# Industrial agglomeration and regional economic development: the case of China

## 1. Introduction

As a developing country with a vast territory, and the implementation of the policy that letting some people and some regions prosper before others since the Reform and Opening-up, China presents different trends of economic development in different regions. Based on China multi-regional input-output tables with 8 regions and 17 industries, this paper analyses industrial agglomeration and its relation with regional economic development. First, we attempt to explore which industry has the feature of geographic concentration by the spatial Gini coefficient. Second, we try to find out inter-regional linkages, namely industry groups between regions by average propagation lengths.

## 2. Methodology

### 2.1 The spatial Gini coefficient

The spatial Gini coefficient of sector $i$ in China can be defined as follows:

$$G_i = \sum_{r-=1}^{8} (m_r - n_{ri})^2, i = 1, 2, 3...17 \qquad (1)$$

Where $G_i$ denotes the spatial Gini coefficient of sector $i$, $m_r$ is the share of value added of region $r$ in national total value added. $n_{ri}$ is the share of value added of region $r$, sector $i$ in value added of sector $i$.

### 2.2 Average propagation lengths

Suppose that there are $m$ sectors in a country. First, we define variables as follows:

$$\mathbf{x} = \begin{pmatrix} x_1 \\ x_2 \\ \vdots \\ x_m \end{pmatrix}; \quad \mathbf{A}^d = \begin{pmatrix} a_{11} & a_{12} & \cdots & a_{1m} \\ a_{21} & a_{22} & \cdots & a_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ a_{m1} & a_{m2} & \cdots & a_{mm} \end{pmatrix}; \quad \mathbf{y} = \begin{pmatrix} y_1 \\ y_2 \\ \vdots \\ y_m \end{pmatrix}$$

Where $\mathbf{x}$ is the column vector of output, $x_i$ is the output of sector $i$, $i = 1, 2, 3 \cdots m$. $\mathbf{A}^d$ is input coefficient of domestic intermediates, and $a_{ij}$ denotes that the production of one unit output of sector $j$ needs $a_{ij}$ unit input of sector $i$, with $i = 1, 2, 3 \cdots m$, $j = 1, 2, 3 \cdots m$. $\mathbf{y}$ is the column vector of final output, and $y_i$ is the output of sector $i$, with $i = 1, 2, 3 \cdots m$.

Input-output model can be represented in matrix notation as

$$\mathbf{x} = \mathbf{A}^d \mathbf{x} + \mathbf{y} \qquad (2)$$

From equation (2), we can get

$$\mathbf{x} = (\mathbf{I} - \mathbf{A}^d)\mathbf{y} = \mathbf{L}\mathbf{y} \qquad (3)$$

Where $\mathbf{L}$ is Leontief inverse matrix。From equation (3), we know that

$$\Delta\mathbf{x} = \mathbf{L} * (\Delta\mathbf{y}) = (\mathbf{I} + \mathbf{A} + \mathbf{A}^2 + \mathbf{A}^3 + \cdots) * (\Delta\mathbf{y}) \qquad (4)$$

So the total increase in the output of sector $i$,due to a final output increase in sector $j$ ($i \neq j$) is given by

$$\Delta x_i = l_{ij} = a_{ij} + \sum_k a_{ik} a_{kj} + \sum_k \sum_n a_{ik} a_{kn} a_{nj} \qquad (5)$$

When $i = j$

$$\Delta x_i = l_{ii} = a_{ii} + \sum_k a_{ik} a_{ki} + \sum_k \sum_n a_{ik} a_{kn} a_{ni} \qquad (6)$$

According to Dietzenbacher and Romero(2007)，the total increase in the output of sector $i$,due to a final output increase in sector $j$ is $\Delta x_i$，$\Delta x_i = l_{ij}$.Where the share $a_{ij} / l_{ij}$ requires one step（sector $j$ directly impacts on sector $i$），$\sum_k a_{ik} a_{kj} / l_{ij}$ requires two steps（sector $j$ first impacts on sector $k$, then sector $k$ impacts on sector $i$），$\sum_k \sum_n a_{ik} a_{kn} a_{nj} / l_{ij}$ requires three steps(sector $j$ first impacts on sector $n$, then sector $n$ impacts on sector $k$, then sector $k$ impacts on sector $i$), and so on. Thus the average number of steps it takes the final output increase of sector $j$ to affect the output of sector $i$ can be expressed as

$$(1 \times a_{ij} + 2 \times \sum_k a_{ik} a_{kj} + 3 \times \sum_k \sum_n a_{ik} a_{kn} a_{nj} + \cdots) / l_{ij} \qquad (7)$$

In the case where $i = j$， one unit final output increase of sector $j$ causes one unit output increase of sector $j$ immediately，but this initial effect occurs irrespective of the production structure. Thus in the case where $i = j$, we just care the increase of（$\Delta x_j - 1$）or（$l_{jj} - 1$).In this case, the average propagation lengths (APLs) is

$$(1 \times a_{jj} + 2 \times \sum_k a_{jk} a_{kj} + 3 \times \sum_k \sum_n a_{jk} a_{kn} a_{nj} + \cdots) / (l_{jj} - 1) \qquad (8)$$

According to Dietzenbacher and Romero(2007), the APLs is

$$APLs_{ij}=\begin{cases} h_{ij}/l_{ij}, & i\neq j \\ h_{ij}/(l_{ij}-1), & i=j \end{cases}$$, where $h_{ij}$ is the element of matrix $\mathbf{H}$, $\mathbf{H}=\mathbf{L}(\mathbf{L}-\mathbf{I})$

2.3 Data

For our empirical analysis, we have used China multi-regional input-output tables with 8 regions and 17 industries of year 2002 and 2007,which comes from *2002, 2007 China multi-regional input-output tables*, China Statistics Press. The authors are Yaxiong Zhang and Shuchang Qi.

## 3. Empirical results

### 3.1 Basic facts of industrial agglomeration in China

Table 1 has ranked the spatial Gini coefficients of 17 sectors in China for year 2002 and 2007.Table 1 shows that, the top three sectors for year 2002 and 2007 are: Manufacture of electrical machinery and electronic communication equipment, Manufacture of textiles and wearing apparel, Quarrying. The extent of industrial agglomeration of Quarrying increased a lot, while the extent of industrial agglomeration of Manufacture of textiles and wearing apparel decreased. Overall, the extent of services in China is the lowest. Table 1 shows that the extent of industrial agglomeration of Business and transport, Other services came last.

Table 1 The ranking of spatial Gini coefficient of different sectors

| Ranking (from high to low) | Spacial Gini coefficient of each sector for year 2002 | | Spacial Gini coefficient of each sector for year 2007 | |
|---|---|---|---|---|
| 1 | Manufacture of electrical machinery and electronic communication equipment | 0.0841 | Quarrying | 0.0838 |
| 2 | Manufacture of textiles and wearing apparel | 0.0682 | Manufacture of electrical machinery and electronic communication equipment | 0.0789 |
| 3 | Quarrying | 0.0604 | Manufacture of textiles and wearing apparel | 0.0537 |
| 4 | Manufacture of wood and furniture | 0.0442 | Other manufacture | 0.0335 |
| 5 | Manufacture of nonmetallic mineral products | 0.0321 | Agriculture | 0.0266 |
| 6 | Manufacture of food and tobacco | 0.0261 | Manufacture of nonmetallic mineral products | 0.0233 |
| 7 | Agriculture | 0.0179 | Manufacture of pulp, printing and stationeries | 0.0229 |
| 8 | Manufacture of pulp, printing and stationeries | 0.0174 | Manufacture of machinery | 0.0226 |
| 9 | Manufacture of machinery | 0.0170 | Manufacture of wood and furniture | 0.0223 |

| | | | | |
|---|---|---|---|---|
| 10 | Other manufacture | 0.0163 | Manufacture of food and tobacco | 0.0210 |
| 11 | Manufacture of transport equipment | 0.0137 | Manufacture of transport equipment | 0.0193 |
| 12 | Manufacture of chemical products | 0.0094 | Production and supply of electricity, steam, Gas and water | 0.0055 |
| 13 | Construction | 0.0046 | Manufacture and processing of metals | 0.0053 |
| 14 | Manufacture and processing of metals | 0.0036 | Manufacture of chemical products | 0.0048 |
| 15 | Other services | 0.0030 | Construction | 0.0038 |
| 16 | Production and supply of electricity, steam, Gas and water | 0.0021 | Other services | 0.0035 |
| 17 | Business and transport | 0.0013 | Business and transport | 0.0005 |

## 3.2 Inter-regional linkages using average propagation lengths

To distinguish the change of APLs from 2002 to 2007,we make two thermal maps according to APLs of 8 regions and 17 sectors in China for year 2002 and 2007(the APLs for each year is a matrix of 136*136), see figure 1 and figure 2. In figure 1 and figure 2, from 1 to 136 in horizontal (vertical) axis represents 8 regions and 17 sectors in China. For example, from 1 to 17 is 17 sectors of Northeast China, from 18 to 34 is 17 sectors of Beijing and Tianjin, and so on.[1] Figure 1 and figure 2 are made up of 64 matrixes. Define the number t matrix on the right, the number s matrix above as $R^{st}$. For example, the matrix in the lower right corner is $R^{18}$, the matrix in the upper left is $R^{81}$。

Then we read figure1 and figure 2 from the perspective of economic meaning. First, the color of 8 matrixes in the counter-diagonal in figure 1 and figure 2 reflects the value of regional APLs of each region. We can find the extent of industrial linkage of this region from the color of the corresponding matrix. Second, the color of matrixes out of the counter-diagonal represents the value of inter-regional APLs. We can find the extent of industrial linkage of any two regions from the color of the matrix. For example, $R^{18}$ in the lower right represents the APLs it takes the final

[1] These 8 regions are listed in order as following: the Northeast area, Beijing and Tianjin, the northern coastal area, the eastern coastal area, the southern coastal area, the central area, the Northwest area and the Northwest area. The 17 sectors are listed in order as following: Agriculture, Quarrying, Manufacture of food and tobacco, Manufacture of textiles and wearing apparel, Manufacture of wood and furniture, Manufacture of pulp, printing and stationeries, Manufacture of chemical products, Manufacture of nonmetallic mineral products, Manufacture and processing of metals, Manufacture of machinery, Manufacture of transport equipment, Manufacture of electrical machinery and electronic communication equipment, Other manufacture, Production and supply of electricity, steam, Gas and water, Construction, Business and transport, Other services.

output increase in the Southwest area to affect the output in the Northeast area. $R^{18}$ reflects the extent of industrial linkage between the Southwest area and the Northeast area.[2] Third, the counter-diagonal of the total 64 matrixes reflects regional industrial linkages in the same sector. For instance, the counter-diagonal of matrix $R^{72}$ is nearly blue, which reflects that as the demand-puller, Beijing and the Northwest area has strong industrial linkage.

From figure 1 and figure 2, we can see that, first, in the aspect of regional industrial linkage, the local industrial linkage of these 8 regions all faded. From the Thermal maps, we can see that the blue color of the 8 matrix in the counter-diagonal is fading, which means that APLs is increasing. Second, in the aspect of inter-regional industrial linkage, inter-regional industrial linkage is weakened in total nationally. From the Thermal maps, we can see that lots of red color arises out of the counter-diagonal. Third，inter-regional industrial linkages in the same sector is fading. From the thermal maps, we can see that the blue color of the counter-diagonal of the 64 matrixes is fading.

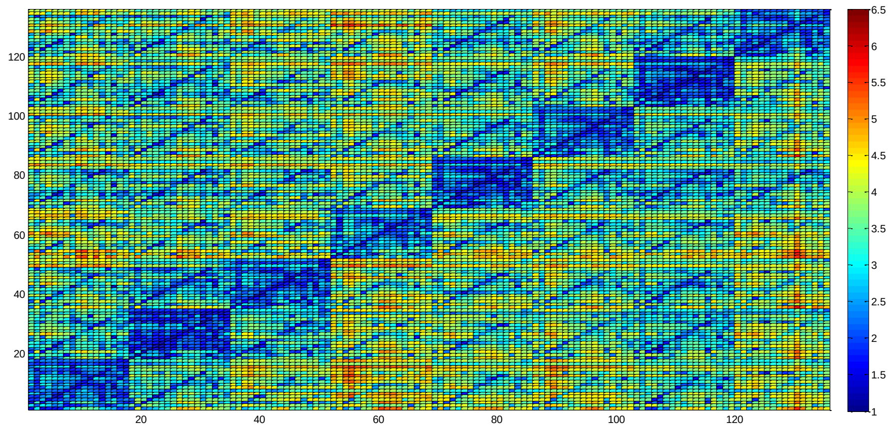


Figure 1 Thermal map of APLs of 8 regions and 17 sectors in China for year 2002

[2] The effect of the Southwest area on the Northeast area.

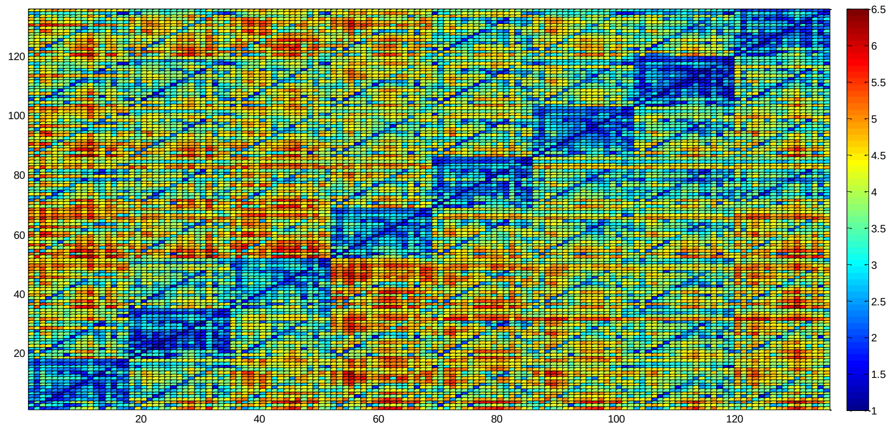


Figure 2　Thermal map of APLs of 8 regions and 17 sectors in China for year 2007

### 3.3 Inter-regional industrial linkage with the eastern coastal area and the southern coastal area as the core

When analyze the APLs between the eastern coastal area and other regions, we find that the eastern coastal area has strong industrial linkage with other regions in sectors 3,4,5,6,8,12.[3] Similarly, the southern coastal area has strong industrial linkage with other regions in sectors 3,4, 6. Compared with year 2007, we find two points: first, sector 12(Manufacture of electrical machinery and electronic communication equipment) is no longer strong linkage sector between the eastern coastal area and other regions. Second, sector 4(Manufacture of textiles and wearing apparel) is no longer strong linkage sector between the eastern coastal area and other regions too.

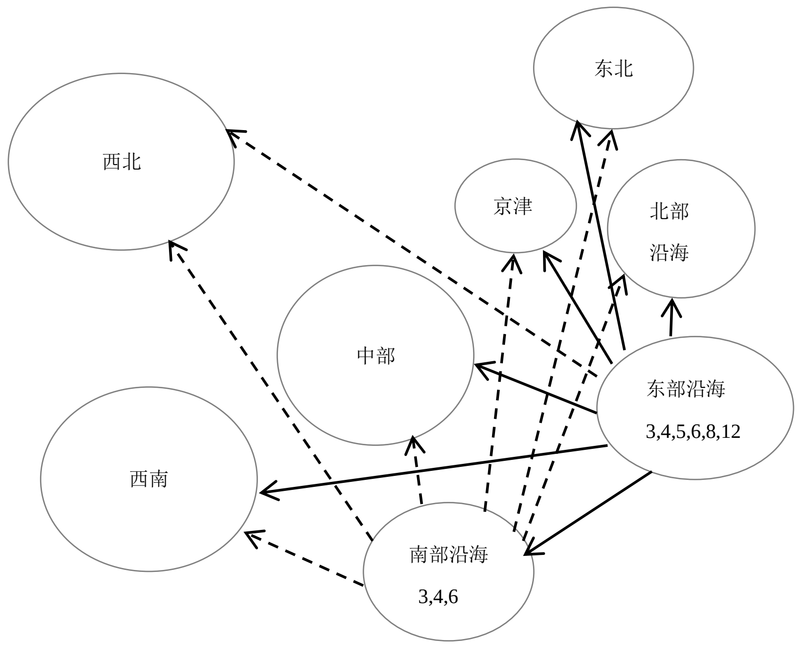


Figure 3　Inter-regional industrial linkage with the eastern coastal area and the southern coastal area as the core for year 2002

[3] If APL<=2,we take it as strong industrial linkage. Table 3 shows the corresponding sectors.

Table 2 17 sectors in China multi-regional input-output tables

| | |
|---|---|
| 1 | Agriculture |
| 2 | Quarrying |
| 3 | Manufacture of food and tobacco |
| 4 | Manufacture of textiles and wearing apparel |
| 5 | Manufacture of wood and furniture |
| 6 | Manufacture of pulp, printing and stationeries |
| 7 | Manufacture of chemical products |
| 8 | Manufacture of nonmetallic mineral products |
| 9 | Manufacture and processing of metals |
| 10 | Manufacture of machinery |
| 11 | Manufacture of transport equipment |
| 12 | Manufacture of electrical machinery and electronic communication equipment |
| 13 | Other manufacture |
| 14 | Production and supply of electricity, steam, Gas and water |
| 15 | Construction |
| 16 | Business and transport |
| 17 | Other services |

## References

Dietzenbacher E, Romero I. Production chains in an interregional framework: Identification by means of average propagation lengths[J]. International Regional Science Review, 2007, 30(4): 362-383.