The Influence of Location on Rural Industrial Development in Beijing Suburbs : A GIS Analysis

Xiaoping Shen

Department of Geography ,Central Connecticut State University
165 Stanley Street, New Britain, CT 06050-4010

Abstract
Rural industrial development in Beijing suburban area has experienced a rapid growth since economic reforms. The spatial pattern of rural industrial development has been influenced by location factors that reflect market forces and government policies. Using GIS, this paper reveals an unbalanced spatial pattern of rural industrial development, and analyzes relationship between rural industrial development and location factors at township level in Beijing suburbs. The optimum location areas that are identified by major factors of industrial location theory have a high correlation with those towns and townships that have highly developed rural industry. This result shows a significant influence of market forces on the spatial pattern of rural industrialization in national capital region.

I. INTRODUCTION

China's fundamental reforms have changed economy from a completely centrally planned economy to a dual economy that includes planned and market economic sectors. Rural industry, the fastest growing market economic sector, has surpassed state-owned industry and become the largest industrial sector in China since 1993. 55% of total national industrial output was produced by rural industry in 1995. Different from state owned industries, decisions on rural industrial development are made by millions of individual enterprises based on profit, which is the first nation wide experience in China after 1949. On the other side, rural industrial development is still constrained spatially by government policies. That makes the experience of China's rural industrialization very different from those in market economies where individual entrepreneurs have more freedom on location selection.

Beijing is the national capital and the second largest metropolitan region with a large suburban area in China (Figure 1). There were 62,845 rural enterprises with 987,233 employees that accounted 15% of total employed population in Beijing in 1995 (CSSB. 1996). The output value of rural industry was 56 billion yuan in 1995, that accounted 3/4 of rural total social output and 1/5 of total industrial output in Beijing (BSB, 1996). Obviously, rural industry has become the major income source of suburbs and also an important industrial sector in Beijing. Compared to other provinces, Beijing's rural industry is highly developed, but its spatial distribution is very imbalance (Shen, 1995). The difference in the output between the developed towns and the backward townships is greater than 1500 times. Besides, Beijing's national capital's status and its local policies on decentralizing rural industry have made this study more interesting.

The purpose of the paper is to reveal the spatial pattern of rural industrial development, to analyze its relationship with location factors, and to identify the influences of market forces and government policies on rural industrial development in Beijing. Using Beijing's town and township level rural industrial output and regional characteristic data, this study tests two hypotheses that are incorporated location factors from the experiences of a market economy, such as agglomeration effects, and transportation costs. Most previous studies, such as Gu's book (1995) and Guo and Gu's article (1992), analyzed the relationship between rural industrial development and location factors using only statistical data aggregated at administrative level, but not factors with different spatial patterns and boundaries, such as transportation network, physiographic divisions, and population density. It probably is due to the lack of information and a good tool for the analysis, which may cause bias in results. Using statistical data, maps and GIS method, this study attempts to reveal the relationship between rural industrial development and location factors both statistically and spatially. The findings of the analysis provide us with a better understanding on the influences of market forces versus government policies on rural industrial development, and also on the applicability of industrial location theory, behaviour theory in a reforming dual economy.

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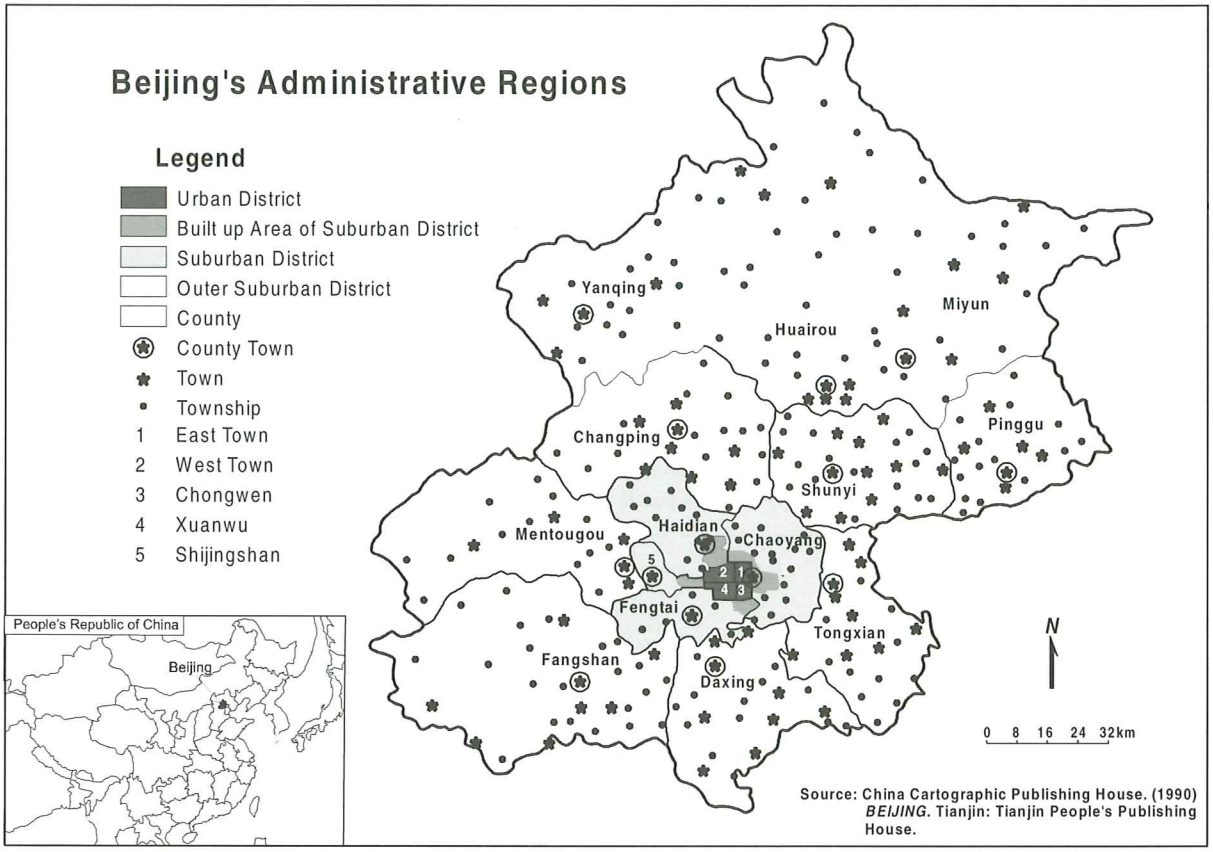

Figure 1. Beijing's administrative regions

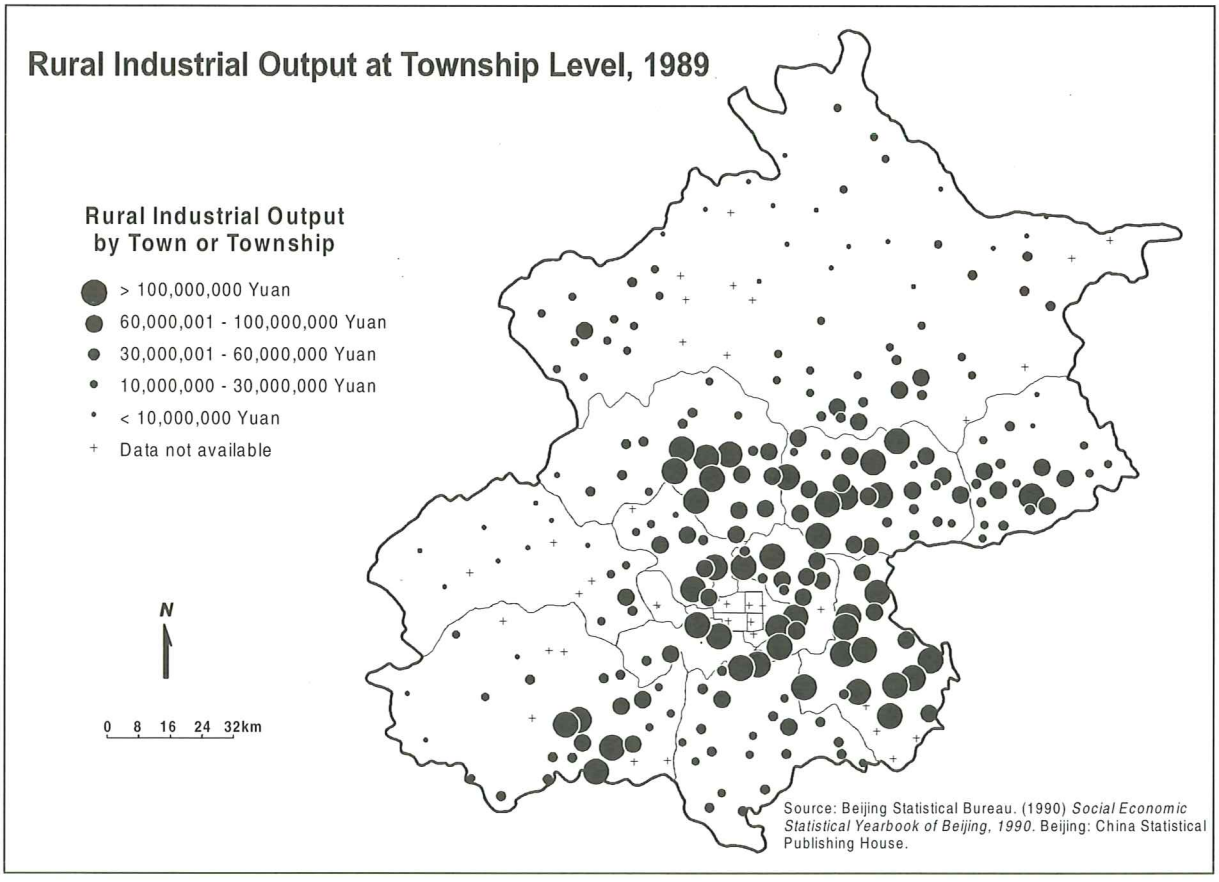

Figure 2. Rural industrial output at township level, 1989

II. RURAL INDUSTRIAL DEVELOPMENT AND GOVERNMENT POLICIES

China's rural enterprise is defined as the enterprise owned by peasants or agricultural residents collectively, jointly, and privately (CSSB. 1988). This is different from those in other countries who define rural industry by location, scale, and industrial sectors (Austin, 1981). "The status of agricultural or non-agricultural residents is determined at birth according to household registration (*hukou*) regulations" (CSSB. 1988). The region where agricultural residents live is mainly in rural area, market town, part of designated town (*jianzhizhen*), and part of suburban districts. Since a change in residential status is difficult in China, the definition implies that China's rural industry can be any size including large scale enterprises, can produce any industrial products, and can employ full time workers who still keep their agricultural resident status. Being the national capital and large metropolitan region, Beijing has the most strict *hukou* system that not only controls the change of the status from agricultural to non-agricultural, but also controls the movement of residents from outer suburbs to suburbs.

Different from state owned industries, rural industrial production is adjusted by market demand, and their survival depends on profit. They can make decisions for themselves, which most state-owned industries could not, on opening, closing, changing product, hiring, layoff, and deciding employee's salary and bonuses. Although rural industry has existed since the foundation of the People's Republic of China, it has been always outside the central plan and considered as "the second economy in China" (Los, 1990). From 1949 to 1978, rural industry was not allowed to exploit centrally controlled resources (which included most major resources), to produce certain kinds of products and sell them in centrally controlled commercial channels.

Owing to its market characteristics, it was considered as "the capitalist tail" and strictly constrained, if not prohibited, during the decade of Cultural Revolution (Ho, 1995; Zhu and Feng, 1995). Since the market oriented economic reforms started in 1978, Chinese government has adopted many favourable policies to encourage the development of rural industry in order to absorb surplus rural labour released by family responsibility system, and also to fill the gap between demand and supply. Rural industry has become the fastest growing industrial sector since then and has even become the largest industrial sector since 1993. There were 69.6 million labourers worked in rural industry in 1994, which accounted for a 350% increase since 1980. Although half of the rural industrial enterprises are collectively owned or directly and indirectly managed by township or village government, their raw materials are purchased on the market, their productions are adjusted by market conditions, and their survivals depend on profit (Zhang *et al.*, 1994; Shi, 1996). Its market economic characteristics were clearly stated in a government document that the major reason for rapid rural industrial development is "its sole responsibility for its profits or losses (*zifu yingkui*)" (Central Committee, 1984). Rural industrial development, its spatial distribution, and its relationship with regional characteristics reflect the spatial behaviour of market economy in China's mixed market and planned economy. Analysis at provincial level has displayed a close relationship between rural industrial development and regional characteristics (Shen, 1998), Beijing's case study will provide an empirical understanding of this interesting phenomenon at regional level.

Although Chinese government has adopted many favourable policies to encourage rural industrial development, China's rural industrial policy has strict controls on rural industrial location. Before 1984, rural industry was only allowed to be built within the rural community where the owner lived. This has been relaxed since 1984, rural industry is allowed to be built in the rural community or in a market town near his community, but it is still not allowed to be built in a city proper (State Council, 1984). The best expression of the policy is the government slogan "leave the land but not the countryside, enter the factory but not the city *(litu bu lixiang, jinchang bu jincheng)*". The location of rural industry is also linked with its level of ownership. Village and lower level enterprises usually located on village land, and township enterprises are usually situated in the township seats (Ho, 1994). The rural industrial location policy works with China's urbanization policy that has strict controls on migration from the backward regions to the developed regions, from small cities to large cities and from rural to urban areas. Both policies constrain labour and industry within the relative closure of a rural region and wish to achieve the control on the growth of large cities, to minimize the burden of urban population and infrastructure, to encourage the accumulation from a rural region to be reinvested in the region. Being the national capital and large metropolitan region, Beijing government not only implements those policies strictly, but also issues its own policy to decentralize rural industries: horizontal economic co-operation *(hengxiang jingji Lianhe)*. The policy requires state-owned firms to help remote rural areas to initialize or develop rural industries in their community through subcontracting mature products, transferring second hand equipment, providing technical support, etc. The policy also offers incentives, such as tax ex-

emption, for those horizontal co-operated enterprises. The policy mobilized about 10,000 engineers and experts to help rural industry in 1987 and continued the efforts since then (Huang, 1987). Under this situation, the rural industry in Beijing should be more evenly distributed in the rural area than in other municipalities and provinces. In fact, rural industrial distribution is very unbalanced spatially (Figure 2). Most towns and townships with high rural industrial output value mainly located either near urban centre or in southern and southeastern Beijing. The highest output at township level was 357 million yuan and the lowest output was 0.18 million, the difference was greater than 1500 times in 1989. The driving forces that cause this distribution will be next discussed.

III. LOCATION THEORIES AND HYPOTHESES

Industrial location theory has discussed the relationship between profitability of an industrial plant and location factors, such as transportation, labour, and market. A number of authors have also explored the idea that agglomeration effects, including inter-industry linkages and sharing of well developed infrastructure, can result in higher productivity for plants located in some large urban-industrial complex if that urban center is not over congested (Hayter, 1997; Martin, *et al.* 1993; Shen, 1987; Moomaw, 1983). Using multiple variables, Smith (1981) developed a space cost curve to identify a profitable, or optimum, location area for an industrial plant. If a plant is located within the optimum area, the plant can be profitable and growing. Otherwise, it may lose money, lose competitiveness, and eventually go out of business due to high initial investment for infrastructure, high transportation cost, high utility charge, high labor cost, etc. Friedmann (1966) pointed out that investors seek out locations with good accessibility to markets, other industrial firms, transportation network, and urban services to minimize their production cost. In market economies, entrepreneurs (particularly those who build large plants) usually conduct feasibility study before building their new plants in order to locate their plants in the profitable, or optimum, location area. However, there are always factories that locate outside of the optimum location area and resulted in higher cost. In long run, the factories within optimum location areas have much better chance to survive and grow. As discussed above, location factors play the role as factors of natural selection to all of industrial plants on determining winners and losers in space.

Different from those plants in market economies, China's rural industrial enterprises have much less spatial freedom on seeking a suitable location. They are constrained not only by government policies on rural industrial locations, but also by their own knowledge about other regions. Therefore, when rural industrial entrepreneurs want to build a plant, they just build it within their township or in a market town near their home in most cases, no matter if the location is good or not for that particular product. Among those millions of new plants, some of them are located within profitable or optimum location area by luck, others are not. No matter where they are located, they are facing the same market competition, which is similar to those plants in market economy, and their survivals depend on profitability of their products. This made the assumption valid that the location factors that influence profitability of plants in market economy also influence the development and distribution of China's rural industry. Since China's rural industries do not choose their locations as most entrepreneurs do in other countries, the location factors influence rural industrial development in the way that enterprises happened to locate within the optimum location areas have better chance to survive and grow. As a result, the spatial distribution of the survival enterprises should reflect the optimum location areas in the region. Behaviour theory has explained this as: a large number of individuals making random decisions at a certain time, the spatial distribution of the survival firms over time should represent viable or even optimum location pattern, even if the decision makers themselves do not know the location conditions of success or try to achieve them by changing locations (Alchian, 1950; de Souza, 1990). The spatial pattern of Beijing's rural industry today is a result of a large number of individuals making random decisions over the last two decades. Moreover, it is the first nation wide industrialization that left the decision to millions of individual plants after the foundation of the People's Republic of China in 1949. As discussed above, after two decades of natural selection by location factors in Beijing, the spatial distribution of surviving and growing rural enterprises should reflect the optimum location pattern at certain level. This research intends to reveal the relationship between location factors and the spatial distribution of rural industrial enterprises by comparing the results between a deductive study of optimum location areas selected by location factors and an inductive study of the existing spatial pattern of rural industry in Beijing.

There are some contributions to the literature on regional differences in rural industry or rural economy at the regional level, either within a province or a smaller region. Gu (1995) mapped Beijing's towns and townships with rural industrial output over 100 million-yuan. He found the decline of rural industrial output from suburbs to outer suburbs and a concentrated zone between 8 and 25 kilometres from the ur-

ban centre, but no further analysis on those townships inside the zone with low output and those outside the zone with high output. Besides distance, there was no detailed discussion on the influence of other location factors. Guo and Gu (1992) investigated the spatial distribution of township industry in Shanghai's suburban area using county level data. They also reported a declining trend from suburbs to outer suburbs and an increasing inequality between suburbs and outer suburbs from 1980 to 1985. Because they use aggregated county level data, only 10 county level units were discussed. Regional differences within a county were masked, and the relationship between rural industrial development and the influences of location factors was only discussed in general. Ho (1994) analyzed rural non-agricultural development in Jiangsu province based on a detailed survey data, but spatial issue was only discussed briefly. Other publications such as Powell's (1984) "the rural economy on the urban fringe: Nanjing municipality - production possibilities, management forms and commercial accessibility", Lo's (1989) "analysis of the spatial restructuring of rural region in Zhujiang Delta", Veeck and Pannell's (1989) "rural economic restructuring and farm household income in Jiangsu province" dealt with spatial issues of rural economic reforms. Rural industrial development has been discussed in those articles as one of the rural economic activities, not the focus of the research. The distribution of rural industry in local areas has also been mentioned by some researchers, such as Pang (1991), Liu (1990), but no in depth analysis has been done on this issue. Some other works on small town development have partially included or mentioned this issue (Tan, 1990; Liu, 1990; Lo, 1989). Despite the volume of research on rural industrial sectors, little if any in depth and comprehensive work had been done on the relationship of rural industrial development with location factors at township level in Beijing. This probably is due to lack of information and limitation of statistical method.

This research attempts to reveal the spatial pattern of rural industrial development in Beijing, and the influences of location factors on rural industrial development. Two hypotheses will be tested: first, as a market economic sector, rural industrial development is driven mainly by market forces not by government policies. This implies that the location factors, which influence profitability of plants in market economy, affect rural industrial development and distribution in Beijing as well. Second, since the development of China's rural industry is the result of a large number of individual decisions over a period of time, and their survivals depend on profit, the spatial distribution should represent viable or even optimum location patterns at certain level. In other words, location factors play a key role on determining winners and losers of rural industrial development, although rural industrial entrepreneurs have no spatial freedom to select optimum locations for their plants. Because economic circumstances present the opportunities and also impose limits to profitability of plants, there is a prior ground for expecting plants develop more in certain area, profitable or optimum location, than the others. The profitable, or optimum, location varies from plant to plant due to many internal factors, such as products, scale, and technology. But in general, most industrial firms will be more profitable at a location that has a low cost good land, more surplus and skilled labour, a higher agricultural productivity, an easy access to a large market, industrial infrastructure, transportation facilities, and urban services. Most factors discussed above are the agglomeration effects or external economies that firms benefit from areal concentration of industrial activities (Smith, 1981). This theory has been supported by many studies in market economies (Moomaw, 1983). This paper tests applicability of the theory on rural industrial development in Beijing by identifying optimum areas for rural industrial development using those location factors and then analyzing the relationship with actual distribution of rural industries.

IV. STUDY AREA

Beijing is a large metropolitan region that covers 16,809 square kilometres area and has a varied topography. The mountainous region in Beijing covers 62% of the area, and 38% of Beijing's area is an alluvial plain. Figure 1 shows Beijing's administrative regions. There are four urban districts, six suburban districts, and eight counties. The urban built up area of 395.4 square kilometres includes four urban districts and partly suburb districts, and is shown as darker shades in Figure 1. The built up area forms the regional core of Beijing municipality. There are about three million agricultural residents (about 30% of total population) live in 77 towns and 209 townships. Town and township are the lowest level of government in China's administrative hierarchy. Two type towns, county town (*xiancheng)* and town (*zhen)*, can be identified in Figure 1. County town is the town that county government is located, and in most cases the largest town in the county. Township is a community that could have a smaller built up area (market town) surrounded by rural areas or can be a completely rural community.

V. DATA AND METHOD

The data used in this research are the rural enterprise output, other statistical data, and the census of popu-

lation data. Output data is collected and published yearly by different level's government statistical department. Although the precision of the statistics is not discussed in the statistical books, the interviews during the fieldwork in Beijing however verified the statistical relationships and gave some information about the data. According to managers of enterprises, officers of township industrial departments and county and city industrial departments, the output data are usually more precise than other data such as cost and profit. Because many small rural enterprises do not have professional accountants, some financial data are not very carefully recorded, but the output of production can usually be reported close to the real value. In some cases, the output data are even more precise than employment data due to the usage of part time workers and seasonal operation. Since the output data are acceptable, and profit or income data are not available, the rural industrial output is used to measure general achievement and overall scale of industrial production. Another dataset used in the research is the census of population. China held its fourth population census on July 1, 1990. The results were published after 1991 (NOCPUSCC, 1993). The quality of the census was very good especially for the total population that is the data used in the analysis (BCPO, 1991).

The major base map used in the research is 1:600,000 topographic map published by China Cartographic Publishing House in March, 1990. The information plotted on the map was dated March 1989, fortunately, which matches the time period when the rural industrial output data and population data were available. Other maps such as 1:800,000 administrative map, 1:800,000 geomorphology map, 1:800,000 highway system map, and 1:800,000 railway network map supplement the analysis (EDBPC, 1988).

The combination of available data sets and base maps makes a GIS analysis possible. GIS is a very suitable tool for identifying the relationships among regional characteristics that have different spatial units and boundaries. Using location factors and GIS method, this research identifies optimum areas for rural industrial development in Beijing, then studies the relationship between the optimum areas and rural industries of towns and townships. A statistical analysis on the output data from GIS analysis provides a quantitative result in addition to the visual result produced by GIS analysis.

VI. ANALYSIS

Although Beijing's rural industry is highly developed and Beijing is not a big region, the spatial distribution of rural industry in Beijing is very unbalanced. The tax and profit of rural industry per rural capita is gradually decreasing from suburban districts, counties on the plain, to counties in mountainous region. Most suburban districts, such as Haidian, Fengtai, Shijingshan, Mentougou, and Fangshan, have higher tax and profit value than counties that are farther away from urban centre. Counties, such as Miyun, Huairou, Yanqing in the mountainous region have the lowest tax and profit per rural inhabitant (BSB. 1990).

At the town and township level, the unbalanced distribution of rural industry is showed more clearly (Figure 2). Generally speaking, most towns and townships in suburban districts have more developed rural industry; the towns and townships in the counties closer to the central urban area, especially in the east and southeast of Beijing, also have more developed rural industry; mountainous region in the north and west Beijing has the lowest rural industrial development level. In addition, most county towns and towns have higher rural industrial output than townships. The unbalanced distribution of rural industrial output within county is also shown on the map. Some counties such as Tongxian and Shunyi are more evenly distributed than the others. How this distribution correlates with the location factors will be next analyzed.

Selection of Optimum Areas for Rural Industrial Development

Five categories of location factors are included according to the hypotheses. They are (1) market orientation, (2) accessibility to transportation system,

Table 1. Location Factors

Category	Location Factor
Market Orientation	Population Density
Accessibility to	Highway System
Transportation System	Railway Network
	Physiographic Division
Industrial Development	Industrial Output
Agricultural Development	Agricultural Output per Rural Worker
Proximity to an Urban Centre	Distance from Urban Centre
	Near a County Town or a Town

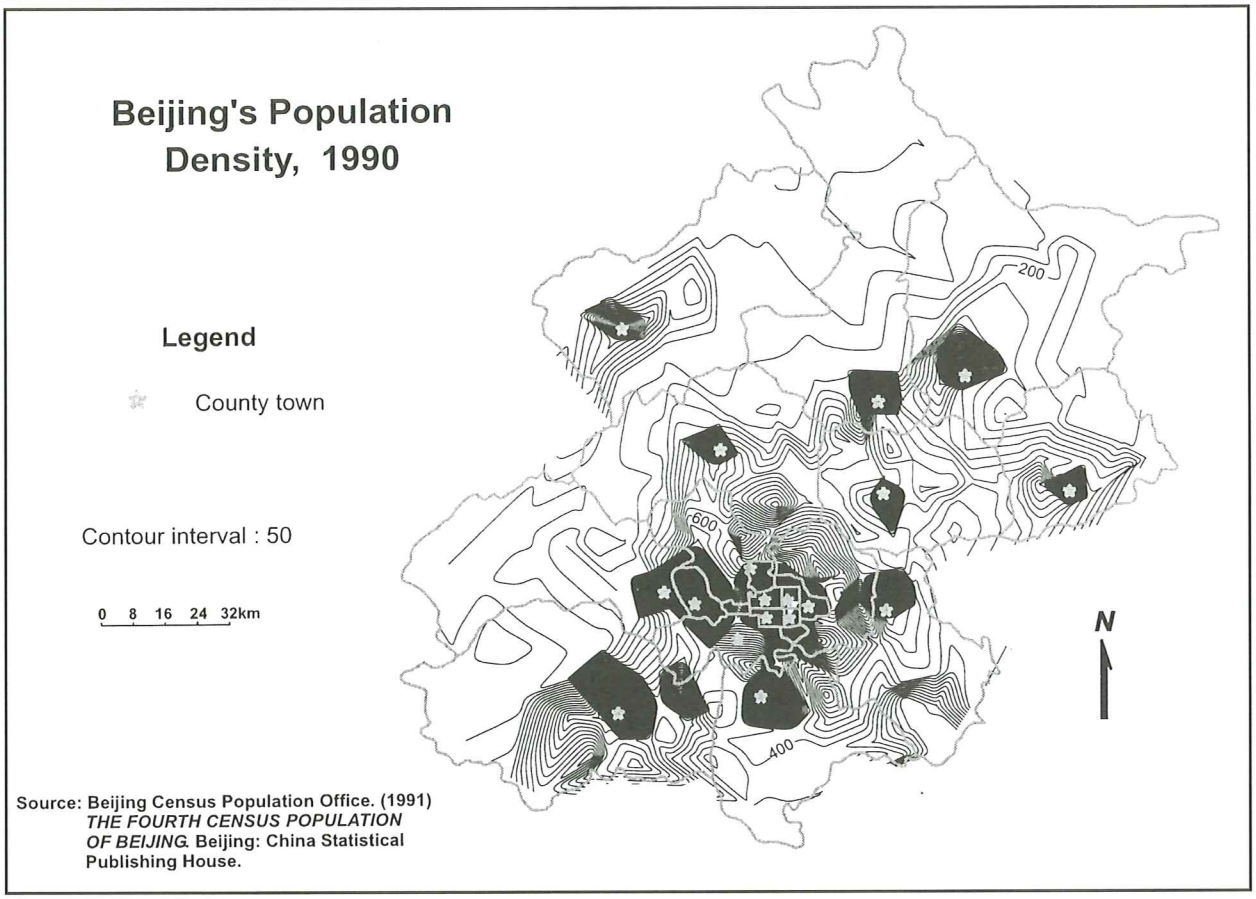

Figure 3. Beijing's population density, 1990

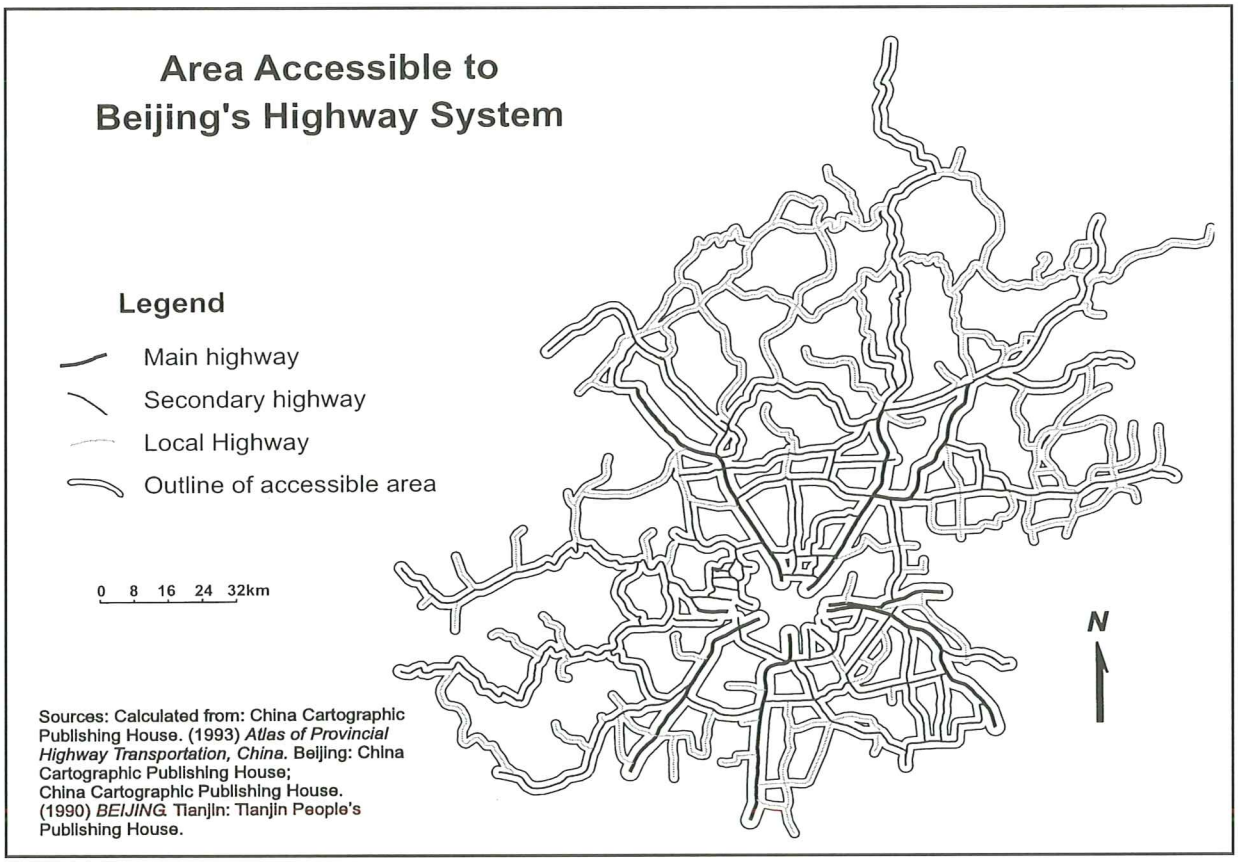

Figure 4. Area accessible to Beijing's highway system

(3) industrial development, (4) agricultural development, and (5) proximity to an urban centre. Since this study deals with the entire rural industrial sector, the location factors above are factors of external economy that can influence cost of a plant based on accessibility to market, transportation network, infrastructure, and services. In other words, these factors represent agglomeration effects. The location factors that represent those five general categories are listed in Table 1 and discussed one by one in following section.

Population Density

Population density is one of the most important indicators in economic analysis. Since household income data are not available at township level, population density is used to represent market and labour force potential. According to the Fourth Census of Population, 10.8 million people lived in Beijing in 1990 and 30% of them were classified as rural population. Figure 3 displays a very uneven distribution of population density in Beijing in 1990. The most densely populated area in Beijing is the downtown area that is about 25,000 to 30,000 people per square kilometre that places a central gravity to the whole region. Most county towns have higher population density than the surrounding areas and smaller towns. The population density in county towns is about 600 people per square kilometre. The sparsely populated area is in the mountainous region. The population density can be as low as 30 people per square kilometre.

Transportation Accessibility

Transportation accessibility has significant influence on industrial development because every factory needs to bring in raw materials and ship out products, especially when the factory serves the market larger than its local community. Beijing's rural industry today is no longer a local product producer. It manufactures raw materials from all over the country, involves in services of the national market, and even enters the competition of international market. The export value counted about 15% of total rural industrial output in Beijing in 1995 (DREMAC. 1996). Transportation clearly plays an important role in Beijing's rural industrial development. Three indicators are used to represent various aspects of this category.

Beijing has a highly developed highway system (Figure 4), the highway density in Beijing municipality was 0.56 km/km^2 in 1989, and it was the highest in the whole country at provincial level (including Shanghai and Tianjin municipalities) (CSSB. 1990). Unpaved local roads and urban streets are not included in the research. The area accessible to the highway system is identified by a buffer analysis. The accessible distance is an empirical value, it was determined by the rural industrial entrepreneurs during the author's fieldwork in 1991.

The railway is the most important transportation facility for both passenger and freight at the medium and long distance in China. Although railway transport is not that important within Beijing municipality, some peripheral areas still benefit from the railway, and is therefore included. Figure 5 shows the railway network in Beijing. The area accessible to railway network is the area close to railway stations.

Physiographic indicator is included in this category, because the accessibility of a location is influenced by its topographic characters. Highways in the mountainous areas may close more often for maintenance during the raining and snowing seasons; the speed limit in mountainous area is also lower than that in the flat area. Railway transportation is in the same situation. Topography also influences industrial land use, market, and population density, that has been shown clearly in the population density map (Figure 3). It also influences the suitability of certain regions for industrial development, e.g. slope, drainage, water supply, etc. The physiographic divisions are shown in Figure 6. The mountainous region covers the area at high elevation (500-1500 metre) with deep slopes and small level areas. A smooth terrain includes the area with a high elevation (about 1000 metre) but relatively large area of flat land. This type of area is usually the local centre in mountainous area, e.g. Yanqing county town. The alluvial plain is a very flat area that lies at 50-100 metre elevation. Beijing's urban centre and most county towns are located in this area. Since Beijing does not have a large water surface except for three reservoirs, water areas are classified as reservoirs.

Proximity to an Urban Centre

As indicated above, there are three levels of urban centres in Beijing. They are central urban centre, county town, and town. The central urban centre's influence can be observed everywhere in Beijing. The linear distance from the urban centre was considered as a major factor for rural industrial development in suburbs (Gu, 1995; Guo and Gu, 1992). This research divides Beijing into 6 concentric zones by the distance from the urban centre. The first 5 zones are in 10 kilometres increment from the urban centre, the sixth zone is the area beyond 50 kilometres from the urban centre (Figure 8). The county towns and towns are the local nucleus and influence rural industrial development in its surrounding area. The influenced

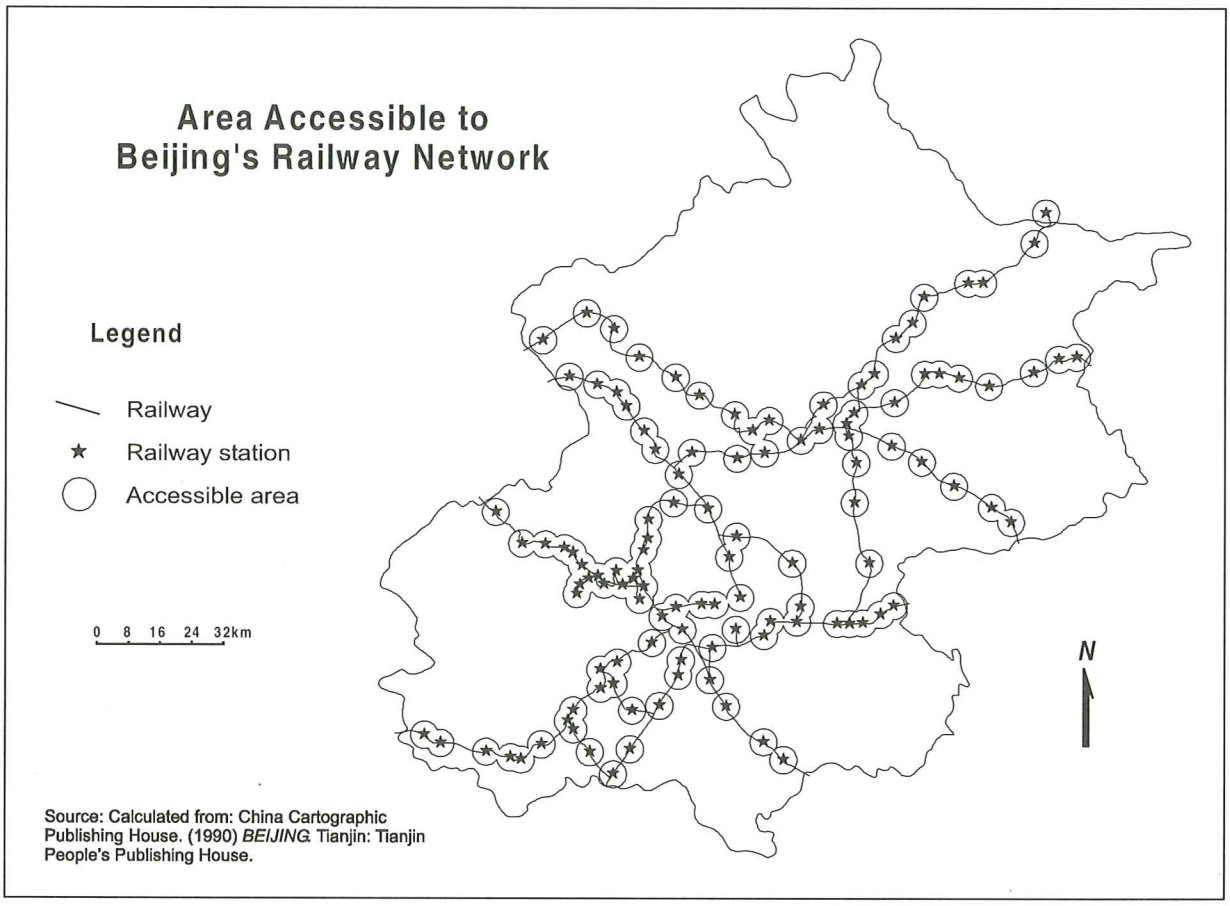

Figure 5. Area accessible to Beijing's railway network

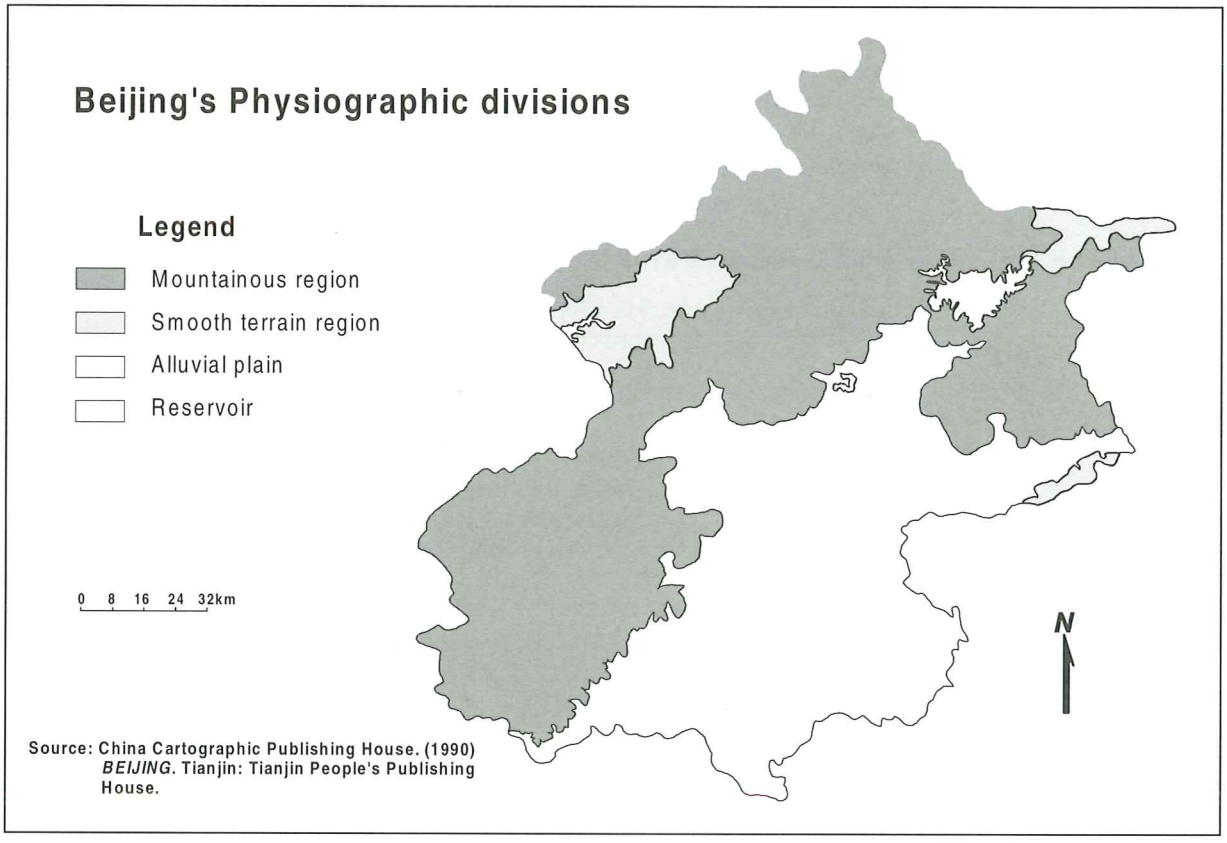

Figure 6. Beijing's physiographic divisions

areas of a county town and a town are identified.

Urban Industrial Development

Urban industrial output reflects the local industrial development level and industrial infrastructure in the region. Rural industry in the same region can benefit from urban industry both by subcontracting, technical support, sharing of industrial infrastructure, and availability of skilled labour force. Considering that about half of rural enterprises are producing parts and providing services for urban industry, the relationship between rural industry and urban industry is very important (Gu, 1995). Beijing's urban industrial output data are only available at the county level. As a general indicator, it is accepted. Figure 7 shows Beijing's urban industrial output. The largest industrial output can be found in suburban districts and Fangshan where Beijing Yianhua Petrochemical Company is located. Downtown Beijing districts are at the second level, and the third level includes counties in the southeast of Beijing. The lowest level of industrial production is observed in mountainous counties.

Agricultural productivity

Agricultural productivity is important to provide initial funds, surplus labour, and resources to rural industry. The relationship between agricultural development and rural industrial development will be tested. Agricultural output per rural worker at the county level is displayed by Figure 7. The regions with the highest output are three suburban districts and two counties, Changping and Shunyi. The lowest levels of agricultural output can be found in mountainous areas.

Criteria of the Optimum Location for Rural Industrial Development

GIS map overlays have been conducted for all of eight location factors. The optimum areas for rural industrial development are selected according to the criteria in Table 2. The distance from urban centre are added to the final map after the selection of optimum areas, in order to test the influences of the selected optimum areas and the distance on rural industrial development.

VII. RESULTS

The final result of the GIS analysis is shown on Figure 8. The optimum areas for rural industrial development coincide with the rural industrial output. The optimum level 1 covers 1,897 square kilometres which is about 11% of Beijing's area. The optimum level 2 area covers 2,154 square kilometres, and is about 15% of Beijing's area. The rest of the area in Beijing is classified as the area outside the optimum areas and occupies about 74% of total Beijing's area. The concentric circles indicate the distance from urban centre. These circles further divide each optimum level into 6 zones.

Observing the towns and townships at the top three levels' rural industrial output on Figure 8, the relationship between rural industrial development and optimum areas can be seen clearly. Most of towns and townships with over 100 million Yuan output (output level 1) located in the level 1 optimum areas, and most of the second level's towns and townships (output between 60 and 100 million yuan) located in both level 1 and level 2 optimum areas. The third level's rural industries located mostly in level 2 optimum areas and some of them out of the optimum areas.

Table 2. Criteria of Optimum Area for Rural Industrial Development

Level 1:
1. Population density over 400 per square kilometre
2. Physiographic division is plain
3. Accessible to main highway or secondary highway
4. Urban industrial output is higher than 800 million Yuan
5. Value of agricultural output per rural worker is higher than 3,200 Yuan
6. Near a county town is included in this level even it does not meet the criteria above

Level 2:
1. Physiographic divisions are plain or smooth terrain areas
2. Population density is 200 - 400 people per square kilometre
3. Accessible to secondary highway or local highway
4. Accessible to railway station
5. Urban industrial output is higher than 235 million Yuan
6. Value of agricultural output per rural worker is higher than 2,200 Yuan
7. Near a town is included in this level, even it does not meet the criteria above

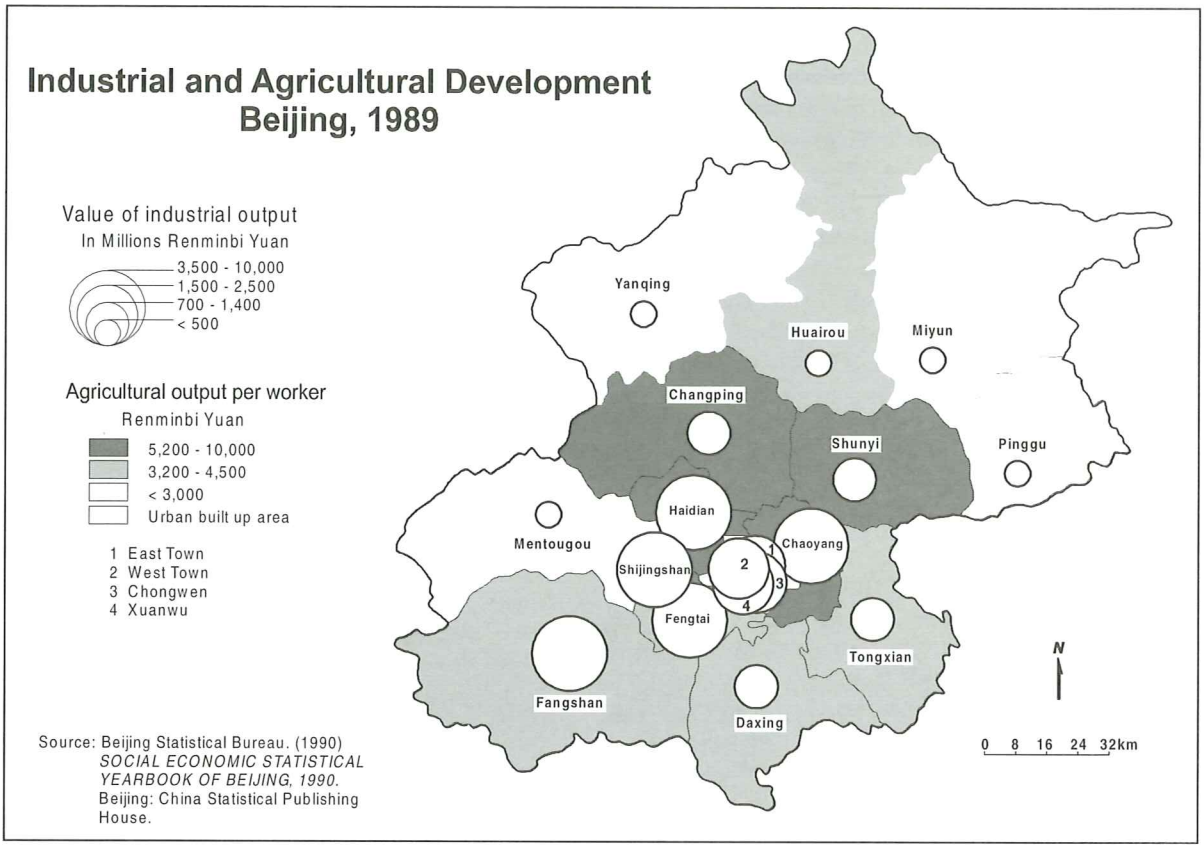

Figure 7. Industrial and agricultural development, Beijing, 1989

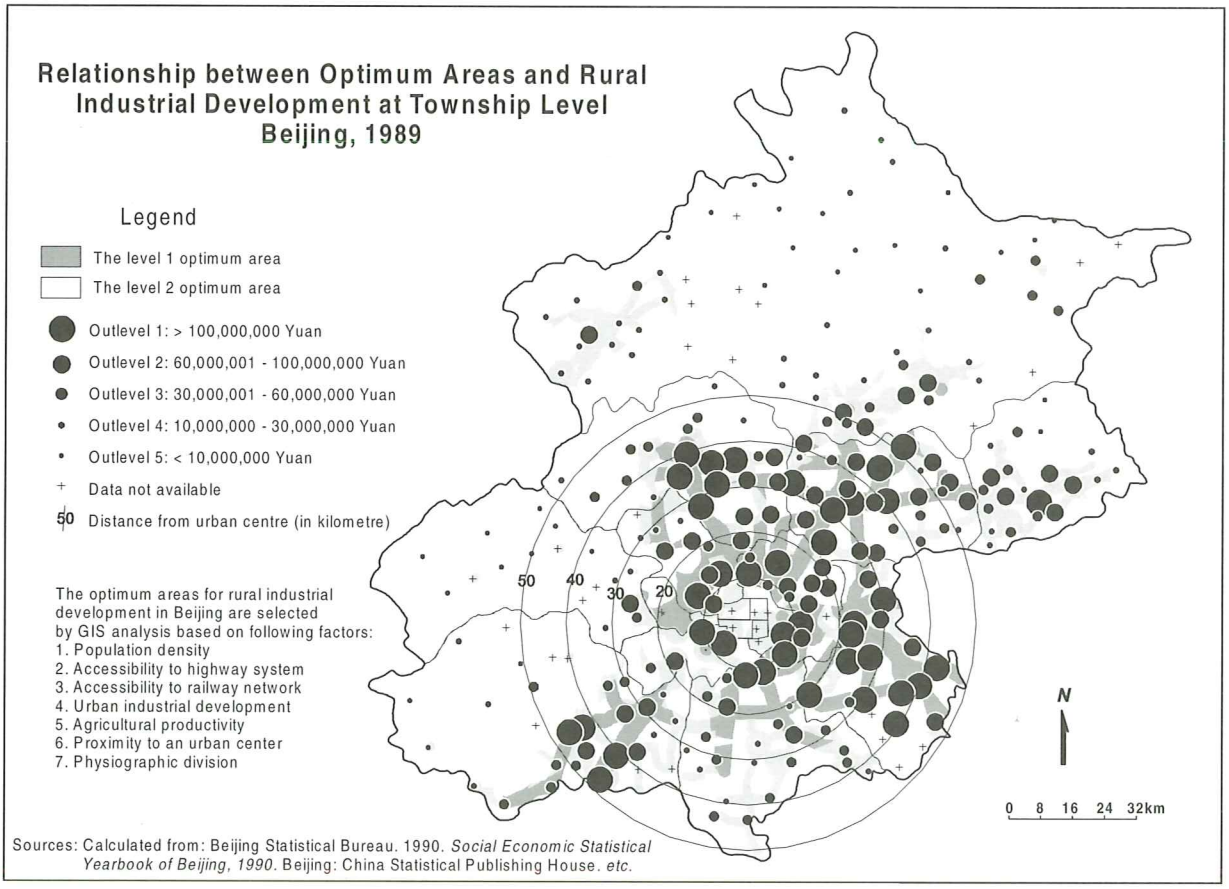

Figure 8. Relationship between optimum areas and rural industrail development at township level, Beijing, 1989

The statistics obtained from the GIS analysis give a more detailed picture of the relationship that exists between rural industrial development and regional actors. Two-way frequency analysis has been done, and the result is shown in Table 3. Three optimum levels are included in the table, 1, 2, 3 represents the optimum level 1, level 2, and the area outside the optimum areas. Five rural industrial output levels that include all of town and township level units on Figure 8 are in the table. They are OUTLEVEL (Output Level) 1 to 5, OUTLEVEL 1 represents the highest output, over 100 million yuan. The classification of the five output levels is the same as shown on Figure 8. The correlation between the rural industrial output and the optimum areas is shown very clearly in the table. In 1989, 78% of the highest level's rural industries were located in the level 1 optimum area, 17% of them were located in the level 2 optimum area, and only 5 percent were out of the optimum areas. On the other side, 93% of the lowest level towns and townships with industrial output less than 10 million yuan were located out of the optimum areas, and 7% of them were located in the level 2 optimum area, but none of them were located in level 1 optimum area. The percentage of rural industries located in the level 1 optimum area decreases very quickly from 78.05% of OUTLEVEL 1 to 0% of OUTLEVEL 5. But the percentage of rural industries located out of the optimum areas increases quickly from 4.88% of OUTLEVEL 1 to 93.1% of OUTLEVEL 5. The middle level's rural industries such as OUTLEVEL 3, OUTLEVEL 4, located in the level 2 optimum areas more than other areas.

This result supports the hypothesis that the distribution of rural industries in Beijing represents a viable or even optimum location pattern, although the individual entrepreneurs did not try or were not allowed to change locations to achieve the location conditions for success. The obvious spatial concentration of rural industry and strong correlation with location factors show that rural industrial development is influenced by market forces more than government policies, that attempt to decentralize rural industrial development, even in the highly controlled national capital region.

The influence of each location factor on rural industrial development has been tested during the selection process of optimum areas. This provided a better understanding of the relationship between rural industrialization and regional characteristics in Beijing. Among those location factors, two of them, population density, and areas accessible to highway system, have more influence on rural industry than others. This result indicates the strong market bias of rural industrial distribution in Beijing.

Table 3. Two Way Frequency Table, Rural Industrial Output by Optimum Location Area.

OUTLEVEL / OPTIMUM	1	2	3	Total
1	32	7	2	41
	13.62	2.98	0.85	17.45
	78.05	17.07	4.88	
	45.07	7.78	2.70	
2	24	19	7	50
	10.21	8.09	2.98	21.28
	48.00	38.00	14.00	
	33.80	21.11	9.46	
3	12	34	9	55
	5.11	14.47	3.83	23.40
	21.82	61.82	16.36	
	16.90	37.78	12.16	
4	3	28	28	59
	1.28	11.91	11.91	25.11
	5.08	47.46	47.46	
	4.23	31.11	37.84	
5	0	2	28	30
	0.00	0.85	11.91	12.77
	0.00	6.67	93.33	
	0.00	2.22	37.84	
Total	71	90	74	235
	30.21	38.30	31.49	100.00

STATISTICS FOR TABLE OF OUTLEVEL BY OPTIMUM

Statistic	DF	Value	Prob
Chi-Square	8	140.153	0.000
Likelihood Ratio Chi-Square	8	143.650	0.000
Mantel-Haenszel Chi-Square	1	19.574	0.000
Phi Coefficient		0.772	
Contingency Coefficient		0.611	
Cramer's V		0.546	

Sample Size = 235

Note: Levels of optimum location area are shown by columns. 1, 2, 3 represents the level 1 optimum area, the level 2 optimum area, and the area outside the optimum areas.
Outlevel 1 to Outlevel 5 are represented by 1 to 5 rows. Outlevel refers to the rural industrial output level of town or township. See Figure 8 for the value range.

The proximity to a county town or a town, also has obvious influence on the rural industrial development. All of the county towns and over 60 percent of towns have a high level of rural industrial development (OUTLEVEL 1 or OUTLEVEL 2), but only 29 percent of townships are at the high level rural industrial output categories. This distribution reflects the core periphery hierarchy in Beijing and the hierarchy is reinforced because the rural industry adds higher output to local cores but not to the peripheries.
The influence of distance from urban centre is tested by 18 optimum location zones. The rural industrial output level of towns and townships within a zone is reported in Table 4. A three-digit code is used to index

Table 4. Two Way Frequency Table: Rural Industrial Output by Optimum Location Zone

OUTLEVEL / Frequency / Percent / Row Pct / Col Pct	ZONE 110	120	130	140	150	160	210	220	230	240	250	260	310	320	330	340	350	360	Total
1	2	7	5	10	6	2	2	1	3	1	0	0	0	0	0	1	1	0	41
	0.85	2.98	2.13	4.26	2.55	0.85	0.85	0.43	1.28	0.43	0.00	0.00	0.00	0.00	0.00	0.43	0.43	0.00	17.45
	4.88	17.07	12.20	24.39	14.63	4.88	4.88	2.44	7.32	2.44	0.00	0.00	0.00	0.00	0.00	2.44	2.44	0.00	
	66.67	50.00	38.46	45.45	60.00	22.22	66.67	16.67	18.75	8.33	0.00	0.00	0.00	0.00	0.00	14.29	10.00	0.00	
2	0	5	5	6	4	4	1	2	3	3	1	9	0	2	4	1	0	0	50
	0.00	2.13	2.13	2.55	1.70	1.70	0.43	0.85	1.28	1.28	0.43	3.83	0.00	0.85	1.70	0.43	0.00	0.00	21.28
	0.00	10.00	10.00	12.00	8.00	8.00	2.00	4.00	6.00	6.00	2.00	18.00	0.00	4.00	8.00	2.00	0.00	0.00	
	0.00	35.71	38.46	27.27	40.00	44.44	33.33	33.33	18.75	25.00	7.69	22.50	0.00	100.0	66.67	14.29	0.00	0.00	
3	1	2	1	5	0	3	0	3	5	4	10	12	0	0	1	0	5	3	55
	0.43	0.85	0.43	2.13	0.00	1.28	0.00	1.28	2.13	1.70	4.26	5.11	0.00	0.00	0.43	0.00	2.13	1.28	23.40
	1.82	3.64	1.82	9.09	0.00	5.45	0.00	5.45	9.09	7.27	18.18	21.82	0.00	0.00	1.82	0.00	9.09	5.45	
	33.33	14.29	7.69	22.73	0.00	33.33	0.00	50.00	31.25	33.33	76.92	30.00	0.00	0.00	16.67	0.00	50.00	6.12	
4	0	0	2	1	0	0	0	0	5	4	2	17	0	0	1	4	1	22	59
	0.00	0.00	0.85	0.43	0.00	0.00	0.00	0.00	2.13	1.70	0.85	7.23	0.00	0.00	0.43	1.70	0.43	9.36	25.11
	0.00	0.00	3.39	1.69	0.00	0.00	0.00	0.00	8.47	6.78	3.39	28.81	0.00	0.00	1.69	6.78	1.69	37.29	
	0.00	0.00	15.38	4.55	0.00	0.00	0.00	0.00	31.25	33.33	15.38	42.50	0.00	0.00	16.67	57.14	10.00	44.90	
5	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	1	3	24	30
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.85	0.00	0.00	0.00	0.43	1.28	10.21	12.77
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.67	0.00	0.00	0.00	3.33	10.00	80.00	
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.00	0.00	0.00	0.00	14.29	30.00	48.98	
Total	3	14	13	22	10	9	3	6	16	12	13	40	0	2	6	7	10	49	235
	1.28	5.96	5.53	9.36	4.26	3.83	1.28	2.55	6.81	5.11	5.53	17.02	0.00	0.85	2.55	2.98	4.26	20.85	100.00

Note:
In the table the hundredth number indicates the optimum level selected by the other seven location factors, e.g. 100 is for optimum level 1 area and 200 is for optimum level 2 area. The tenth number indicates the maximum distance from urban centre. For example, 20 indicates the zones that lie between 10 to 20 kilometres from urban centre. 60 is the number for all of areas beyond 50 kilometres from urban centre, e.g. 160 represents the optimum level 1 area that is more than 50 kilometres away from urban centre.
Outlevel 1 to Outlevel 5 are represented by 1 to 5 rows. Outlevel refers to the rural industrial output level of town or township. See Figure 8 for the value range.

each zone. The hundredth number indicates the optimum level as above discussed, e.g. 100 is for optimum level 1 area and 200 is for optimum level 2 area. The tenth number indicates the maximum distance from urban centre. For example, 20 indicates the zones that lie between 10 to 20 kilometres from urban centre. 60 is the number for all of areas beyond 50 kilometres from urban centre, e.g. 160 represents the optimum level 1 area that is more than 50 kilometres away from urban centre.

The study has found that relationship between linear distance from urban centre and rural industrial output is not as strong as the optimum areas selected by other location factors. The towns and townships in the top two output levels were quite evenly distributed among distance zones within level 1 optimum area. That means the areas that meet those location criteria are very suitable to rural industrial development no matter what linear distance they are from urban centre. The impact of distance is mostly shown by low output level towns and townships (outlevel 4 and 5). None of those low output towns and townships was located within 20 kilometre radium from urban centre. In other words, the rural industries located near urban centre had better chance to grow. Over 85% of the towns and townships with the lowest output level (OUTLEVEL 5) were located more than 50 kilometres away from urban centre. Among them, 93% were out of the optimum areas. This again shows strong correlation between rural industrial development and the location factors. Table 4 shows a gradual decline of output level away from urban centre. The high output towns and townships were mainly concentrated within 10 to 50 kilometre zones, although they are better correlated with optimum areas than distance zones. The areas within 10 kilometre radium are mostly urban districts and urban built up areas. As discussed above, rural industry is not allowed to be built in urban districts, therefore, only a few rural towns and townships located in the areas have rural industry. The division between high and low output towns and townships at 25 kilometre radium that Gu (1995) found using 1991 data does not appear in this study using 1989 data. The output produced by towns and townships located within 25 kilometre radium was only 31% in 1989. That is less than half of 84% that was reported by Gu (1995) using 1991 data. If this tremendous change is not caused by calculating method, the changing concentration occurred during the two year period can be a very interesting issue.

The urban industrial development and agricultural productivity do not show very significant influence on rural industry, the aggregated county level's data are partly responsible for that, even though, urban industrial output shows better correlation with rural industry than agricultural output per rural worker. This result indicates that rural industry is a market oriented economic sector more than an agricultural product processing industry. Rural industrial development does not depend on the funding accumulated from agricultural output and the income from rural industry is seldom reinvested into local agricultural production, although this has been one of the government objectives for developing rural industry.

VIII. CONCLUSION

Beijing's case study has given a clear picture on rural industrial development in China at regional level. Rural industrialization in Beijing is driven mainly by market forces. Its behaviour obeys market rules. Its spatial distribution is influenced by location factors more than government policies, even though Beijing's government had special policy to promote rural industrial development in remote rural areas.

The spatial analysis of Beijing's rural industrial development reveals the influences of the location factors on the spatial pattern of market economic development in China's reforming economy. The hypotheses tested in the research are the theories and experiences drawn from a market economy, and supported by Beijing's rural industrial development case. Using GIS, this study identifies the optimum areas for rural industrial development by the real spatial form (point, line, and area) of location factors. The high correlation between the optimum areas and the developed towns and townships shows the applicability of industrial location theory on Chinese market economic development.

Among eight location factors analyzed in the study, accessibility to transportation network, particularly highway system, and population density are the most important factors on determining optimum areas for rural industrial development. Proximity to an urban centre and industrial development level can be ranked third after transportation and population density. The factor of near a county town or a town improves overall correlation by adding more weight to the administrative centres in rural area, which appears to be important. Next factor is urban industrial output, although its influence on rural industry in this case study may not reflect its real influence due to the aggregated data at county level. Linear distance from urban centre is one of factors that influence suburban rural industrial development, however, it is shown clearly by this research that linear distance from urban centre is much less important than the other factors above. Therefore, it is important to be aware

of possible bias that may be caused by using linear distance as the only location factor on suburban rural industrial development study. Agricultural development is the least influential factor in this case study partly due to the aggregated data also.

Considering that 55% of the total national industrial output was produced by rural industry in 1995, what appears clear is that the Chinese economy has become a dual economic system, and market force is playing a more and more important role in China's economic development and spatial distribution.

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