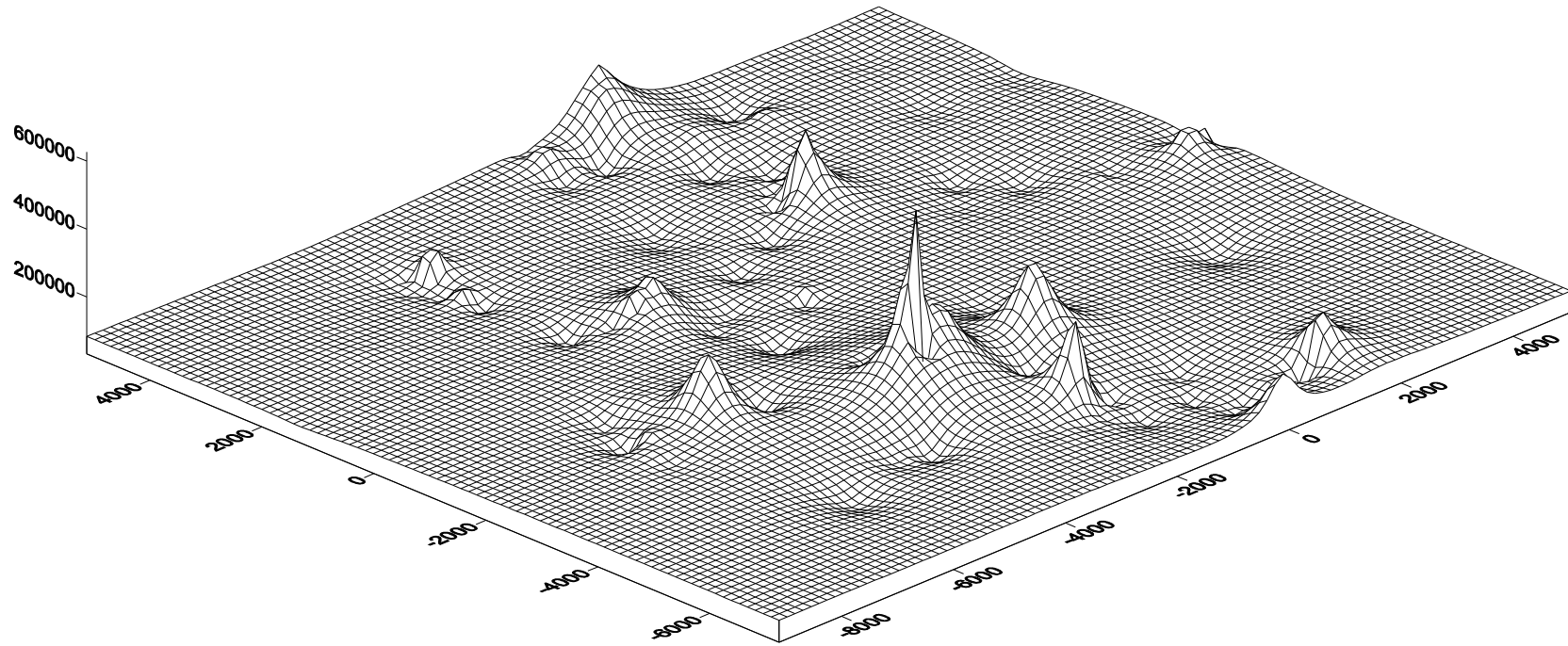
Fig.18

Fig.19

3. Discussion and conclusion

3.1 Discussion

Based on the above quantitative analysis, the distribution features of enterprises in Nanning can be summarized as follows:

(1) Its pattern is more influenced by the layout in the planned economy. Almost all of the large-scale enterprises are located in the Beihu, Xijiao, Hantang, and Jiangnan Industrial Zones which have been built successively since 1958. The enterprises above designated size are mainly distributed in a range of 2 to 8 km away from the city center. The number of enterprises reaches the climax at the distance of 6 to 7 km from the city center and then falls afterwards, demonstrating the feature similar to normal distribution. And the number of distribution is relatively large in the industrial zones in the north and south.

(2) With the introduction of market mechanism since the 1990s, the development speeds of the four tradition industrial zones have shown different features. The industrial and economic growth is concentrated in the northern and southern industrial zones, with Jiangnan Industrial Zones in the south having the highest efficiency where the main enterprises of Nanning are concentrated, which is accordant with the inflow intensity of industrial population. In contrast, the development of industrial zones in the west is comparatively slow.

(3) The concentration scale merit is not obvious in the newly-built state-level high-tech industrial development zone and the economic and technological development zone, the effect of technological outflow is not ideal, which demonstrated that the selection of location lacks the scientific and rational analysis and judgment.

The spatial distribution of enterprises is greatly affected by the historical inertia, which can be explained by the theories of Spatial Economics. The spatial location selected by enterprises is amplified due to "path dependence", resulting in the "lock-in" effect, which is then strengthened by the circulatory accumulation. Therefore, both the concentrated industries and the concentration location possess the nature of "historical dependence".

3.2 Conclusion

Through the case study on Nanning, an ordinary provincial capital city in West China, it can be concluded that although the market mechanism has been introduced here since the 1990s, the layout formed during the planned economy still have a great influence on the current industrial distribution in the city. Along with the introduction of market mechanism, the development speeds of the industrial zones have shown different features. The industrial and economic growth is still concentrated in the traditional industrial zones, where the economic efficiency is also high. As a contrast, the economic efficiency of the newly-built development zones is relatively low. According to the theories of Spatial Economics, the location of enterprises is amplified due to "path dependence", resulting in the "lock-in" effect, which is enhanced by the circulatory accumulation. As a result, both the concentrated industries and the concentration location have the nature of "historical dependence". Although there are policy and land advantages in the newly-built development zones, the concentration scale merit is not obvious. This demonstrates that the traditional theory of comparative advantages has played a secondary role. The concentration of some industrial in a certain area is not caused by the intrinsic advantages of the factors in this area. It is the close economic relationship rather than comparative advantages that leads to the concentration. The technological outflow is a secondary factor for concentration, and low-technology industry can

also form concentration.

Based on the above analysis, this paper concludes that in Nanning, the typical Chinese cities which are transforming from planned economy to market economy, the spatial distribution of enterprises is greatly influenced by the historical inertia, and path dependence is the major factor that affects the spatial distribution of enterprises and their output values, which demonstrates that the theories of Spatial Economics have important practical values in the developing countries like China.

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Notes:

① "Enterprises above designated size" refer to those whose annual output value is above five million yuan (RMB).

② IDW interpolation is a method to calculate the information of a certain point based on a group of known data. Specifically, suppose the information of Point A is unknown, but there is a group of known data in the area close to Point A. according to these data, a weight is assigned to each known datum point (the weight is determined by the distance of each point from Point A). Then, the information of Point A is calculated by using the weighted average method on the above data:

$$Z = \frac{\sum_{i=1}^{n} Z_i d_i^{-p}}{\sum_{i=1}^{n} d_i^{-p}}$$

"Z" represents the calculated value of Point A, "Z_i" is the information of each point close to Point A, "d_i" is the distance of each neighboring point from Point A, "p" is the weight parameter, "n" is the number of neighboring points.

In this case, the parameter set by the method of IDW in ArcGIS is as follows:
Selected Method: Inverse Distance Weighting
Method Parameter(s):
    Power: 1
Searching Neighborhood:
    Neighbors to Include: 15 (include at least 10)
    Searching Ellipse:
        Angle: 0
        Major Semiaxis: 4697.2
        Minor Semiaxis: 4697.2

     Sector Mode: 1

③ Every parameter is set as follows:

    Along the direction of X: space between – 100; number of rows – 142 (approximately);

    Along the direction of Y: space between – 100; number of rows: 125 (approximately);

    Weight: 1; smooth: 0; the rate of anoisotropy: 1; angle: 0; no search.

④ After calculation, the output values of 20% of the enterprises account for 62% of those of the total

100 enterprises.

⑤ NIU Xiong. Study on Spatial Structure of Mega City of Nanning amid Rapid Urbanization. Tsinghua

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