Scaling and Simulation on Measuring Regional Economic Disparities based on Grid

Spatial Scaling Effect analysis

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Abstract- The measurement of regional economic disparities is a scientific issue, closely related with scale. Based on Geographical information system (GIS) technology, selecting Lorenz curve, GINI coefficient and THEIL coefficient as the measuring index, this paper discusses the spatial scaling effect using grid method by up scaling. The main findings are as follows: With the increase of spatial grain in size, GINI coefficient and THEIL coefficient both present a decreasing tendency and the degree of downward bending of Lorenz curve is also decreasing, which all show regional economic disparities decrease. With the first 3-7 increase of spatial extent, GINI coefficient and THEIL coefficient change greatly and they are no obvious regularity. Since then, the measuring results tend to stabilization with the increase of spatial extent. On the large scale, the whole spatial rule is easy to find, but the details on the small scale are omitted. Meanwhile, on the small scale, the micro rules are easy to find, but the macro rule cannot be presented. Therefore, the suitable scale in the study of regional economic disparities can be determined by the specific research purpose and research object.

Keywords- regional economic disparities; scaling; grid; GIS

I. INTRODUCTION

Since the 1970s, the regional economic disparity of China has been one of the cores of academia. Different scholars have done much valuable research work [1-17], but according to different scholars, the conclusions are different. The reasons are the differences such as analytical method, statistical index, research angle, etc. but more important, is the difference of temporal-spatial scale [18].

Scale is a basic scientific issue in both natural and societal science fields, and its implication is different in different discipline. Geographers think that scale is the hierarchies of charactering, experiencing and organizing geographical event and geographical process [19]. Ecologists think that scale is the temporal or spatial measurement of research objects or phenomena [20]. Remote sensing experts think that scale is the spatial measuring scope and temporal measuring interval to measure earth from space [21]. These shows the emphasis is different in different disciplines. S C Li has summarized scale to: intrinsic scale and non-intrinsic scale. Intrinsic scale exists objectively and is hidden in natural entity unit, pattern and process, while non-intrinsic scale is a subjective scale.

From theory, regional economic disparity is a scientific issue, closely related with scale [22]. Scale here includes temporal scale and spatial scale. Temporal scale includes temporal grain and temporal extent, and spatial scale includes spatial grain and spatial extent. Grain is the smallest temporal unit or spatial unit. Extent is the temporal scope or spatial scope that regional economic disparities contribute. The implication of scale in regional economic disparities is opposite to that in Geography or Cartography. Large scale corresponding to small scale or low resolution in Geography and Cartography usually represents large spatial scope or spatial grain in size, and small scale corresponding to large scale and high resolution in Geography and Cartography usually represents small spatial scope or spatial grain in size.

Scaling is the important research content of scale. Scale is a static concept, which only characterizes the temporal-spatial feature of pattern or process, while scaling is the connection of different pattern or process and it imply changes. Scaling include formally up scaling and down scaling. By up scaling, the results on the small scale can be deduced to that on the large scale. On the contrary, by down scaling, the macro data or results can be deduced to that on the local area [23]. The scaling methods mainly include: regression analysis method, semivariable function method, autocorrelation analysis method, spectra analysis method, fractal method, wavelet analysis method, hierarchical theory, grid method, grid computing, remote sensing and Geographical Information System technology, etc.

The most study of regional economic disparities of China is based on special spatial scale: three belts (the east belt, the central belt, the west belt) scale, 30 or 27 province urban districts scale. In addition, some study is based on southern region and northern region scale, some is based on southeast region, northeast region and west region scale and some is based on county scale. Some scholars also study the regional economic disparities of China in multi-spatial scale based on THEIL coefficient decomposition method [18]. Different

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measuring scales have important influences on the measuring results of regional economic disparities. If the spatial extent is same, the results are different based on the different size of spatial grain, even the theory, index, model and time are all same. Similarly, if the spatial grain is fixed in size, the measuring results are also different with the change of spatial extent. The literatures about multiple spatial scales of regional economic disparities are rare, especially about the scaling. Therefore, it is necessary to fully research scaling effect of regional economic disparities, which has not only great academic significance for scientific understanding of the rules of regional economic development but also important practical meaning for making regional development policy.

Based on Geographical information system (GIS) technology, selecting Lorenz curve, GINI coefficient and THEIL coefficient as the measuring index, this paper discusses the spatial scaling effect from two aspects using grid method by up scaling: as spatial extent stays the same, the scaling effect of regional economic disparities with the change of spatial grain in size; as spatial grain in size stays the same, the scaling effect of regional economic disparities with the change of spatial extent.

II. METHODOLOGY

Selecting Lorenz curve, GINI coefficient and THEIL coefficient as measuring index, this paper studies the scaling effects of regional economic disparities based on up scaling using grid method. The study region is regularly meshed. Every cell represents a region and has been given population attribute and GDP attribute. Therefore, the size of a cell determines the size of spatial grain. The different spatial extents are obtained by continuously increasing cells along diagonal.

A. Measuring Index

1) GINI coefficient

In measuring methods of GINI Coefficient, the most commonly used formula can be defined as [24]:

$$G = 1 - \sum_{i=1}^{n} p_i (2Q_i - w_i) \tag{1}$$

Where

$$Q_i = \sum_{k=1}^{n} w_i \tag{2}$$

Data is sorted in ascending order based on per capita income. Where w_i is income proportion, and p_i is population proportion.

2) THEIL Coefficient

THEIL Coefficient can be expressed as [25]:

$$T = \sum_{i=1}^{n} y_i \log \frac{y_i}{p_i} \tag{3}$$

Where y_i is income proportion, p_i is population proportion.

3) Lorenz curve

Lorenz curve can be used to represent income distribution, where the percentage of cumulative population is plotted on the x-axis; the percentage of cumulative income is plotted on the y-axis. The degree of downward bending of Lorenz curve represents the degree of regional economic disparities.

B. Spatial Grain

The research region is regularly meshed. Every cell has been given randomly population data and GDP data. The size of spatial grain increases by different spatial merged rules.

1) Merged rules of 2*2

The study region is meshed by 100*100 cells. Based on this spatial grain, Lorenz curve is plotted; GINI coefficient (G1) and THEIL coefficient (T1) are calculated. The spatial grains increase in size by merging 2*2 cells into one cell (Fig.1). That is, the data of four cells is added and merged into the data of one cell, thus spatial scale of 50*50 cells is obtained. Following the same rule, spatial scales continue to increase and spatial scale of 25*25 cells is obtained. Based on the different spatial grain in size, Lorenz curves are respectively plotted; GINI coefficient (G1) and THEIL coefficient (T1) are respectively calculated.

2) Merged rules of 3*3

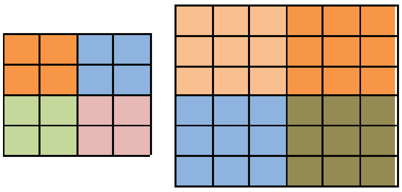
The study region is meshed by 90*90 cells. Based on this spatial grain, Lorenz curve is plotted; GINI coefficient (G1) and THEIL coefficient (T1) are calculated. The spatial grains increase in size by merging 3*3 cells into one cell (Fig.1). That is, the data of nine cells is added and merged into the data of one cell, thus spatial scale of 30*30 cells is obtained. Following the same rule, spatial scales continue to increase and spatial scale of 10*10 cells is obtained. Based on the different spatial grain in size, Lorenz curves are respectively plotted; GINI coefficient (G1) and THEIL coefficient (T1) are respectively calculated.

3) Merged rules of 5*5

Based on 100*100 cells, Lorenz curve is plotted; GINI coefficient (G1) and THEIL coefficient (T1) are calculated. The spatial grains increase in size by merging 5*5 cells into one cell. That is, the data of 25 cells is added and merged into the data of one cell. Spatial scales of 20*20 cells and 4*4 cells are respectively obtained. Based on the different spatial grain in size, Lorenz curves are respectively plotted; GINI coefficient (G1) and THEIL coefficient (T1) are respectively calculated.

4) Randomly merged rules

Based on 100*100 cells, Lorenz curve is plotted; GINI coefficient (G1) and THEIL coefficient (T1) are calculated. Under the constraint of connectivity among spatial units, all the spatial cells are merged randomly into 1000 cells. Following the same rule, the cells are further merged randomly into 100 cells and 10 cells. Based on the different spatial grain in size, Lorenz curves are respectively plotted; GINI coefficient (G1) and THEIL coefficient (T1) are respectively calculated.



a. 2*2 merged b. 3*3 merged

Figure 1. The rules of grain increase in size

C. Spatial extent dividing

The study region is meshed by 100*100 cells. Fig.2 shows the method of spatial extent divided. The basic spatial extent is 5*5 cells. Spatial extent of 10*10 cells is obtained by continuously increasing cells along the diagonal. Following the same rule, different spatial extent of 15*15 cells, 20*20 cells, 25*25 cells and so on are respectively gotten. Based on the different spatial extent, Lorenz curves are respectively plotted; GINI coefficient (G1) and THEIL coefficient (T1) are respectively calculated.

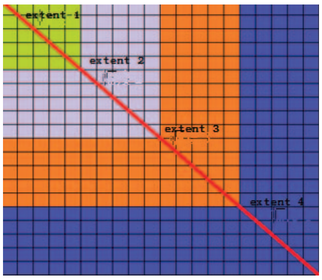


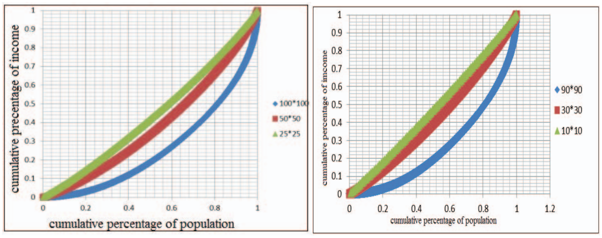
Figure 2. Spatial extent division

III. SCALING EFFECT ANALYSIS

A. Multi-scale Analysis Based on Different Spatial Grain in Size

The partial measuring results show in Fig.3 and table 1. Based on the rules of 2*2 merging and 3*3 merging, GINI coefficient and THEIL coefficient both decrease and the degree of bending of Lorenz curve (Fig.3) also decrease with the increase of spatial grain in size. As tab.1 shown, by 5*5 merged rule, GINI coefficient are respectively 0.482, 0.0864, 0.013 based on 100*100, 20*20 and 4*4 spatial scale, which shows that GINI coefficient take a decreasing trend with the increase of spatial grain in size. THEIL coefficient presents the same tend and the degree of bending of Lorenz curve also decrease. By the rule of randomly merging, GINI coefficient is 0.488 and THEIL coefficient is 0.227 based on 100*100 scale; GINI coefficient is 0.149 and THEIL coefficient is 0.0157 based on 1000 cells; GINI coefficient is 0.046 and THEIL coefficient is 0.025 based on 100 cells; GINI coefficient is 0.013 and THEIL coefficient is 0.008 based on 10 cells, which all show the regional economic disparities decrease with the increase of spatial grain in size.

In a word, regional economic disparities present decreasing tendency with the increase of spatial grain in size. That is, the spatial heterogeneity has decreased and many details on the small grain have been omitted.



a. 2*2 merged b. 3*3 merged

Figure 3. Lorenz curves based on different spatial grain in size

TABLE I. PARTIAL MEASURING RESULTS OF GINI COEFFICIENT AND THEIL COEFFICIENT

scale	*G1*	*G2*	*T1*	*T2*
100*100	0.488	0.486	0.227	0.218
1000 cells	0.149	0.079	0.0157	0.023
100 cells	0.046	0.025	0.0015	0.0021
10 cells	0.013	0.008	0.0001	0.0002
100*100	0.482	0.478	0.2167	0.21
20*20	0.0864	0.0844	0.0054	0.005
4*4	0.013	0.015	0.0001	0.0002

B. Multi-scale Analysis Based on Different Spatial Extent

The partial measuring results show in table II and Fig.4. With the first 3-7 increase of spatial extent, GINI coefficient and THEIL coefficient change greatly and they are no obvious regularity. Since then, the measuring results tend to stabilization with the increase of spatial extent. From fig.4, we can find that GINI coefficient and THEIL coefficient change greatly with the first several times increase of spatial extent, but at last, GINI coefficients stay about 0.47 and THEIL coefficients stay about 0.21.

In brief, with the increase of spatial extent, the nonlinear characteristic decrease and linear characteristic increase, thus the whole spatial rule has been presented.

CONCLUSION

From the above study, we can conclude:

(1) With the increase of spatial grain in size, GINI coefficient and THEIL coefficient both decrease and the degree of bending of Lorenz curves also decrease, which shows that regional economic disparities decrease. That is, with the increase of spatial grain in size, spatial heterogeneity decrease and the details on the small grain have been omitted.

(2) With the first several times increase of spatial extent, the measuring results change greatly and have no obvious regularity, but the results tend to stability at last, which shows that with the increase of spatial extent, linear characteristics increase and the whole spatial rule has been presented.

(3) The measuring results are related closely with scale. On the large scale, we pay more attention to the whole rule, but the details on the small scale are omitted. On the small scale, the micro rules can be found easily, but the macro tangency cannot be taken. Therefore, the suitable spatial scale in measuring regional economic disparity is determined by specific research purpose and research object.

TABLE II. PARTIAL MEASURING RESULTS BASED ON DIFFERENT SPATIAL EXTENT

extent	*G1*	*T1*	*G2*	*T2*	*G3*	*T3*	*G4*	*T4*
5*5	0.537	0.412	0.342	0.094	0.558	0.288	0.408	0.129
10*10	0.461	0.229	0.404	0.154	0.503	0.257	0.509	0.253
15*15	0.477	0.229	0.439	0.176	0.501	0.262	0.483	0.213
20*20	0.469	0.217	0.474	0.205	0.489	0.247	0.494	0.218
25*25	0.475	0.223	0.475	0.201	0.476	0.228	0.487	0.213
30*30	0.462	0.208	0.477	0.206	0.478	0.22	0.483	0.21
35*35	0.465	0.208	0.475	0.204	0.482	0.224	0.482	0.208
40*40	0.47	0.21	0.474	0.204	0.474	0.216	0.473	0.199
45*45	0.467	0.204	0.473	0.206	0.481	0.219	0.476	0.202
50*50	0.471	0.209	0.475	0.206	0.478	0.216	0.476	0.203
55*55	0.472	0.215	0.478	0.21	0.48	0.216	0.475	0.201
60*60	0.476	0.217	0.474	0.204	0.483	0.218	0.472	0.198
65*65	0.478	0.22	0.475	0.208	0.484	0.219	0.472	0.197
70*70	0.478	0.221	0.474	0.207	0.484	0.219	0.472	0.198
75*75	0.481	0.223	0.475	0.208	0.481	0.217	0.475	0.2
80*80	0.482	0.224	0.475	0.209	0.482	0.216	0.475	0.201
85*85	0.48	0.222	0.476	0.21	0.48	0.214	0.476	0.202
90*90	0.479	0.221	0.478	0.213	0.481	0.216	0.476	0.202
95*95	0.479	0.219	0.477	0.213	0.48	0.215	0.475	0.2
100*100	0.481	0.221	0.478	0.213	0.481	0.215	0.476	0.201

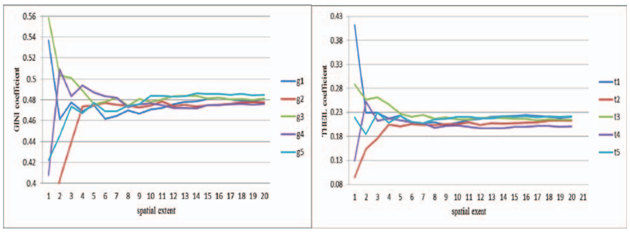


Figure 4.The measuring results based on different spatial extent

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