Spatial Changes of Chinese Cities Under the Condition of Exo-Urbanization

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Abstract: *Only a preliminary framework is sketched in this report. The first part is theoretical study, trying to model urban-rural interlaced area (desakota) in China using multifractals dimension spectra. The second part is empirical analysis, and the object is to reveal the dynamic process of development and evolution of urban-rural interlaced area under the condition of exo-urbanization. The first part has been finished based on digital simulation, but the second part, the main body of this project, is still in progress*.

The spatial structure of cities in Southeast China has been changing under the condition of exo-urbanization stemming from the open policy since 1980s. This project is mainly devoted to research on the transformation of urban structure resulting from foreign direct investment (FDI) made by trans-national corporations (TNCs). Besides, the social and cultural geographical effects of the changes of urban spatial structure are also in my study's sphere. Based on the data analysis, the exo-urbanization-reduced spatial-temporal patterns of regional structure, especially appeared in *desakota* in China, will be model in a simple way (the concept of exo-urbanization is suggested by Sit and Yung, 1997; see also Pacione, 2001; As for *desakota*, see McGee, 1991).

This study on spatial structure changes of Chinese cities is divided into two parts. One is theoretical research, and the other empirical analysis. The first part has been complete already, and the original aim has been achieved basically (Chen, 2004a; 2004b). The second part is still in prospect. In the following subsections, I will report the whole framework of my study summarily.

1 Theoretical framework: modeling spatial structure of *desakota*

If we thought of urban area to be a state, and rural area another area, urbanization as a self-organizing process can be regarded as a kind of phase transition from a rural to an urban settlement system (Sanders, 1997; Anderson, 2002; Chen, 2004a). The phase transition in nonequilibrium process always result in self-organized critical state associated with fractal structure (Bak, 1996). As pointed by White, *et al* (1997): "As cities are evolving systems, we might expect, $\cdots$, that they would display characteristics of a phase transition system balanced between order and chaos. In fact, this seems to be the case. Intuitively, the complexity we see in cities seems to express a struggle between order and chaos. And empirically it has been shown that cities do have fractal structures. (Page 324)". What we interest is the transformation of urban structure of China resulting from foreign direct investment (FDI) made by trans-national corporations (TNCs). Based on the preliminary data processing, we can model the exo-urbanization-reduced spatial-temporal patterns of urban structure especially appeared in so-called *desakota* in China in multi-fractals geometry (As for multifractals, see Feder, 1988).

Table 1 Recursive structure of interlaced belt of urban and rural area

<table>
<tr><td>0</td><td colspan="16">Regional population: 1 unit</td></tr>
<tr><td>1</td><td colspan="8">Urban population (u): Z</td><td colspan="8">Rural population (r): 1-Z</td></tr>
<tr><td>2</td><td colspan="4">Non-agricultural population: Z^2</td><td colspan="4">Agricultural population: $Z(1-Z)$</td><td colspan="4">Non-agricultural population: $(1-Z)Z$</td><td colspan="4">Agricultural population: $(1-Z)^2$</td></tr>
<tr><td>3</td><td colspan="2">NASP: Z^3</td><td colspan="2">ASP: $(1-Z)Z^2$</td><td colspan="2">NASP: $Z^2(1-Z)$</td><td colspan="2">ASP: $Z(1-Z)^2$</td><td colspan="2">NASP: $(1-Z)Z^2$</td><td colspan="2">ASP: $(1-Z)^2Z$</td><td colspan="2">NASP: $Z(1-Z)^2$</td><td colspan="2">ASP: $(1-Z)^3$</td></tr>
<tr><td>…</td><td>…</td><td>…</td><td>…</td><td>…</td><td>…</td><td>…</td><td>…</td><td>…</td><td>…</td><td>…</td><td>…</td><td>…</td><td>…</td><td>…</td><td>…</td><td>…</td></tr>
<tr><td>n</td><td colspan="16">Binomial distribution: $C_n^r Z^{n-r}(1-Z)^r$, (r=1,2, $\cdots$, n)</td></tr>
</table>

Note: ASP means agricultural service population, and NASP denotes non-agricultural service population.

Suppose that a region comprise two kinds of lands, urban area and rural area. The urban area and rural area are with one another. If the whole region is regarded as one unit, then urban population proportion can be represented by level of urbanization Z, and rural population proportion represented by 1-Z (table 1). We assume that the urban population and rural population in our studied area follow scaling laws, the cascade structure of urban and rural interlaced area can be characterized by a scaling exponent (Chen, 2004b)

$$\tau(q) = \frac{\ln[Z^q + (1-Z)^q]}{\ln 2}, \tag{1}$$

where q is a parameter coming between positive infinity and negative infinity. Derivative of equation (1) with respect to q gives a singularity exponent such as

$$\alpha(q) = -\frac{\mathrm{d}\tau}{\mathrm{d}q} = -\frac{1}{\ln 2}\frac{Z^q \ln Z + (1-Z)^q \ln(1-Z)}{Z^q + (1-Z)^q}. \quad (2)$$

According to the Legendre transform, the fractal dimension, $f(\alpha)$, corresponding to α is as follows

$$\begin{aligned} f(\alpha) &= \tau(q) + q\alpha(q) \\ &= \frac{1}{\ln 2}[\ln[Z^q + (1-Z)^q] - \frac{Z^q \ln Z^q + (1-Z)^q \ln(1-Z)^q}{Z^q + (1-Z)^q}], \end{aligned} \quad (3)$$

Then the general dimension D_q of urban and rural interlaced space can be defined by

$$D_q = \begin{cases} \frac{\tau(q)}{1-q}, & q \neq 1 \\ -\tau'(1), q = 1 \text{ and } \tau(q) \text{ is differentiable} \end{cases}, \quad (4)$$

or

$$D_q = \frac{1}{q-1}[q\alpha(q) - f(\alpha)]. \quad (5)$$

The key lies in how to determine the numerical value of parameter *Z*. Z value depends on the concrete spatial structure of urban and rural interlaced area. Before investigating *desakota* in China, we can give the multifractals pattern of analytic geometry based on value simulation (figure 1). Take Z=0.75, the calculated values of related scaling exponents and fractal dimension is tabulated (table 2).

Table 2 Multifractal dimension spectra of interlaced belt of urban and rural area

q	$\tau(q)$	$\alpha(q)$	$f(\alpha)$	D_q
-500	1006.0708	2.0121	0.0000	2.0081
-200	402.4283	2.0121	0.0000	2.0021
-100	201.2142	2.0121	0.0000	1.9922
-50	100.6071	2.0121	0.0000	1.9727
-40	80.4857	2.0121	0.0000	1.9631
-30	60.3642	2.0121	0.0000	1.9472
-20	40.2428	2.0121	0.0000	1.9163
-10	20.1214	2.0121	0.0003	1.8292
-5	10.0663	2.0059	0.0366	1.6777
-2	4.1731	1.8552	0.4626	1.3910
-1	2.4232	1.6152	0.8079	1.2116
0	1	1.2116	1	1
1	0	0.8079	0.8079	0.8079
2	-0.6732	0.5679	0.4626	0.6732
5	-2.0495	0.4172	0.0366	0.5124

10	-4.1101	0.4110	0.0003	0.4567
20	-8.2203	0.4110	0.0000	0.4326
30	-12.3304	0.4110	0.0000	0.4252
40	-16.4405	0.4110	0.0000	0.4216
50	-20.5506	0.4110	0.0000	0.4194
100	-41.1013	0.4110	0.0000	0.4152
200	-82.2026	0.4110	0.0000	0.4131
500	-205.5065	0.4110	0.0000	0.4118
1000	-411.0129	0.4110	0.0000	0.4114

Note: The parameter values are given by simulation.

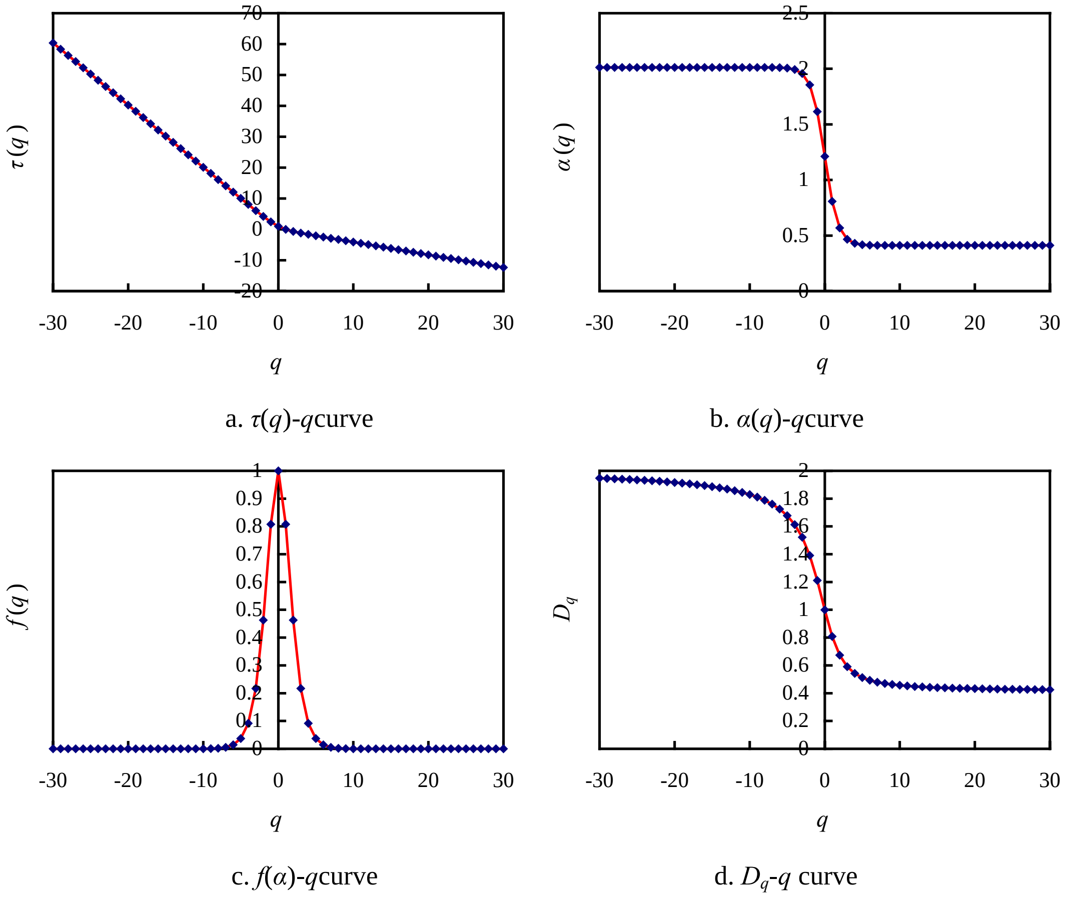

Figure 1 Multifractals pattern of urban-rural interlaced area based on simulation parameters

(Z=0.7521, 1-Z=0.2479)

Further, the efficience of spatial utilization can be defined by

$$E_s = \frac{D_{-\infty} - D_{\infty}}{d} = \frac{\max(D_q) - \min(D_q)}{2}. \tag{6}$$

where d=2 denotes the dimension of the Euclidian space. For example, given Z=75.21%, it follows that E_s=79.85%; if Z=36.09% as given, then E_s=41.1%. The higher the level of urbanization is, the more efficient a regional space is made use.

2 Empirical analysis: dynamic mechanism of *desakota*

2.1 Macro level: urban potential and FDI flow

There exists cross correlation between urbanization and economic development (Zhou, 1989). Foreign direct investment (FDI) made by trans-national corporations (TNCs) influence industrialization and thus further urbanization of developing countries (Figure 2). In fact, FDI affects regional economic development, which in turn affect the direction of subsequent FDI flow.

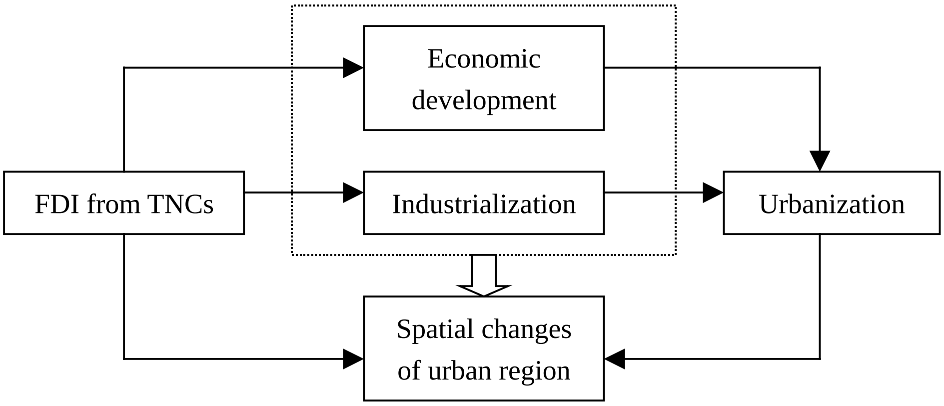

Figure 2 A sketch chart of exo-urbanization in the less-developed countries

Besides various reasons of location selection studied by other scholars, I find that trans-national corporations prefer high potential regions to common ones. Based on the model of gravity, the potential formula is defined by

$$E_i = \sum_{j=1}^{n-1} E_{ij} = m_i \sum_{j=1}^{n-1} \frac{m_j}{r_{ij}}, \tag{7}$$

in which E denotes potential, m_i represents the economic size of the ith city. By means of GDP values and geographical distance, the economic potential of each provincial capital is easy to be calculated, and the realized FDI values can be found in statistical yearbook (table 3). A discovery is that realized FDI values of provinces are proportional/relative to the economic potentials of provincial capitals (figure 3). A least squares computation gives the following power relationship

$$FDI\ value = 0.000000000072 Economic\ Potential^{1.2488}.$$

The determination coefficient is R=0.6675.

The economic potentials of Shanghai, Nanjing, and Hangzhou come out top in table 2. They are ranked as No. 1, No. 5, and No. 6, respectively. In 2002, the realized FDI value accepted by Jiangsu province occupied 19.3% of the whole country's amount (second only to Guangdong). Among the largest 500 TNCs of the whole world, no less than 170 TNCs have invested in Jiangsu province. However, more than 98% of Jiangsu's FDI value was concentrated in the cities of Suzhou, Wuxi, and Changzhou. In fact, Suzhou-Wuxi-Changzhou is just situated in the economic triangle area of Shanghai-Nanjing-Hangzhou.

Table 3 Economic potential (2000) of provincial capitals and realized FDI values (2002) of the corresponding provinces in China (FDI value: 10-thousand dollars)

Provincial Capital	Economic potential	Province or Municipality	FDI value
Shanghai	7047312779657.580	Shanghai	427299
Beijing	6186060997233.090	Beijing	172464
Tianjin	4658003090150.010	Tianjin	158195
Guangzhou	2344251396514.750	Guangdong	1184596
Hangzhou	2274463671564.800	Zhejiang	307610
Nanjing	2223713021092.230	Jiangsu	1018960
Wuhan	2192535901910.950	Hubei	142665
Jinan	1716753591981.530	Shandong	473404
Shenyang	1691340689464.700	Liaoning	341168
Shijiazhuang	1223514166452.480	Hebei	78271
Chuangchun	1044648528790.740	Jilin	24468
Xi'an	987779725572.200	Shanxi	36005
Changsha	827660648100.852	Hunan	90022
Zhengzhou	818233816282.908	Henan	40463
Chengdu	1770857877994.320	Sichuan	75159
Haerbin	780413665651.730	Heilongjiang	35511
Nanchang	680224377411.547	Jiangxi	108197
Taiyuan	658685578705.043	Shansi	21164
Fuzhou	636031909579.712	Fujian	383837
Hefei	569734159160.766	Anhui	38375
Kunming	453639721184.742	Yunnan	11169
Lanzhou	328519883503.266	Gansu	6121
Guiyang	287525354904.759	Guizhou	3821
Nanning	247122005502.427	Guangxi	41726
Huhehaote	193863607224.658	Neimenggu	17701
Wulumuqi	151484865381.585	Xijiang	1899
Yinchuan	95332564826.996	Ningxia	2200
Xining	73095658936.858	Qinghai	4726

Note: Economic potential (left part) is calculated based on the provincial capitals, while the realized FDI values (right part) are estimated according to provinces. For example, the city of Guangdong is the capital of Guangzhou province. Economic potential is compute using GDP and geographical distance, while the FDI values come from *the Ministry of Business*, PRC, 2003. In order to reveal time lag effect, economic potential and FDI values are figured out in different years. For both geographical and historical reasons, Hainan is integrated into Guangdong, and Chongqing is integrated into Sichuan.

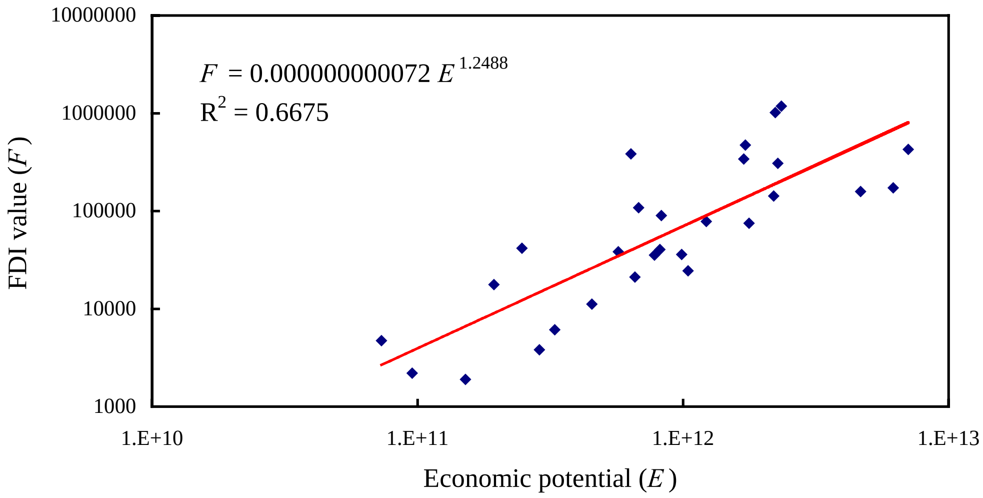

Figure 3 Linear relationship between FDI values and economic potential

(E represents economic potential, F denotes realized FDI values)

The cost of labors and land in China is low, and potential market is vast. Cost factor and market factor attract many foreign corporations. However, a great majority of foreign capital is put into labor concentrated industry, which attracts a great many native labors. Moreover, with the lapse of time, foreign enterprises are gradually localized. Then a great number of intellectuals enter the foreign corporations. Labor-concentration-oriented investment and industry localization is two important elements of exo-urbanization process in China.

2.2 Micro level: evolutional process of *desakota* in China (Main body)[1]

2.2.1 Distribution of foreign enterprises in city hierarchies

The first factor furthering urban-rural interlaced area may be that the hierarchy of foreign enterprises agrees with the hierarchy of cities and towns. At the beginning of 1980s when the open policy was fresh in China, various foreign enterprises came into what is called special economic district (*jing ji te qu*) in southeast China, for example, Shenzhen city in Zhujiang delta. At the initial stage, the policy, bylaws, rules and regulations, and management are not very clear and

[1] This part is in process.

sound. A variety of foreign corporations enter the large cities of China. With the development of economy and society, the rules and regulations become sounder and sounder, and the management way becomes more and more advanced. So at the second stage, the first-tier cities, e.g. Shenzhen, began to set high demands on the foreign enterprises. The low-grade foreign enterprises with low profits or high pollution were driven out of Shenzhen by means of differential rent and related policy. These kinds of enterprises came into the middle-tier cities such as Dongguan, Huizhou, etc. At the third stages, the middle-tier foreign enterprises were driven from Shenzhen to Dongguang, or Huizhou, while the low-tier foreign enterprises were driven from Donguang and Huizhou to lower cities or towns. Finally, the first-tier foreign enterprises are mainly distributed in large cities, the middle-tier foreign enterprises are principally placed in median-size cities, and the bottom-tier enterprises are chiefly located in the small towns (figure 4). Though this process of development is not absolute, but it does reflect how FDI influence urban-rural interlaced area.

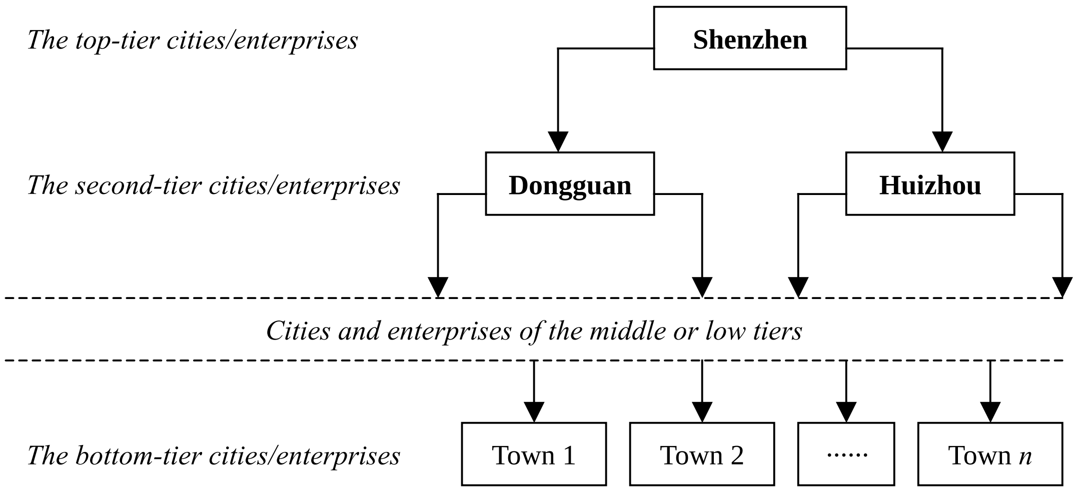

Figure 4 Foreign enterprises are distributed along the hierarchy of cities

(Zhujiang delta is taken as an example to show the developing process of urban-rural interlaced area)

Maps and data will be provided here in the coming paper.

2.2.2 Location selection and technology separation

Location selection and technological process decomposition also affect the evolution of urban-rural interlaced area. Foreign corporations, especially the enterprises from Japan, often divide production or technological process into several sub-processes for multiple purposes.

Different sub-processes of production demand different natural or social environments. Technology decomposition is convenient for finding best the location for different sub-process (for *optimal location* purpose). Generally speaking, the factors affecting investment location selection include cost, market, agglomeration effect, laws, rules and regulations, and what not. Moreover, technological process decomposition can prevent technology giveaway (for *technology blockade* purpose). It is effective methods to stop host countries from mastering the whole technological process. Thus, different sub-processes are usually placed in different cities or towns. The production process of multi-locations reinforces the spatial interaction between cities and cities, cities and towns, or urban area and rural area, which are connected with each other by matter flow, energy flow, and information flow (figure 5).

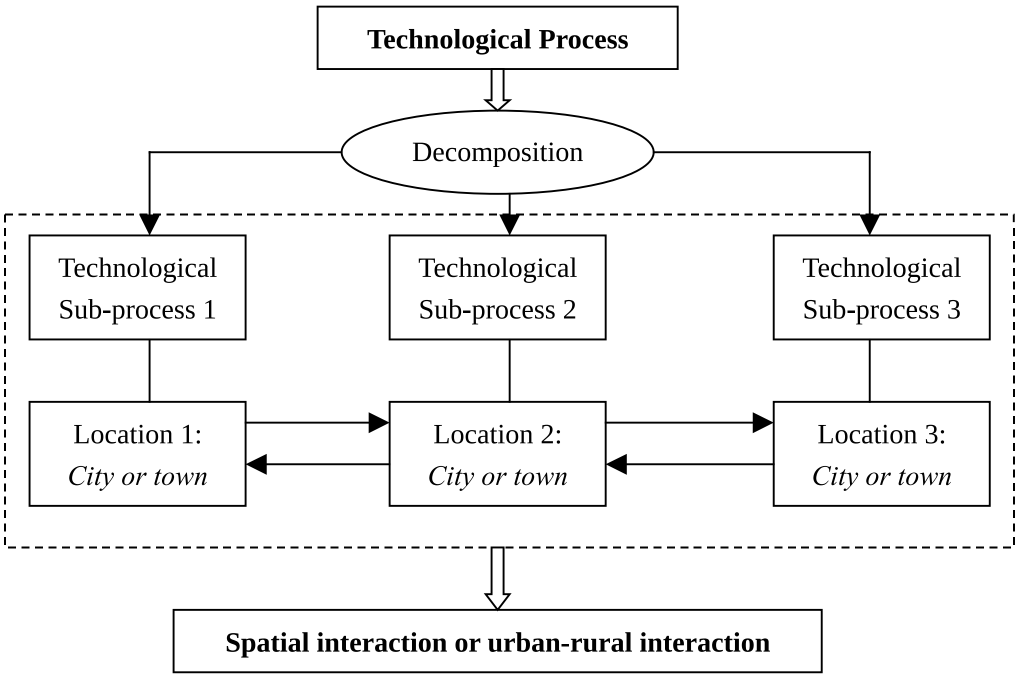

Figure 4 Foreign enterprises are distributed along the hierarchy of cities

Maps and data will be attached here in the future paper.

2.2.3 Cross-region borrowing land and regional cooperations

New type of regional cooperation has appeared in the Changjiang delta marked by Shanghai-Nanjing-Hangzhou economic triangle area recent year. FDI furthers urbanization, which in turn furthers attracting FDI. Some developed cities or regions need more land to accommodate foreign enterprises. Then they “borrow” land from the nearby cities or regions, which are less developed.

What is called “borrowing” land is in fact buying/leasing land use at a low price (figure 5). For example, Hangzhou borrow land from Haining, Jiangyin borrow land from Jingjiang. These phenomena are very common in the Suzhou-Wuxi-Changzhou area.

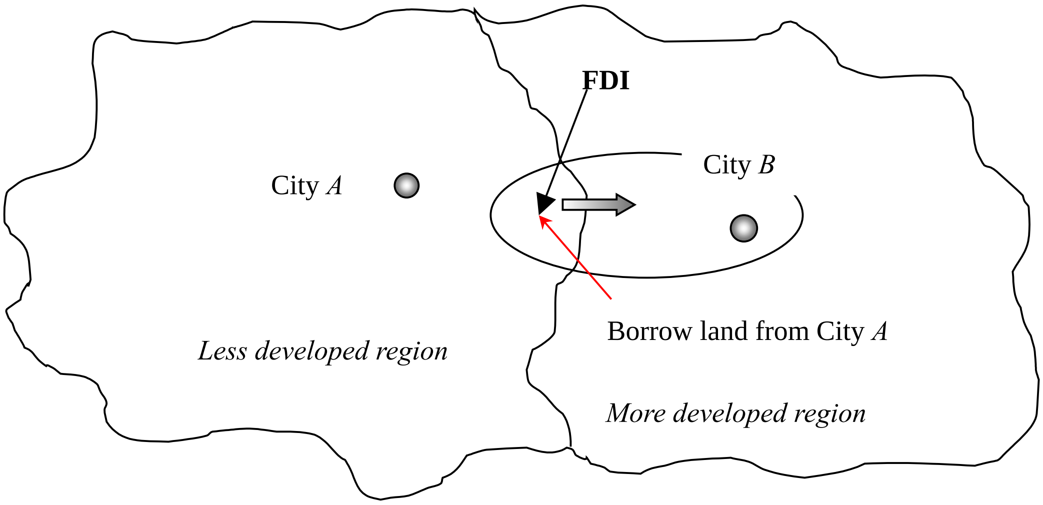

Figure 5 A sketch map: city B borrows land from city A

The phenomena of “borrowing land” in China are directly or indirectly related to international capital or foreign investment. It is interesting to research the spatial structure changes resulting from borrowing land.

Maps and data will be given here in the coming paper.

3 Conclusion remarks

The aforementioned content is only an outline of my research. Next steps are as follows.

First, how to connect the theoretical model with the observed phenomena of Chinese cities.

Second, how to simulate the dynamic process and interpret the spatial evolution of exo-urbanization in China.

Third, how to predict the future tendency of spatial changes of Chinese cities under the condition of exo-urbanization.

My research has not yet been completed so far. I cannot provide clear conclusions here. However, I have found many data. I will try my best to finish this project and provide a systematic framework including maps, cases, and data sets. These days, I have been busy in sorting out the data, calculation, analysis, and so on. I will try my best to guarantee both quality and quantity to complete this research task, though I cannot finish it on time.

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