

# Social Physics and China's Population Migration

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**Abstract.** Based on the social physics theory, this paper analyzes the economic disparities between different regions in China, and contributes a conceptual model of population migration among eastern, central, western and north-eastern regions. The national 1% population sample investigation data is adopted to build a network of inter-provincial population migration, and the population migration network is analyzed with social network analysis. The results are shown that there is a very strong correlation between migrant population and economy disparity in China, and the migration with obviously geographical characteristics. The eastern region is the main areas for migration-inflow; the central region is the main areas of migration-outflow; the western region is relatively "locked-up", with a little of population flow; and the migration of the northeast is mainly within its own regional territory.

**Keywords:** Social physics, Social network analysis, Population migration, Economy disparity.

## 1 Social Physics

Social physics is an "old" subject which has long history and covers a wide range of subjects. In addition to its distinctive features of sociology and physics, it also has a profound philosophy, psychology and economics base [1]. The word of social physics was put forward by Auguste Comte, who was the well-known French sociologist and philosopher in 19th century. The core idea of social physics is to make use of some physics concepts and methods to study the phenomenon and social laws [2]. A well-known French philosopher, Simone Weil, he thought that Marx was the first one who had the twin idea of taking society as the fundamental human fact and of studying therein as the physicist does in matter, the relationship of force [3]. To a certain sense, it is precisely because of the social physics' thinking and concepts that caused the research of social issues into modern social sciences. Moreover, the impact still exists and plays an important role. As pointed out by American sociologist, George Lundberg in 1939: It may be that the next great developments in the social sciences will come not from professional social scientists, but from people trained in other fields [4].

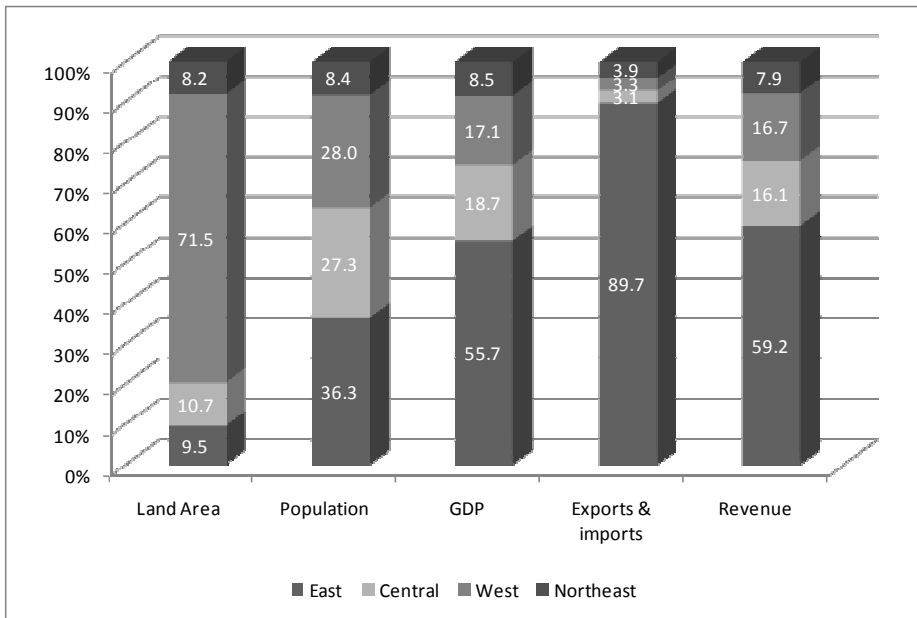
In general, social physics is a complex subjects which use the natural science's thinking mode, basic principles and methods to qualitatively and quantitatively

analyze the complex issues of society, economy and other complex issues. From Chinese social physics community’s point of view, there would be a understanding of the following framework to explore the mechanism in the process: (1) both natural systems or human systems, without exception, anywhere (space) and anytime (time) will emerge the "difference" absolutely; (2) as long as there are a variety of "differences" or "difference set", there will be bound to have a "gradient" in the broad sense; (3) as long as there is a broad sense of "gradient", there is bound to have a "power" in the broad sense; (4) as long as there is a broad sense of "power", there will be bound to have a "flow" in the broad sense [5]. Therefore, if there are differences in society, there will inevitably be “gradient”, “power” and “flow”.

On the basis of social physics theory, this paper primarily analyzes the disparities of regional economic in China, and based on this disparities, builds a concept model of China's inter-provincial population migration, and uses survey data to analyze it with social network analysis. The results will be a valuable reference for the building of a harmonious society.

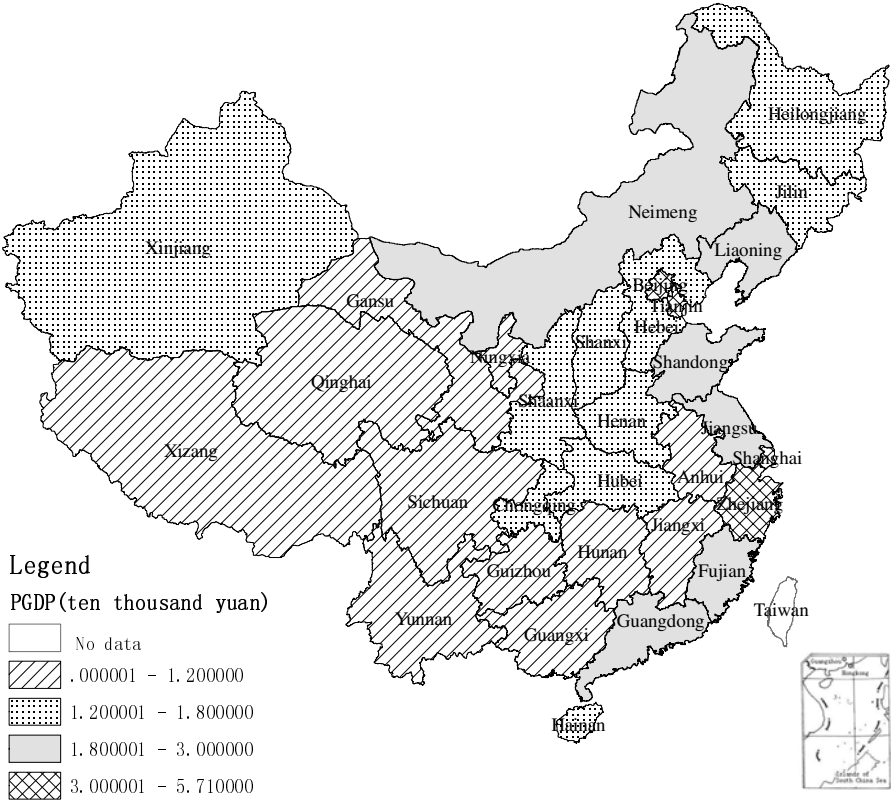
## 2 China’s Regional Disparity

Recognizing the difference is the base of analyzing the “power” and “flow”. According to the framework of social physics, the generation of “power” must be due to the existence of “differences”. China's inter-provincial differences are existed in many ways, this paper analyzes the inter-provincial differences from economic aspects.



Data source: National bureau of statistics of China.

**Fig. 1.** Regional disparity in land area, population, GDP, exports & imports, and revenue in China in 2006



Data source: National bureau of statistics of China.

**Fig. 2.** Regional disparity in per capita GDP in China in 2006

Since the reform and open door policy of the late 1970s, China has achieved magnificent economic growth. The fruits of the growth, however, have not been distributed fairly across China's regions. And it has become one of the important issues that the geographers, economists and government regulators concerned about [6]. In order to control rising regional disparity, China has shifted its focus from the coast onto the interior regions. The central government put the "western development strategy" into practice in 1998, with the "northeast revival strategy" following in 2003. Most recently, the "rise of central China" strategy has been implemented. But regional disparity in China continues to be serious [7].

China's regional disparity is mainly in the different development level of eastern, central, western and north-east region. There are a few definitions of the four zones, which are changing over time. Academic and official definitions are also sometimes inconsistent. We use the definition of national Bureau of Statistics of China, the eastern region includes the following 10 provinces and municipalities: Beijing, Tianjin, Hebei, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong and Hainan. The central



Data source: National bureau of statistics of China.

**Fig. 3.** Regional disparity in per capita income in China in 2006

region includes the following 6 provinces: Shanxi, Anhui, Jiangxi, Henan, Hubei and Hunan. The western region includes the following 12 provinces and municipalities: Inner Mongolia, Guangxi, Chongqing, Sichuan, Guizhou, Yunnan, Tibet, Shan’xi, Gansu, Qinghai, Ningxia and Xinjiang. The northeast region includes the following 3 provinces: Heilongjiang, Jilin and Liaoning.

Data shows that despite the efforts of the central government, regional disparity continued to widen during the period from the late 1990s to the early 2000s. Figure 1 shows the shares of land area, population, GDP, exports & imports, and revenue among eastern, central, western and northeast regions in 2006. Taking the indexes of each region into account, the east had disproportionately large shares of GDP, exports and imports, revenue. The central, western and northeast region in particular had negligible percentages of exports and imports, 3.1%, 3.3% and 3.9% respectively.

Per capita income and per capita GDP is important indicator which measure the level of regional development. Figure 2 shows the spatial distribution in the real per capita GDP of China’s provinces. Although the real per capita GDP of all the provinces increased significantly during 1979 to 2006, we can see a tremendous difference among the eastern, central, western and north-east region in spatial

distribution. In 2006, China's regional income distribution was clearly unequal in terms of real per capita GDP. The real per capita GDP of the richest region, Shanghai, was about ten times that of the poorest region, Guizhou.

Figure 3 shows the spatial distribution in the per capita income of China's provinces, this indicator composed by annual per capita disposable income of urban households and per capita net income of rural households. We also can see a tremendous difference among the eastern, central, western and north-east region in spatial distribution. The per capita income of the richest region, Shanghai, was about three times that of the poorest region, Guizhou.

### 3 Concept Model of Population Migration and Empirical Analysis

#### 3.1 Concept Model of China's Population Migration

Through analysis of previous, we can learn there are a variety of inter-province differences in China, these "economic differences" led to the "income gradient" between different regions and different income groups, and the existence of "income gradient" would certainly give rise to the existence of "income attraction power", the greater the "income gradient", The greater the "income attraction power", the society bound to lead to a variety of "flow" under the "income attraction power".

Economic differences would lead to the occurrence of multiple streams, such as population flow, capital flow, information flow, technology flow and so on, these flow have respective laws and intertwined, form a multi-layer, multi-dimensional network. In this paper, we take population migration network as an example, build concept model of China's Population migration under the economy differences(see Figure 4). It is worth noting that the population migration network only consider the economic differences, there is still a variety of differences in reality that will cause

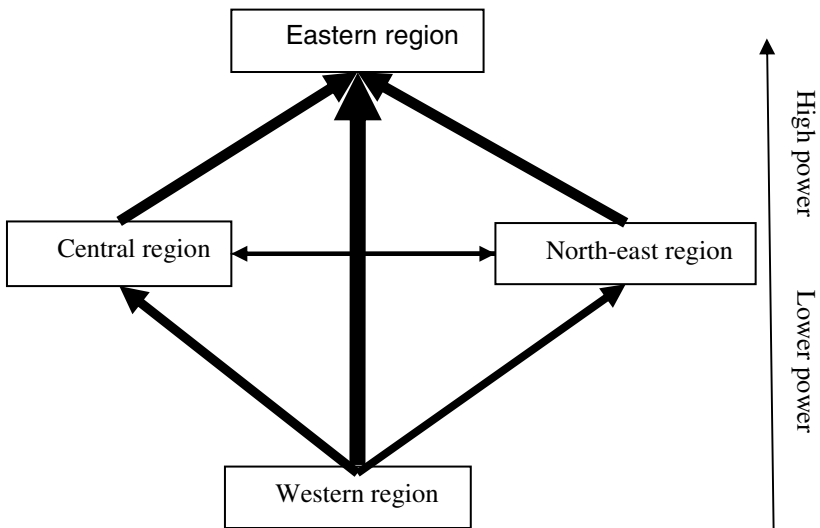


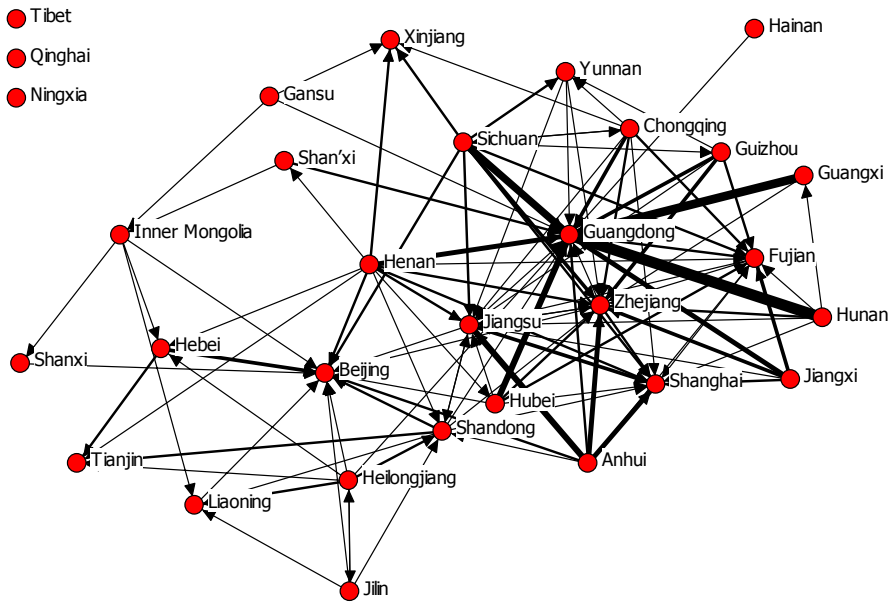
Fig. 4. Concept model of China's population migration

population migration, such as the differences in culture and climate, thus, the ultimate population migration networks is the stacking effect of variety differences that can cause population migration.

In figure 4, arrows indicate the direction of flow, the thickness of the lines indicate the scale of the flow. As can be seen from the figure, due to the existence of gradient, the relatively developed eastern region has become the first choice for the migration population in the central, western and north-eastern region. There is no doubt that a large number of immigrants will bring vitality to economy, but at the same time, it also will inevitably bring about social instability in a variety of factors, which we have encountered in some region, such as Beijing, Shanghai, Guangdong and other relatively developed provinces.

### 3.2 Empirical Analysis

Adopting the national 1% population sample investigation data in 2005 which investigated by national bureau of statistics of China, we construct a adjacency matrix that the migration population from the locus of registered permanent residence move to the current residence among 31 provinces. Adjacency matrix is a static and multi-dimensional arrays, the elements of matrix indicate the right value from one provinces to another provinces. Such as,  $X_{ij}$  indicate the number of population that migrate from provinces  $i$  to provinces  $j$ , by the same token, we can finally get a 31\*31 matrix. Use social network express this matrix, as shown in Figure 5. In which, node on



Data source: the national 1% population sample investigation in 2005

**Fig. 5.** Inter-provincial population migration network(The number is greater than 1000 person)

behalf of the provinces, the arrows indicate the flow of the population, the thickness of the lines indicate the number of population. For the sake of clarity, the figure does not show the link that the number of migration population less than 1,000 people, that is, if the migration population from provinces  $i$  to provinces  $j$  less than 1000, then  $x_{ij}=0$ , and there is no line from  $i$  point to  $j$ .

There are a number of indicators which can measure the weightiness of node and the network's overall structure [8]. Such as the network density, centrality, subgroup and role analysis, this paper use degree centrality and structural analysis to analyze the migration network. Centrality is an important indicator that can measure the superiority and privileges of the node in network [9]. There are four measures of centrality that are widely used in network analysis: degree centrality, betweenness, closeness, and eigenvector centrality. Degree centrality is defined as the number of links incident upon a node [10]. If the network is directed (meaning that ties have direction), then usually define two separate measures of degree centrality, namely outdegree and indegree.

Outdegree:

$$C_{DO}(n_i) = \sum_{j=1}^n X_{ij} \quad (1)$$

Indegree:

$$C_{DI}(n_j) = \sum_{i=1}^n X_{ij} \quad (2)$$

Where,  $n_i$  indicate province;  $X_{ij}$  is the adjacent matrix constructed based on inter-provincial population migration.

According to the formula (1) and (2), we get the outdegree and indegree of the network (Table 1). As can be seen from the table, the outdegree of Sichuan, Anhui, Hunan, Henan, Jiangxi and other regions are high, that mean these provinces are the main region which export population; the indegree of Guangdong, Zhejiang, Shanghai, Jiangsu, Beijing and other regions are high, that mean these provinces are the main region which absorb migrant population. This is consistent with Figure 1.

Next, in order to distinguish the role of various provinces in the network, structural analysis is applied. In this paper, we use Concor (Convergence of iterated correlations) method to analyze the network structure. Concor is an analysis method that based on correlation coefficient. The formula that calculate the correlation coefficient between two provinces as follows:

$$r_{ij} = \frac{\sum (x_{ki} - \bar{x}_{\cdot i})(x_{kj} - \bar{x}_{\cdot j}) + \sum (x_{ik} - \bar{x}_{\cdot i})(x_{jk} - \bar{x}_{\cdot j})}{\sqrt{\sum (x_{ki} - \bar{x}_{\cdot i})^2 + \sum (x_{ik} - \bar{x}_{\cdot i})^2} + \sqrt{\sum (x_{kj} - \bar{x}_{\cdot j})^2 + \sum (x_{jk} - \bar{x}_{\cdot j})^2}} \quad (3)$$

for  $i \neq k, j \neq k$  .

Where,  $\bar{X}_i$  is the average of all provinces emigrate to i province,  $\bar{X}_i$  is the average of i province emigrate to all provinces,  $X_{ki}$  indicate the population that k province emigrate to i province.

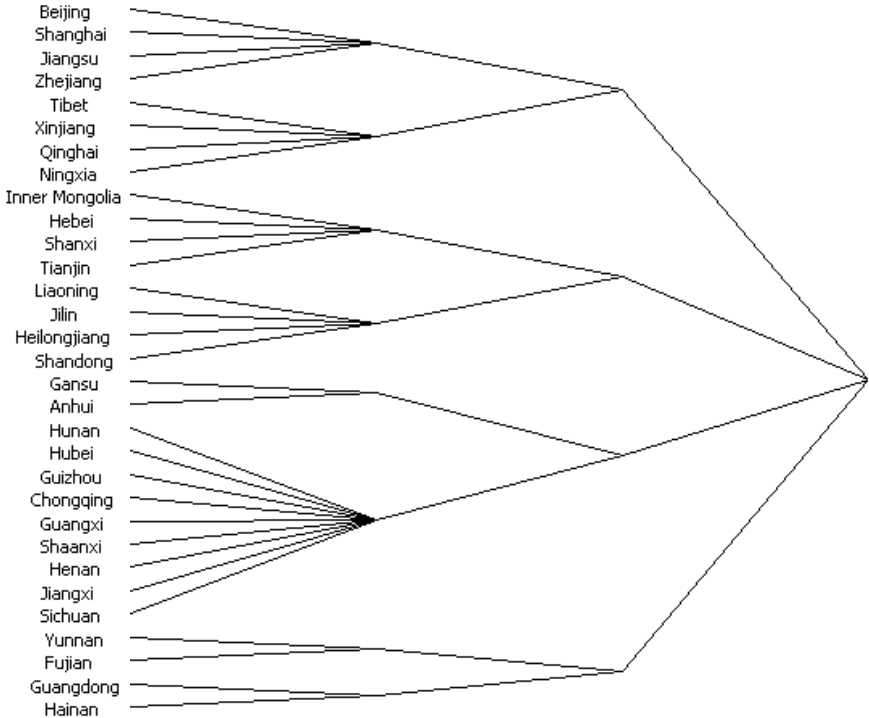
Use formula (3), we can get the first correlation coefficient matrix among the 31 provinces. Concor method is based on this matrix. Using formula (3) to calculate the first matrix, the second matrix is get, and then repeat the calculation, the correlation coefficient would be convergence step by step. Based on the results of convergent matrix, cluster is made[11]. According to Concor methods, China's inter-provincial population migration network can divide into 8 categories, the clustering show in Figure 6.

**Table 1.** Outdegree and indegree of the inter-provincial population migration network

ID	Province	OutDegree	InDegree	NrmOutDeg	NrmInDeg
23	Sichuan	77351	6603	5.732	0.489
12	Anhui	76042	4552	5.635	0.337
18	Hunan	61636	4209	4.568	0.312
16	Henan	59692	3667	4.423	0.272
14	Jiangxi	49056	3307	3.635	0.245
17	Hubei	47014	6008	3.484	0.445
20	Guangxi	37467	4849	2.777	0.359
22	Chongqing	30784	4631	2.281	0.343
24	Guizhou	30601	5032	2.268	0.373
10	Jiangsu	23606	55973	1.749	4.148
8	Heilongjiang	20940	5217	1.552	0.387
15	Shandong	18830	16768	1.395	1.243
3	Hebei	18541	11494	1.374	0.852
11	Zhejiang	16270	81989	1.206	6.076
27	Shan'xi	14209	4966	1.053	0.368
13	Fujian	12844	37453	0.952	2.775
7	Jilin	10840	3982	0.803	0.295
28	Gansu	8835	2133	0.655	0.158
5	Inner Mongolia	8815	9288	0.653	0.688
25	Yunnan	8592	10653	0.637	0.789
6	Liaoning	6461	14636	0.479	1.085
19	Guangdong	5566	215994	0.412	16.006
4	Shanxi	5135	5434	0.381	0.403
21	Hainan	2215	3863	0.164	0.286
31	Xinjiang	2054	13572	0.152	1.006
1	Beijing	1972	44903	0.146	3.328
9	Shanghai	1854	61298	0.137	4.543
29	Qinghai	1635	1628	0.121	0.121
2	Tianjin	1384	15602	0.103	1.156
30	Ningxia	1295	1531	0.096	0.113
26	Tibet	259	560	0.019	0.041

Note: NrmOutDeg is normalized outdegree centrality, NrmInDeg is normalized indegree centrality.





**Fig. 6.** Clustering of population migration network use Concor method

We can see clearly from the figure that the classification has obvious geographical characteristics. Beijing, Shanghai, Jiangsu, Zhejiang is the major areas of absorbing migrant population, and the four provinces all in the eastern region; Hunan, Hubei, Guizhou, Chongqing, Guangxi, Shan'xi, Henan, Jiangxi, Sichuan is the main area of emigrating population, most of them are in central region; Liaoning, Jilin, Helongjiang, Shandong is clustered into a category. They are all in northeast region except Shandong. The main feature of this category is population migration mainly restricted in these areas; Tibet, Xinjiang, Qinghai, Ningxia have the characteristics of less immigration and less emigration, all in the western region and relatively closed; Inner Mongolia, Hebei, Shanxi and Tianjin is clustered into a category, the main feature of this category is emigrant population mainly enter into Beijing. Gansu and Anhui is clustered into a category, the flow of emigrant population in this category is relatively dispersed. Yunnan and Fujian's emigrant population are mainly enter into Jiangsu, Zhejiang and Guangdong, and the immigrant population are mainly from Sichuan, Chongqing and Guizhou. In Guangdong and Hainan, there are a large number of immigrant populations and few emigrant populations.

#### 4 Summary and Discussion

Population migration is a very complex process, which involve a variety of factors. Based on the analysis of economy disparity, this paper builds a concept model of

China's regional population migration, and empirical analyzed with the national 1% population sample investigation. The results may provide important information for policy-makers to carry out macro-control and social management. However, due to space limitations, this paper does not discuss the measures and policies. In short, social physics theory provides good ideas for solving social problems, and social network analysis is a very effective tool in solving social problems.

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