City Economical Function and Industrial Development: Case Study along the Railway Line in North Xinjiang in China

Cai-ping Chen[1]; Yong-jian Ding[2]; and Shi-yin Liu[3]

Abstract: The area along the North Xinjiang Railway (ANXR) is the region with industry concentration and is the most convenient communication region in the Xinjiang Uygur autonomous region. There are nine cities and eight counties in the region. This paper analyzes the economical functions and industry of the cities in the region from the following aspects: urban scale, the growth pole level, specialization sectors, and the difference of industry gradients using the principal component analysis, cluster analysis, and method of location quotient methods. These analyses clearly indicate the urban function of each city in ANRX at present and find disadvantages of similar urban functions. The results released three modes of industry collaboration for urban development in the coming years, which will provide some references for urban planning in equivalent areas.

DOI: 10.1061/(ASCE)0733-9488(2008)134:4(153)

CE Database subject headings: Urban development; Case reports; China; Rail transportation.

Introduction

The area along the North Xinjiang Railway (ANXR) has become a leader in the economic development and urbanization of the Xinjiang Uygur autonomous region (hereafter referred to as Xinjiang), making a great economic contribution to northwest China. A series of papers (Fu and Ren 1995; Liu 1995; Li et al. 2002) have studied industrial structure and urbanization in the area. These studies emphasized only the aspect of economic development, but did not consider each city's function in the region area.

In fact, a large number of studies, such as those of Fujita (1991), Mouleart et al. (1991), Pandit (1991), Meyer (1991), Begg (1993), Harris (1943), Nelson (1955), and Berry (1972), have broadly documented the urban function from different aspects. The industrial function of a city is reflected by three factors, i.e., specification sectors, intensity of function, and scale of function (Zhou and Bradshaw 1988; Zhou and Sun 1997). Applying this theory to urban function study in ANXR, this research will illustrate the urban developing trends by studying the urban scale, radicalizations, and driving to regional economy and specialization sectors. This paper made a rational division of urban economic function and industrial structure to give some proposals to optimizing urban function allocation, which may provide reference or suggestion as well as practical applications.

[1]Ph.D. Student, Cold and Arid Regions Environmental and Engineering Research Institute, CAS, No. 260 Donggang West Rd., Lanzhou 730000, China (corresponding author). E-mail: caipinglz@163.com

[2]Professor, Cold and Arid Regions Environmental and Engineering Research Institute, CAS, No. 260 Donggang West Rd., Lanzhou 730000, China. E-mail: dyj@lzb.ac.cn

[3]Professor, Cold and Arid Regions Environmental and Engineering Research Institute, CAS, No. 260 Donggang West Rd., Lanzhou 730000, China. E-mail: liusy@lzb.ac.cn

Note. Discussion open until May 1, 2009. Separate discussions must be submitted for individual papers. The manuscript for this paper was submitted for review and possible publication on October 10, 2006; approved on March 11, 2008. This paper is part of the ***Journal of Urban Planning and Development***, Vol. 134, No. 4, December 1, 2008. ©ASCE, ISSN 0733-9488/2008/4-153–158/$25.00.

This paper is organized as follows: First, we describe the status quo of the urban economy in the area studied. Then, in the origin of data and method are introduced followed by a presentation of the results of our research. Finally, we summarize the results and clarify what we might do in the future.

Description of Study Area

The ANXR is located in the pluvial and alluvial fans at the north slope of the Tianshan Mountains in China. ANXR is about, 1,000 km from eastern Mori country to western Wenquan country (Xie 1998). It covers an area of approximately 92,000 km^2, accounting for 19.16% of the whole Xinjiang area (Statistical Bureau of Xinjiang 2005). In 2004, the urban population of ANRX was 4.96 million with 58.58% urbanization level. The ANXR is about 25.64% of the whole population and 9.13% of the land area in Xinjiang. The statistical results show that the region contributed to 47.55% of the gross domestic product (GDP) and 70.21% of the gross industrial output value of Xinjiang (Statistical Bureau of Xinjiang 2005). The study zone consists of 17 cities and counties along the North Xinjiang Railway, including Urumqi, Karamay, Shihezi, Kuitun, etc. (Xie 1998), which are the main cities of economic contribution and development of all of Xinjiang (Fig 1). Up to 2004, there were three municipalities (Urumqi, Karamay, Shihezi); three cities at prefecture level (Changji, Bole, Fukang); three cities at county level; and over 50 towns along the railway in north Xinjiang (Statistical Bureau of Xinjiang 2005).

These cities in the ANRX can be classified into five districts according to economic development. Table 1 presents the main economic indicators of the five economy districts. It indicates that the socioeconomic developmental level of the Urumqi district is the highest among them. Urumqi district has 59,328.19 million yuan of gross product (at current prices), accounting for 52.71% of the GDP in Xinjiang, and 55,334 million yuan (at current prices) of the gross industry output value, accounting for 45.76% of corresponding of Xinjiang. The level of urbanization reached 71.04%. The Kuitun and Shihezi districts are followed. The re-

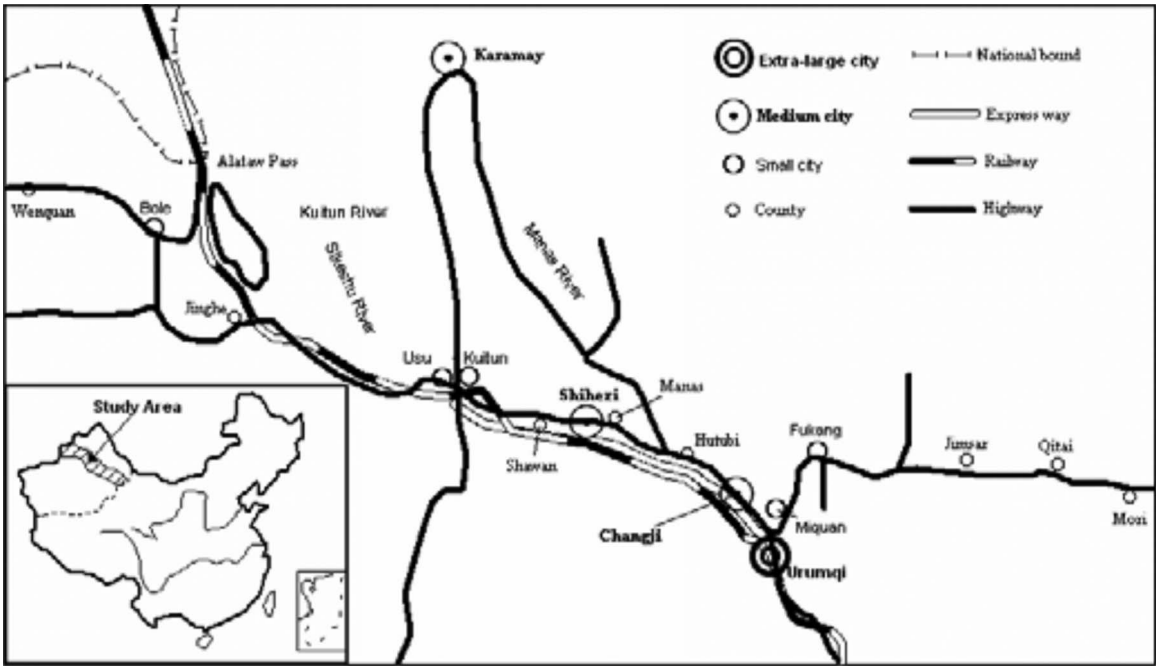

Fig. 1. The location of the cities and counties along the North Xinjiang Railway

gion (from Urumqi to Kuitun) is the most developed economic core area. The Kuitun district has the highest per capita GDP in ANRX and is twice as much as that of the Urumqi district. However, the Qita and Bole districts in the east and west of ANRX are undeveloped regions. As a result, the unevenness features of "three wealthy and two undeveloped" regions on spatial distribution area are characterized in the urban economy of ANRX.

Method and Data

In recent years, many methods have been applied to the study of urban development, such as multicriteria decision-making (Teng et al. 2006) and the cellular automata-based model (Leao et al. 2004). GDP is considered as an evaluation index of economical development level, but it is too simplistic and can not reflect the problem impersonally and roundly. Multivariate statistics analysis has been used to overcome the problem (Liao and Zheng 1998; Li et al. 2002). The principal component analysis (PCA) (Lu 2002) and cluster analysis (CA) have been used in the study. There are ten social–economic indexes selected, i.e., nonagriculture population; gross industry output value; business volume of post and telecommunications; local governments revenue; balance of deposits in urban and rural areas; value of farm, forestry, herding, and fishery; retail volume of social commodities; number of hospital beds; number of registered students in institutions of higher education and specialized secondary school; and gross production value. These data are collected from the Xinjiang Statistical Annual Book—2005 (Statistical Bureau of Xinjiang 2005). The factor analysis is applied to 17 counties and cities, and the extraction method of communal factors is the PCA (Lu 2002). According to the first and second principal components, we use CA to classify all the cities in ANRX into four kinds of growth poles.

The location quotient (LQ) is often used to study specialization sectors; Haggett et al. (1977) put forward LQ to apply to locational analysis. The other approaches, such as compositive commodity ratio and the centralization indexes can also be applied in the compartmentalization of the specialization of specialization sectors. LQ is seen as a classical method of economic base analysis, and is studied in this paper. The location quotient of industry i is area j is defined as follows:

Table 1. Social–Economic Development Status of Counties and Cities in Each Economic District along the Railway in or near Xinjiang (Unit: 10^4 Yuan) (Adapted from Statistic Bureau of Xinjiang 2005)

District	Urumqi district	Shihezi district	Kuitun district	Qitai district	Bole district
Cities (counties)	Urumqi Changji Fukang Miquan	Shihezi Shawan Manas Hutubi	Kuitun Karamay Usu	Qitai Mori Jimsar	Bole Jinghe Wenquan
GDP	5,932,819	1,616,156	3,490,100	310,365	377,432
Occupied % of that in the whole region	50.59	13.78	29.76	2.65	3.22
Gross industrial output value	1,858,303	291,593	2,620,042	35,736	34,566
Occupied % of that in the whole region	38.39	6.02	54.13	0.74	0.72
Investment in fixed assets	2,578,613	624,260	1,482,437	317,786	158,618
Occupied % of that in the whole region	49.96	12.09	28.72	6.16	3.07
Level of nonagriculturalization (%)	71.04	51.09	63.71	26.24	30.75
Per capita GDP (yuan)	22,836.1	13,221.17	45,729.82	6,906.21	8,350.27

Table 2. Structure of the ANRX Urban Grade and Scale (Unit: 10^4 Persons) (Adapted from Statistic Bureau of Xinjiang 2005)

Sequence of urban rank size	Population scale	Number of cities	Name of city	Total nonagriculture population	Average rainfall for city
First level	Above 100	1	Urumqi	146.26	146.26
Second level	50–100	None			
Third level	20–50	3	Shihezi Karamay Changji	84.29	28.10
Fourth level	10–20	2	Kuitun Shawan	29.13	14.57
Fifth level	5–10	7	Bole Hutibi Usu Fukang Miquan Qitai Manas	51.3	7.33
Sixth level	2–5	3	Jimsar Jinghe Mori	8.44	2.81
Seventh level	Below 2	1	Wenquan	1.89	1.89

$$LQ_{ij} = \left(e_{ij} \Big/ \sum_{i=1}^{N} e_{ij} \right) \Big/ \left(e_i \Big/ \sum_{i=1}^{N} e_i \right) \quad (1)$$

where e_i=total number of those employed in industry i in the entire country. That is, the location quotient is defined as the percentage of total employment in a certain area engaged in a particular industry divided by the corresponding percentage for the whole country. If the sectors' location quotients that are in the background of the whole of Xinjiang and ANRX are both more than one, we defined them as relative specialization sectors. Among these relative specialization sectors, if the number of employed persons ranks before the eighth place, this paper defined them as main specialized sectors.

Results and Discussion

Rank Discrepancy of Cities' Scales

According to the rank standard of Chinese city population scale, the cities and counties in ANRX can be classified into seven ranks (Table 2). Urumqi is a leading city of the urban system in ANRX. It is the only extra-large city with over 1.82 million urban populations in 2004, which accounted for 36.77% of the whole population in ANRX. There is no city with a population between half a million and 1 million. The urban primacy index is 2.89, exhibiting a typical primacy distribution in ANRX. The third rank includes Changji, Shihezi, and Karamay. The cities in the fourth rank and under are small cities whose economies are lagging. This classification result implies that the current urban system is not perfect in ANRX. Kuitun, Karamay, and Usu are the three leading cities located in the northwest of Xinjiang. These cities will give full industrial combination advantages. We find that this region is well suited to develop is a large city to consummate the urban system. This measurement can eliminate the urban economy "faultage" phenomena and accelerate the urban economy to form a "double cores" system on spatial distribution, i.e., Urumqi metropolitan region (Urumqi is the center, including its neighboring Changji; Fukang, Shihezi, Turpan, and Wujiaqu) and Kuitun–Karamay–Usu urban region.

Hierarchy Discrepancy of Growth Poles' Functions

The PCA and CA method analysis results demonstrated four kinds of growth poles (Fig. 2) using statistical data from the Xinjiang Yearbook. These growth poles include compound growth pole, industrial growth pole, agricultural and industrial compositive growth pole, and farming growth pole.

Urumqi, as a capital city of Xinjiang, is a compound economic growth pole and its city function is developed perfectly. In 2004, its nonagriculture population was 1.4626 million. Its GDP reaches 484.26 hundred million, retail volume of social commodities is 190.97 hundred million yuan, business volume of post and telecommunications comes to 43.14 hundred million yuan, and the number of registered students in institutions of higher education is 103.4 thousand persons (Urumqi Statistical Bureau 2005). This indicates that Urumqi has the strongest function of radialization and driver among all the cities and counties. Urumqi, as a compound growth pole, works not only in ANRX, Xinjiang, but also on China. Karamay, a petroleum industrial city developed in the desert, belongs to the industrial growth pole. The productive specialization of oil is outstanding. Its population reached 293.9 thousand and per capita GDP is 66,674 yuan, which is 2.92 times of that in Urumqi. Per capita GDP is the highest in ANRX and even in Xinjiang. The city holds the balance in the economic belt on the northern slope of the Tianshan Mountains. Its function of growth pole reacts only in ANRX. The third type is agricultural and industrial compositive growth poles, including Shihezi, Kuitun, Fukang, Miquan, Bole, Wenquan, Jinghe, Mori, Jimsar. The industrial economy benefits of these cities are not obvious and agriculture plays a dominant role in an urban economy. Shihezi is an open city in which the position of industry is prominent and agriculture is steady. The nonagriculture population was 367.3 thousand. GDP arrived at 446.1 thousand yuan. The function of its growth pole reacts on this region but not on the whole of Xinjiang. Kuitun is also developed on the basis of agricultural exploration with a vantage point of communication and it is of importance to the economic belt on the northern slope of the Tianshan Mountains. Fukang and Miquan are two satellite cities of Urumqi. The main functions of their growth poles are that they receive radiation of the superior city and drive the economy of the inferior area. The functions of Bole, Jinghe, Wenquan, Jimsar, and Mori have only local meaning. The fourth type is local agricultural growth pole, including Usu, Shawan, Changji, Hutubi, Manas, and Qitai. The development of these cities mainly depends on agriculture. Usu and Shawan based themselves on resources of big agriculture. Changji is one of the cities that takes on the task of industry's distributary of Urumqi. The total agricultural value accounts for 44.74, 40.16, and 51.20% of their GDP in Hutubi, Manas, and Qitai, respectively, which reflects the

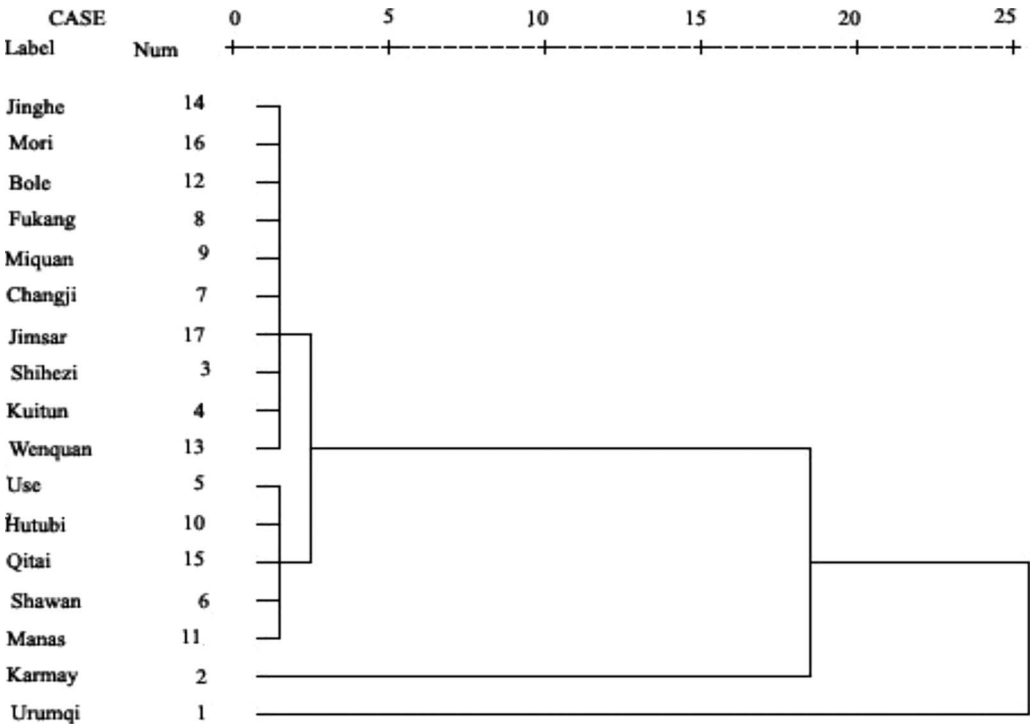

Fig. 2. Cities cluster combine along the North Xinjiang Railway

lag level cities' economies and incomplete urban functions. As a result, the range of these cities' radiation is very small and the functions have only local meaning.

Difference of Industry Specialization in These Cities

Specialization sectors of industry reflect urban developing trends. Table 3 compartmentalizes relative and main specialized sectors of each city using the LQ method.

The statistics indicate that a few cities have their own characteristic specialized sectors in the region. For example, Karamay has as high as 73.60% employees in oil sectors. But the mine of oil comes into later phase. Papermaking and cattlebreeding should be developed into its leading industries and transfer urban function from singleness to diversification in the future. The LQ of the tobacco industry even reaches 60.58% in Kuitun, but the scale is small, so it was not selected into dominant specialization sectors. In fact, with the advantage of a railway in north Xiniang and National Highway Nos. 312 and 207, Kuitun will come into the traffic center and processing and export base. Besides these, the coal industry of Miquan and Fukang is in a favorable position of urban economic development. As satellite cities of Urumqi, the urban functions are providing service for Urumqi and taking on the task of being industrial distributary of Urumqi. Further, Fukang, based on Tianchi tourism resources, is developing in the direction of urban tourism.

However, specialization sectors are mainly in textiles, food industry, leather, electric power and gas production, and supply in most of these cities in the ANRX. This means that division of the urban function is not obvious because the industrial structure of these cities is duplicated seriously to a certain extent. Some high-tech industries, such as medicament making, weaponry, and the electronic industry, are mainly concentrated in Urumqi, but the economic radiation of these industries is relatively weak because of their small scale and low proportion. In fact, the leading industries of the Urumqi district are mainly some capital-intensive industries such as ferrous and nonferrous metals smelting, chemical products, oil chemical processing, ordinary equipment production, transport, communication equipment production, and so on. Although labor intensive, industries such as food processing, textile industry, garment industry, leather products, etc., are ubiquitous in the ANRX, especially in the Qitai and Wenquan districts.

Based on the above-presented analysis, the functions of the cities and counties in ANRX, according to the concrete condition of these cities and development conception, are summarized in Table 4.

Conclusion

Based on the previous discussions, the conclusions are threefold. First, there is no obvious division of urban economical function in ANXR. The oasis urban economy development gathered many economic factors into Urumqi, so Urumqi exerts a service center of regional economic effect on the ANXR area. Second, Urumqi's oil industry is at a disadvantage, whereas this industry is at an absolute advantage in Karamay, which has a prominent specialization function. Comparatively speaking, Urumqi takes on the task of being the regional economic, information, and technology center, whereas the other cities act to process farming byproducts and serve as the material base in the area. Third, in the coming year, the three modes of industry collaboration development among these cities will be complete division, relative division, and regional industry integration. Complete division is adapted to the trades that the other cities have no or almost no condition to develop but one city has good conditions. Kuitun's transport industry has good conditions compared to the other equivalent cities. Relative division is adapted to the trades that all the cities can

Table 3. Sectors of Manufacture Specialization in Cities along the North Xinjiang Railway [Adapted from the Chinese Fifth Census Data (National Bureau of Statistics of China 2001)]

City	Relative specialization sectors	Dominating specialization sectors
Urumqi	R_5 M_{2-3} M_{9-12} M_{14-16} M_{18-28} M_{32-33}	M_{19} M_5 M_{25} M_{24} M_{33} M_{14} M_{23} M_{20}
Karamay	R_2 R_4 M_{13-14} M_{18} M_{21} M_{23-24} M_{28-29} M_{31-32}	R_2 M_{31} M_{13} R_4 M_{14} M_{24} M_{18}
Shihezi	R_1 M_{2-6} M_{9-10} M_{12} M_{18-19} M_{21} M_{23} M_{25} M_{28} M_{30-31}	M_5 M_{19} R_1 M_{25} M_{31} M_3
Kuitun	R_{5-6} M_{1-2} M_{4-9} M_{12} M_{17} M_{21} M_{25} M_{30}	M_5 M_2 M_1 M_{25} M_8 M_5
Usu	R_6 M_1 M_7 M_{12} M_{29} M_{31}	M_1 M_{31}
Shawan	M_1 M_{17-18} M_{21} M_{28}	M_1 M_{17} M_{18}
Changji	R_1 M_7 M_{12} M_{19} M_{27} M_{29}	M_{19} R_1 M_{27}
Fukang	R_2 M_7 M_{12-13} M_{17} M_{21} M_{27} M_{31}	M_{31}
Miquan	R_{1-2} M_1 M_4 M_7 M_{8-9} M_{19} M_{21} M_{25} M_{32}	M_{19} R_2 R_1 M_{25} M_1
Hutubi	M_6 M_{32}	M_6
Manas	M_2 M_{4-5} M_{30-31}	M_5 M_{31} M_2 M_{30}
Bole	R_5 M_1 M_3 M_{5-6} M_8 M_{11-12} M_{19} M_{30-32}	M_5 R_5 M_1 M_{31}
Jinghe	M_1 M_5 M_{17} M_{28} M_{31}	M_5 M_{31} M_1 M_{17}
Wenquan	M_1 M_8 M_{15} M_{28} M_{31}	M_{31} M_1 M_8 M_{15}
Qitai	R_6 M_{12} M_{32}	M_{32}
Mori	M_{6-7} M_{17} M_{30}	M_6 M_{30} M_7
Jimsar		

Note: R_{1-3}=mining; M_{1-32}=products; R_1=coal mining and dressing; R_2=extraction of petroleum and natural gas; R_3=ferrous metal mining; R_4=nonferrous metals mining; R_5=mining and dressing of nonmetal minerals; R_6=other mining; R_7=mining of timber and bamboo; M_{1-32}=production; M_1=food processing; M_2=food production; M_3=drinking production; M_4=tobacco processing; M_5=textile industry; M_6=garments and other fiber products; M_7=leather, furs, down products; M_8=timber, bamboo rattan and herbage production; M_9=furniture manufacturing; M_{10}=papermaking and production; M_{11}=printing industry; M_{12}=cultural, educational, and gymnastic goods; M_{13}=oil processing, coking processing; M_{14}=chemical raw material and production; M_{15}=medicine production; M_{16}=chemical fiber products; M_{17}=rubber products; M_{18}=plastic industry; M_{19}=nonmetal products; M_{20}=ferrous metal smelting and processing; M_{21}=nonferrous metals smelting and processing; M_{22}=metal products; M_{23}=general machinery ammunition; M_{24}=special equipment manufacturing; M_{25}=transport and communication equipment; M_{26}=weapon ammunition manufacturing; M_{27}=electric equipment and machinery; M_{28}=electronic communication equipment; M_{29}=equipment, meter, culture and office machinery; M_{30}=other manufacturing; M_{31}=electric and steam production and supply; M_{32}=gas production and supply; and M_{33}=production and supply of tap water.

develop but there is wide gap among the trades of the cities. Each city can select the trades that have advantaged conditions to develop. The oil industry in Karamay and the textile industry in Shihezi are OK. Regional industry integration is adapted to the trades that have analogous inner structure, and that mostly require agglomeration economy and network economy, such as tourist area, insurance, education, culture and arts, etc. These three modes of industry collaboration will be considered in adjusting cities' functions in urban planning.

Further Study

The conclusion has been drawn only from ANRX. In order to generalize characteristics of arid oasis urban economical functions, it is necessary to compare urban functions in ANRX with that of similar areas. Moreover, the urban system development will lead to the formation of a large city that may affect the division of urban economical functions in ANXR. Further research needs to be conducted in this area.

Table 4. Urban Development Direction Economical Function in ANRX

Grade	Cities and counties	Urban economical function
I	Urumqi	A center of communication, commodity exchange, inside and outside commerce, science and technology, social-economy and organization and command of regional economy in ANRX
II	Karamay	Oil industrial city, which is transferring urban city from simpleness to diversification
	Shihezi	A textile industrial city based on the agriculture exploration
	Changji	Satellite city of Urumqi
	Kuitun	Traffic center and export base in the northwest of Xinjiang
III	Fukang	Satellite city of Urumqi, which is developing into a tourism city
	Miquan	Satellite city of Urumqi
	Usu	Intensive fruit and vegetable product center
	Bole	Export process base
	Hutubi Manas	Preliminary processing center of farming byproduct and material base of Shihezi
	Shawan	
IV	Qitai Mori Jimsar	Local center of agricultural products and byproduct processing, whose task is mainly absorbing surplus rural labor
	Wenquan Jinghe	

Acknowledgments

This study was supported by a grant from the Major State Basic Research Development Program of China (973 Program No. 2007CB411507) and the Chinese National Fundamental Research Program (No. 40701029). The writers appreciate the constructive comments and suggestions by anonymous reviewers and the editor.

References

Begg, I. (1993). "The service sector in regional development." *Regional Studies*, 27(8), 817–825.

Berry, B. J. L. (1972). *City classification handbook: Methods and applications*, Wiley, New York.

Fu, X.-F., and Ren, W.-B. (1995). "Analysis on industry structure of the industrial belt on north slope of Tianshan Mountains." *Arid Land Geography*, 18(1), 1–7 (in Chinese with English abstract).

Fujita, K. (1991). "A world city and flexible specialization: Restructuring of the Tokyo metropolis." *International Journal Urban Region Research*, 15(2), 269–284.

Haggett, P., Cliff, A. D., and Frey, A. (1977). *Locational analysis in human geography*, Wiley, London.

Harris, C. D. (1943). "A functional classification of cities in the United States." *Geogr. Rev.*, 33(1), 86–99.

Leao, S., Bishop, L., and Evans, D. (2004). "Simulating urban growth in a developing nation's region using a cellular automata-based model." *J. Urban Plann. Dev.*, 130(3), 145–158.

Li, C., Zhong, W., and Wang, L.-G. (2002). "Research on economic development pole in economic belt of Tianshan northslope." *Arid Land Geogr.*, 25(4), 354—359 (in Chinese with English abstract).

Liao, C.-M., and Zheng, L.-Y. (1998). "The difference of economic function and the trends of industry development in central cities along the Xijiang River." *Journal of Guangxi Teachers College*, 15(1), 1–4 (in Chinese with English abstract).

Liu, B. (1995). "The preliminary research on the ways of urbanization of the area along the north Xinjiang railway." *Arid Land Geography*, 18(2), 41–66 (in Chinese with English abstract).

Lu, W.-D. (2002). *SPSS for windows statistical analysis*, Publishing House of Electronic Industry, Being, 311–399 (in Chinese with English abstract).

Meyer, D. R. (1991). "Change in the world system of metropolises: The role of business intermediaries." *Urban Geogr.*, 12(5), 393–416.

Moulaert, F., Chikhaoui, Y., and Djellal, F. (1991). "Locational behaviors of French high-tech consultancy firms." *International Journal of Urban Region Research*, 15(11), 92–106.

National Bureau of Statistics of China. (2001). *The Chinese fifth census data*, China Statistic Press, Beijing (in Chinese with English abstract).

Nelson, H. J. (1955). "A service classification of American cities." *Econ. Geogr.*, 31(3), 189–210.

Pandit, K. (1991). "Changes in the composition of the service sector with economic development and the effect of urban size." *Regional Studies*, 25(4), 315–325.

Statistical Bureau of Xinjiang Uygur Autonomous Region. (2005). *Xinjiang statistical yearbook—2005*, China Statistic Press, Beijing (in Chinese with English abstract).

Teng, J.-Y., Huang, W.-C., and Huang, M.-J. (2006). "Multiobjective strategic evaluation for urban development in Kaohsiung, Taiwan: Case study." *J. Urban Plann. Dev.*, 132(3), 160–164.

Urumqi Statistical Bureau. (2005). *Urumqi statistical yearbook—2005*, China Statistic Press, Beijing.

Xie, X.-F. (1998). *The comprehensive exploitation and treatment along the north Xinjiang railway lines*, Xinjiang People's Press, Urumqi, China (in Chinese with English abstract).

Zhou, Y.-X., and Bradshaw, R. (1988). "The classification of industrial function of Chinese cities (including attached counties)—Theory, method and results." *Acta Geogr. Sin.*, 43(4), 287–298 (in Chinese with English abstract).

Zhou, Y.-X., and Sun, Z.-X. (1997). "Rediscussion on China's urban function classification." *Geographical Research*, 16(1), 11–22 (in Chinese with English abstract).