Income Disparity among Chinese Cities: Evidence, Decomposition, and Future Prospects

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The International Centre for the Study of East Asian Development, Kitakyushu
Income Disparity among Chinese Cities:
Evidence, Decomposition, and Future Prospects

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Income Disparity among Chinese Cities: Evidence, Decomposition, and Future Prospects

Abstract
Although income disparity in China is a longstanding and frequently studied problem, scholars only recently have begun to examine income disparity among China’s smaller geographic regions, notably cities or prefectures. This study extends scholarly thread using data from the China City Statistical Yearbook. Income disparity among cities is analyzed using a statistical indicator, followed by a decomposition analysis that divides Chinese cities into eastern and western regions. Then a simulation analysis of the change in income disparity created by city growth is conducted using a simple urban growth model. Data show that during the period 1994–2008 urban income disparity expanded, as did provincial income disparity. Growing income disparity between eastern and western Chinese cities is an important factor in the expansion of disparity. Our simulation shows that income disparity is reduced by enhancing the mobility of labor and capital.

JEL classification: C61, O18, O41, O53, R11, R23
Keywords: Income disparity, City level, China
1. Introduction

China has sustained high economic growth since initiating reforms in the late 1970s, and urbanization advanced quickly alongside economic development. According to the Urban Blue Book: China City Development Report No.3, China’s urban population reached 620 million people in 2009, three times greater than the U.S. population and 25% larger than the combined population of the 27 nations in the European Union. In 2009, China’s urbanization rate reached 46.6%, leading the world’s scale of urbanization. China’s urbanization is expected to advance, and its urban population is projected to exceed its rural population in the near future. Although urbanization is generally regarded as desirable, social problems accompany it and income disparity, both within and among cities, exists. This paper addresses income disparity among cities.

China’s regional income disparity is a longstanding and frequently studied problem. Studies mainly use provincial output data such as per capita gross domestic product or gross regional product (GRP), and they observe that inter-province disparities in China decreased after 1979. In a 1986 study of urban households, Knight and Song (1991) show that China’s urban wage structure is extremely compressed. In contrast, provincial disparities have grown, with the coastal and inland regions showing rising disparities since the mid- or late 1980s. However, studies of income disparity among smaller geographic divisions, such as cities or prefectures, are comparatively recent primarily because available data are not substantial. Among the few studies, Xu and Li (2004) examined income disparity among cities and Sakamoto and Fan (2010) among prefectures. Unfortunately, Xu and Li (2004) examined the period 1989–1999, and their findings are no longer valid. Analysis using the latest statistical data is required, and it is possible to find richer evidence by analyzing smaller geographic divisions than by analyzing provincial data, overcoming at least some problems of data constraints.

This study analyzes income disparity among cities using a statistical indicator. We then conduct a simulation analysis of the change in disparity by city growth using a simple urban growth model. Xu and Li (2004) showed decreasing declining trend in income disparity among cities using β and σ convergence methodologies. If we assume that cities perform similar functions irrespective of their size, income disparity among cities may be reduced. However, researchers generally consider that urban income disparity parallels a well-documented income disparity among China’s provinces. If they are correct, urban

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1 This is written by the Institute for Urban and Environmental Studies Chinese Academy of Social Sciences and Social Sciences Academic Press (China).
2 For instance, Tsui, 1991; Chen and Fleisher, 1996; Jian et al., 1996; Raiser, 1998; Khan et al., 1999; Fujita and Hu, 2001; Cai et al., 2002; Bhalla et al., 2003; Meng, 2004; Kanbur and Zhang, 2005; Demurger et al., 2006; Tsui, 2007; Sakamoto and Islam, 2008; Ramstetter et al., 2009; Fleisher et al., 2010; and Lau, 2010.
3 However, Sakamoto and Fan (2010) focus only on counties of the Yangtze River Delta.
income disparity may also be expanding.4

2. Evidence of City Disparity

China’s administrative boundaries are complicated. Three types of areas are referred to as a “city” (shi). Designated cities—for example, Beijing, Tianjin, Shanghai, and Chongqing—are treated same as provincial (government) level. Area-level cities include prefectures and prefecture-level cities. The final category, xian ji shi, includes cities that receive the same treatment as prefectures. This study analyzes designated cities and area-level cities.5

First, we discuss income disparity among Chinese cities drawing data from the China City Statistical Yearbook6 for the period 1994−2008. Although the examined period may seem brief, Chinese cities changed substantially during that time. Areas previously not treated as cities became treated as such when they met the criteria for population or industrial structure.7 Therefore, although the number of Chinese cities is rising, the number included in this study suffers from sample exclusion arising from the defect of data (Table 1).

Table 2 compares aggregated data from the China City Statistical Yearbook and data from the China Statistical Yearbook. Although Table 1 shows that the number of cities is increasing, population data reflect approximately 80%−90% of China’s population throughout the period. This is because the rural population is contained in areas currently called Cities. On the other hand, GRP will exceed the figure reported in the China Statistical Yearbook, and most probably each city’s GRP has been over estimated. When economic growth is an important evaluation matter for (the government officers of) the province or the city government, GRP is released superfluously in many cases. However, since this is appropriately adjusted with a state level, the way of the number of the China Statistical Yearbook becomes small. Even if examinations of Chinese income disparity use city data drawn from comparisons of these two sources, the entire country generally can be analyzed.

This study adopts two statistical methods to interpret evidence of urban income disparity in China. One is the popular Theil index of disparity (Theil, 1967).

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4 China’s urban income disparities are also discussed outside China. Gluhih and Portnov (2004) proposed coordinate transformations to visualize the pattern of inter-urban income disparities and their dynamics in Israel during 1991 and 1999.
5 In statistical analysis, a prefecture-level city is always treated using prefectural-level data.
6 These data are compiled by Nippon Statistics Center (http://www.nihon-toukei.co.jp/).
7 To qualify as a city in 1993, a municipal district had to contain a non-farm population of 250,000 or more and a GRP of 2,500 million Yuan or more. Its material production (agriculture and industry) had to be 2,500 million Yuan or more, of which industrial production should not be less than 80% and the share of tertiary industry should at least 35%. Its fiscal revenue had to be 200 million Yuan or more. A municipal-government prefecture contained a non-farm population of 200,000 or more. (Notice from the State Affairs Administration of China on May 17, 1993, http://www.siping.gov.cn/spqy/falu/htm/daohang/xzf/mz/mz_data/18.txt).
\[ T_i = \sum \left( \frac{Y_{t,i}}{\sum_j N_{t,i,j}} \right) \log \left( \frac{\sum_j Y_{t,j}}{\sum_j N_{t,j}} \right) \] (1)

where \( Y_{t,i} \) is the GRP of city \( i \) at time \( t \) and \( N_{t,i} \) is the population of city \( i \) at time \( t \).

The Theil index can decompose samples and investigate the factor analysis of regional disparities. For example, China can be divided into the eastern region that is economically developed and the western region that lags economically, enabling an east–west disparity to be analyzed. In this case, we redefine the index to adopt two stages from Eq. (1).

\[ T_i = \sum \sum \left( \frac{Y_{t,k,i}}{\sum_j N_{t,k,i,j}} \right) \log \left( \frac{\sum_r \sum_j Y_{t,r,j}}{\sum_r \sum_j N_{t,r,j}} \right) \] (2)

where \( k \) is region (east or west). Then the Theil index of each region is defined as

\[ T_{t,k} = \sum \left( \frac{Y_{t,k,i}}{\sum_j N_{t,k,i,j}} \right) \log \left( \frac{\sum_j Y_{t,k,j}}{\sum_j N_{t,k,j}} \right) \] (3)

In that case, the Theil index is decomposed as

\[ T_t = \sum_k \left( \frac{\sum_j Y_{t,k,j}}{\sum_r \sum_j Y_{t,r,j}} \right) T_{t,k} + \sum_k \left( \frac{\sum_j Y_{t,k,j}}{\sum_j N_{t,k,j}} \right) \log \left( \frac{\sum_j Y_{t,k,j}}{\sum_j N_{t,k,j}} \right) \] \[ \text{log} \left( \frac{\sum_r \sum_j Y_{t,r,j}}{\sum_r \sum_j N_{t,r,j}} \right) \] (4)

The right-hand side of Eq. (4) indicates the Theil index between the two regions.

\[ T_{t,\text{inter}} = \sum_k \left( \frac{\sum_j Y_{t,k,j}}{\sum_r \sum_j Y_{t,r,j}} \right) \log \left( \frac{\sum_j Y_{t,k,j}}{\sum_j N_{t,k,j}} \right) \] \[ \text{log} \left( \frac{\sum_r \sum_j Y_{t,r,j}}{\sum_r \sum_j N_{t,r,j}} \right) \] (5)

Therefore, overall disparity can be decomposed into intra-city disparities for each region and inter-regional disparities between the two regions:

---

8 Since no reliable data for real growth rates exist, nominal GRP data are used.

9 In our definition of the two regions, eastern cities belong to the following provinces (cities): Beijing, Tianjin, Hebei, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, and Hainan. Western cities belong to China’s other provinces (cities).

10 Akita and Alisjahbana (2002) and Akita (2003) are representative of studies that use two-stage nested Theil decomposition to analyze regional disparity.
Next, we investigate the change in disparity by approximating the density function. The Theil index provides only summarized information about the distribution of disparities. Density function estimation is more effective in examining the details of the distribution change (Quah, 1996, 1997; Sakamoto and Islam, 2008; Sakamoto and Fan, 2010).\textsuperscript{11}

The procedure for approximating the distribution density is as follows. Let $Y_{t,i}/N_{t,i}$ denote the per capita GRP of city $i$ at time $t$. The denominator of the second equation is the cross-section average of $Y_{t,i}/N_{t,i}$. We first want to abstract from the shift in the mean of the distribution, as reflected in the secular movement. We therefore normalize data for different years by their respective cross-section means and take the log as the variable for analysis. We denote this variable as $Z_{t,i}$ so that

$$Z_{t,i} = \log \left( \frac{Y_{t,i}}{\sum_j Y_{t,j}} \frac{N_{t,i}}{\sum_j N_{t,j}} \right) = \log \left( \frac{Y_{t,i}}{N_{t,i}} \frac{\sum_j Y_{t,j}}{\sum_j N_{t,j}} \right)$$  \hspace{1cm} (7)

We begin by approximating the actual distribution of $Z_{t,i}$ for the selected years using the Gaussian normal kernel (Silverman, 1986). The density function used for the approximation is

$$f(Z_t) = \frac{1}{h} \sum_i \frac{N_{t,i}}{\sqrt{2\pi}} \exp \left( -\frac{1}{2} \left( \frac{Z_t - Z_{t,i}}{h} \right)^2 \right)$$  \hspace{1cm} (8)

where $Z_{t,i}$ is an observed value of the variable for city $i$ at time $t$, and $h$ is the window width (assumed to be 0.20 in this study\textsuperscript{12}). The range of $Z$ is assumed to be between $-2.60$ and $2.60$. This function can also decompose samples into an eastern region and a western region, and can draw a density function.

Figure 1 measures the Theil index in a period. Contribution to the disparity index is shown in Table 3. Except for some periods, the index rises. That is, income disparity tends to expand contrary to the findings of Xu and Li (2004). The earlier studies cited here mention this same rising tendency in provincial income disparity. When the contribution of disparity is seen, the disparity among eastern region cities is conspicuous during the measured period beginning in 1994, though the disparity

\textsuperscript{11} Other applications of this approach are given by Hao and Zou (2008), He and Zhang (2007), and Xu and Wang (2008).

\textsuperscript{12} Per Silverman’s rule (Silverman, 1986), Gaussian kernel density is of the window width $h_n = 0.9 \cdot \text{Std} \cdot \text{Num}^{-1/5}$. Std is the standard deviation, and Num is the sample size.
seldom spread thereafter. Therefore, the increased disparity between cities in the eastern and western regions is attributable to the rising disparity among cities in the west. However, note that the number of samples in a measurement year differ in Table 1. Perhaps the income disparity among cities expanded because incomes in areas newly designated as cities was comparatively low. Particularly, the number of cities in the west rose from 126 to 200 (Table 1), and it is believed that income in these cities increased less than the previously defined city. To judge whether this supposition is correct, analysis by kernel density function is needed.

Figures 2−5 measure the income distribution in specific years using a kernel density function. Beginning from 1994, income distribution widens—i.e., income disparity expands. In high-income cities, which shows around 1.5 in the log of relative income (Z in Eq. (7)), the density rises comparatively less. In low-income cities, density rises in the comparatively wide range of −0.8 to −1.8. Differences between the regions are due to the findings that eastern cities are comparatively wealthy, whereas western cities are comparatively poor. Moreover, the tendency is conspicuous. There is the possibility of a bimodal distribution in provincial income disparity observed by Sakamoto and Islam (2008) for eastern cities and by Zhou and Zou (2008) for prefecture-level cities in China.

3. Simple Simulation for Decreasing Disparity

The previous section made it clear that income disparity among cities in China’s urban areas expanded. Although it is important for China’s economic development that the country urbanizes, expanding income disparity among developed cities is a big problem, and a policy to reduce disparity is required. We conclude that it is important to improve mobility of production factors among cities. Our conclusion is confirmed by economic theory (Barro and Sala-i-Martin, 2004) and mirrored by earlier policy suggestions (Chen et al., 2010). This section uses a simple economic model to analyze how improving the mobility of labor and capital reduces income disparity in the simulation.

First, to model a city’s income, we adopt a simple economic growth model with a Cobb–Douglas production function as follows:

\[
Y_{t,j} = \gamma_{t,j} \cdot L_{t,j}^{\alpha} \cdot K_{t,j}^{(1-\alpha)} \quad (9)
\]

where \(L\) and \(K\) are labor and capital, respectively, \(\alpha\) is a share parameter, and \(\gamma\) is a parameter for total factor productivity. According to profit maximization (or cost minimization) problem, first-order conditions of \(L\) and \(K\) are denoted as follows:

\[
P K_{t,j} \cdot K_{t,j} = (1 - \alpha) \cdot P Y_{t,j} \cdot Y_{t,j} \quad (10)
\]
\[ PL_{t,j} \cdot L_{t,j} = \alpha_i \cdot PY_{t,j} \cdot Y_{t,j} \]  \hspace{1cm} (11)

where \( PL \) and \( PK \) are prices of labor and capital, respectively. We assume the price of \( Y (PY) \) as a numeraire.

\[ PY_{t,j} = 1 \]  \hspace{1cm} (12)

Labor and capital are growing dynamically. Their dynamic equations are specified as

\[ L_{t+1,j} = L_{t,j} \cdot (1 + NR) + ML_{t,j} \]  \hspace{1cm} (13)

\[ K_{t+1,j} = (1 - \delta) \cdot K_{t,j} + i r \cdot Y_{t,j} + MK_{t,j} \]  \hspace{1cm} (14)

where \( NR \) is the exogenous labor growth rate, \( \delta \) is the exogenous depreciation rate, and \( i r \) is the exogenous investment rate. We assume these rates are 0.01, 0.05, and 0.40, respectively.\(^{13}\)

\( ML \) and \( MK \)—the highlights of this model—are the total of inter-city movement of labor and capital, respectively. Fukuchi’s (2000) gravity model is adopted using each price difference between two cities.

\[ ML_{t,j} = \sum_j [\varepsilon_{i,j} \cdot \frac{L_{t,j} \cdot L_{t,j}}{\sum_j L_{t,j}} \cdot \log \left( \frac{PL_{t,j}}{PL_{t,j}} \right)] \]  \hspace{1cm} (15)

\[ MK_{t,j} = \sum_j [\varepsilon_{i,j} \cdot \frac{K_{t,j} \cdot K_{t,j}}{\sum_j K_{t,j}} \cdot \log \left( \frac{PK_{t,j}}{PK_{t,j}} \right)] \]  \hspace{1cm} (16)

If the price of labor (capital) in one city is higher than in another, labor (capital) relocates to the former city and exits the latter. The labor (capital) market reorganizes on the basis of this movement. \( \varepsilon \) is set up as a reorganization speed and the simulation by difference of this speed is considered.

Parameters of the production function (\( \alpha \) and \( \gamma \)) are calibrated from the dataset.\(^{14}\) However, the productivity parameter grows at the same rate.

\(^{13}\) Although it is possible to change these various values, there is no essential difference in the result.

\(^{14}\) The calibration process for a standard computable general equilibrium model is adopted.
\[ \gamma_{t+1,d} = \gamma_{t,d} \cdot 1.01 \quad (17) \]

Data were estimated and the model was constructed as follows. First, data for population and GRP are taken from the previous section. We use the total population as the size of the labor force. Capital stock used provisionally what was divided by 0.1 (0.05 is the average investment rate and 0.05 is the depreciation rate) from the record of investment in fixed assets.\(^{15}\) Labor’s share of GRP is calculated from the share of employee compensation in GRP decomposed by value-added components for each province from the *China Statistical Yearbook*, (2008, p.53).\(^{16}\) The resulting figure then was applied to each city in the applicable province. Distribution of capital applied what subtracted labor share from 1 to GRP of each city. Since GRP was divided into the labor portion and the capital portion, what divided the labor portion by the number of population serves as a labor price, and what divided the capital portion by capital stock serves as a capital price.

Figure 6 shows how the Theil index changed on the basis of the simulation results. The simulation is making \(\varepsilon\) in the movement function of labor and capital shown in Eq. (15) and (16), respectively, gradually increase simultaneously (from 0.00 to 0.05 by 0.01). The figure shows the dynamics of the simulation after 10 iterations. First, when no movement is evident \((\varepsilon = 0.00)\), we conclude that income disparity among cities expands by city growth; that is, by a difference in prices of labor or capital between cities. On the other hand, it is found that expansion of disparity eases by raising \(\varepsilon\). Moreover, on a case-by-case basis, it can be made to reduce slightly from the disparity at the time of the base year in 2007.\(^{17}\)

Next, Figures 7 and 8 show the east–west disparity when \(\varepsilon\) is 0.00 and 0.05, respectively. Table 4 shows the contribution to disparity in each case. The contribution of the east is rising and simulation, if any, falls on the level of 10% in the west. Moreover, the contribution of the east–west disparity rises slightly. This tendency is clearer for higher values of \(\varepsilon\). Although improving the population’s mobility can ease overall disparities among cities, it results in disparities being reduced in western cities and increased in eastern cities.

Figures 9–14 measure the income distribution structure between cities after the simulation using a kernel density function. These figures show the dynamics of the distribution structure after the 10 iterations. The figure shows that income distribution reverts to the mean following some change in \(\varepsilon\). It is clear that the density of comparatively higher-income eastern cities (more than 1.5 in the log of relative income \(Z\)) and the comparatively lower-income western cities (less than \(-1.5\)) are falling notably. The densities of the

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15 This method of estimating capital stock applies in Islam et al. (2006, pp.146–149). However, numbers such as a depreciation rate are based on assumptions.

16 The 2009 version of the *China Statistical Yearbook* does not report this decomposition for 2008 but does so for 2007. Therefore, we set 2007 as the base year.

17 However, if \(\varepsilon\) is made into a higher value, the problem that the number of movements increases extremely and the solution to a computer is no longer obtained will arise.
comparatively poor eastern cities and comparatively wealthier western cities rise (all are at levels between \(-0.6\) and \(-0.2\)). This factor contributes to changes in contribution observed in Table 4. These findings show that mobility of labor and capital is a means for reducing income disparity among cities.

4. Conclusion

This study has analyzed income disparity among Chinese cities using data from the *China City Statistical Yearbook* for the period 1994–2008. The analysis revealed that income disparity among Chinese cities expanded during the period. Further, the expanding disparity between China’s eastern and western regions seems attributable to income increases in western cities. Our simulation identified that boosting the mobility of labor and capital is a means for narrowing the general income disparity, and it indicated that east–west disparities could be relieved by improving the mobility of the general population. Overall, Chinese income disparity will probably persist for the immediate future. It is important for future research to continue analyzing urban income inequality in China by gathering more urban household survey data.

References


Table 1 Number of effective samples of cities in this study

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(Source) All tables and figures are author’s calculation.

Table 2 Comparing data with yearbook

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(Note) Population (10,000 person), GRP (100 million Yuan), GRP/Pop (Yuan), Calc/YB (%).
Figure 1 Theil index of city disparity with decomposition

Table 3 Contribution to disparity index (%)

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<th>2007</th>
<th>2008</th>
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<td>50.56</td>
<td>50.27</td>
<td>49.88</td>
<td>48.78</td>
</tr>
<tr>
<td>West</td>
<td>26.33</td>
<td>23.44</td>
<td>23.78</td>
<td>24.93</td>
<td>27.61</td>
</tr>
<tr>
<td>Inter</td>
<td>26.99</td>
<td>26.00</td>
<td>25.96</td>
<td>25.18</td>
<td>23.61</td>
</tr>
</tbody>
</table>

Figure 2 Density of income distribution in 1994
Figure 3 Density of income distribution in 2000

Figure 4 Density of income distribution in 2005

Figure 5 Density of income distribution in 2008
Figure 6 Theil index of city disparity after simulations (base year is 2007)

Figure 7 Theil index of city disparity with decomposition after simulation ($\epsilon = 0.00$)

Figure 8 Theil index of city disparity with decomposition after simulation ($\epsilon = 0.05$)
Table 4 Contribution for disparity index (%)

<table>
<thead>
<tr>
<th>ε</th>
<th>Time</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
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<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
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</thead>
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<td>0.00</td>
<td>East</td>
<td>49.88</td>
<td>50.51</td>
<td>51.11</td>
<td>51.68</td>
<td>52.21</td>
<td>52.72</td>
<td>53.19</td>
<td>53.63</td>
<td>54.05</td>
<td>54.44</td>
<td>54.80</td>
</tr>
<tr>
<td></td>
<td>West</td>
<td>24.93</td>
<td>24.06</td>
<td>23.25</td>
<td>22.49</td>
<td>21.80</td>
<td>21.16</td>
<td>20.57</td>
<td>20.03</td>
<td>19.53</td>
<td>19.06</td>
<td>18.64</td>
</tr>
</tbody>
</table>

| 0.01| East | 49.88| 50.56| 51.22| 51.84| 52.45| 53.02| 53.57| 54.09| 54.59| 55.06| 55.51|
|    | West | 24.93| 23.91| 22.95| 22.05| 21.21| 20.43| 19.71| 19.03| 18.41| 17.82| 17.27|
|    | Inter| 25.18| 25.53| 25.84| 26.11| 26.34| 26.55| 26.72| 26.87| 27.00| 27.12| 27.21|

| 0.02| East | 49.88| 50.61| 51.32| 52.01| 52.68| 53.33| 53.96| 54.57| 55.15| 55.71| 56.25|
|    | West | 24.93| 23.76| 22.65| 21.61| 20.63| 19.72| 18.87| 18.08| 17.34| 16.65| 16.00|
|    | Inter| 25.18| 25.63| 26.03| 26.38| 26.68| 26.94| 27.16| 27.35| 27.51| 27.65| 27.76|

| 0.03| East | 49.88| 50.66| 51.43| 52.19| 52.93| 53.66| 54.36| 55.05| 55.72| 56.37| 57.00|
|    | Inter| 25.18| 25.73| 26.22| 26.64| 27.00| 27.31| 27.57| 27.78| 27.95| 28.09| 28.20|

| 0.04| East | 49.88| 50.72| 51.55| 52.37| 53.18| 53.99| 54.77| 55.54| 56.30| 57.04| 57.76|
|    | West | 24.93| 23.45| 22.05| 20.74| 19.51| 18.37| 17.30| 16.30| 15.37| 14.51| 13.70|
|    | Inter| 25.18| 25.83| 26.40| 26.89| 27.30| 27.65| 27.93| 28.16| 28.33| 28.46| 28.54|

| 0.05| East | 49.88| 50.78| 51.67| 52.56| 53.44| 54.32| 55.19| 56.04| 56.89| 57.71| 58.53|
|    | West | 24.93| 23.30| 21.76| 20.32| 18.97| 17.72| 16.56| 15.48| 14.48| 13.55| 12.68|
|    | Inter| 25.18| 25.93| 26.57| 27.12| 27.58| 27.96| 28.25| 28.48| 28.64| 28.74| 28.79|
Figure 9 Density of income distribution after simulation 10 times ($\varepsilon = 0.00$)

Figure 10 Density of income distribution after simulation 10 times ($\varepsilon = 0.01$)

Figure 11 Density of income distribution after simulation 10 times ($\varepsilon = 0.02$)
Figure 12 Density of income distribution after simulation 10 times ($\varepsilon = 0.03$)

Figure 13 Density of income distribution after simulation 10 times ($\varepsilon = 0.04$)

Figure 14 Density of income distribution after simulation 10 times ($\varepsilon = 0.05$)