WHILE THE RELATIONSHIP BETWEEN ECONOMIC GROWTH and income inequality has been a major concern of economists and policymakers for more than a century, many theoretical and empirical studies have focused on the question of how inequality is generated and how it is related to economic growth (e.g., Kuznets 1955, Kakwani 1980, Lambert 1989, Aghion, Caroli, and Garcia-Penalosa 1999). Kuznets (1955, 1963) began the search for a general relationship between economic growth and income inequality and found an inverted U-shape relation between income inequality and per capita income based on both cross-country and time-series data. The Kuznets hypothesis seemed to account for the experience of the U.S. and several OECD countries from the 1770s to 1970s: both per capita income and inequality level increased significantly from the 1770s to 1870s but, as per capita income continued to increase, the inequality level decreased significantly from the 1870s to 1970s. However, the downward trend in inequality experienced by these countries from the 1870s to the 1970s has reversed sharply in the past two decades. For example, the share of total wealth owned by the 10 percent richest households in the U.S. rose from 50 percent around 1770 to about 75 percent around 1870, then receded back to 50 percent in 1970, but has increased significantly in the past two decades (Aghion, Caroli, and Garcia-Penalosa 1999). The relevance of the Kuznets hypothesis for developing countries has been questioned by several studies (e.g., Adelman and Morris 1973, Anand and Kanbur 1993, Wang, Shi, and Zheng 2002).

Although many empirical studies have been conducted and new theories—such as the new growth theories—have been developed to test the Kuznets hypothesis and derive policy implications, the relationship between inequality and economic growth is still far from being well understood, especially for developing countries and the countries under transition toward market economies. This may be partially due to the lack of consistent data for testing the Kuznets hypothesis and partially due to

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significant differences in socioeconomic variables and development policies across countries. On the other hand, the rapid economic growth and changes in income distribution in countries like China over the past two decades may provide new evidence with which to examine the relationship between economic growth and income inequality (Wang, Shi, and Zheng 2002).

This study is motivated by the dramatic growth of the Chinese economy and significant changes in its income distribution since its economic reform initiated in 1978. Obtaining insights into linkages between income inequality and economic growth for China is, of course, important from a policy perspective. Importantly, few studies have examined such relationships for countries like China with transitional economies. The major objective of this study is therefore to assess changes in China’s urban and rural income distribution since 1978 and to derive economic and policy implications. Specifically, this chapter presents two quantitative analyses. First, Lorenz curves are estimated using the most recently available data from China’s national household survey for the period of 1980 to 2002 for rural residents and 1981 to 2002 for urban residents. Gini coefficients are then estimated from the estimated Lorenz curves. Second, a welfare index is constructed from generalized Lorenz curves for urban residents to examine changes in average social welfare over the study period in urban China. The second analysis has not been conducted for rural residents due to data limitations. As suggested by Lambert (1989), the inequality and welfare analyses compensate each other because Gini coefficients provide information on the changes in inequality or how the “cake” is divided, and the welfare analysis provides information on changes in the overall social welfare, or the size of the “cake.” This chapter will end with a summary of major findings from this study and a discussion of policy implications.

China’s Income Growth and Disparity

With more than 20 percent of the world’s population and remarkable socioeconomic changes in the past five decades, China’s economic growth and income distribution have been the focus of several studies (e.g., Adelman and Sunden 1988, Zhang and Tam 1990, Khan et al. 1993, Griffin and Zhao 1993, Carter 1997, Wang, Shi, and Zheng 2002). Although data on China’s income distribution have been very limited, especially for the period prior to 1980, previous studies generally agree and suggest that China’s income inequality decreased significantly around 1950, remained at a low level from the early 1950s to the late 1970s, and has shown an upward trend since the early 1980s. Such changes in income inequality have been closely related to the ongoing evolution of China’s political and economic systems. For example, while the decrease in inequality around 1950 was largely due to the establishment of the new political system in which every rural household was allocated a piece of land to farm and many urban residents were offered jobs in state-
owned enterprises, the low level of inequality in the following three decades was a result of China’s development policies that focused on state-owned industries in urban areas and collective production and distribution systems in rural areas. China’s income growth and distribution from the 1950s to the 1970s were characterized by slow income growth, a significant gap between urban and rural income, and low inequality in both urban and rural areas. For example, according to Adelman and Sunding (1988), China’s average urban per capita nominal income increased from 280 yuans in 1958 to only 339 yuans in 1977, and the Gini coefficient remained at 0.165 over the period, a low level.

China’s socialist system adopted from the former Soviet Union in the 1950s was a key factor of the low inequality level from the 1950s to the 1970s, but was also responsible for the slow income growth due to the lack of incentives and efficiency. As a result of economic and political pressures after the death of Mao Zedong and several other senior Communist leaders in the mid 1970s, China started its economic reform in the agricultural sector in 1978 and has gradually expanded the market-oriented reform to all other sectors.

Changes in China’s Average Urban and Rural Income Since 1978

China’s economic reform has been considered successful in terms of economic growth as compared to other transitional economies, such as the former Soviet Union, many of whom have been struggling with low economic growth rates and high inflation. For example, as shown in Figure 1, China’s urban per capita income increased steadily from 343 yuans in 1978 to 7,703 yuans in 2002. Figure 1 also

![Figure 1. Changes in China’s Urban per Capita Income, 1981–2002](image-url)
shows that the real per capita income in 1990 Chinese yuan increased from 762 to 3,599 over the same period. The changes in rural per capita income, presented in Figure 2, indicate that per capita rural income increased from 134 yuan in 1978 to 2,475 yuan in 2002, and the real per capita rural income in 1990 Chinese yuan increased from 656 in 1985 to 1,297 in 2002. Real income levels for urban and rural residents are calculated from nominal income and the living cost indices published by the National Bureau of Statistics of China (NBSC). Also, real per capita rural income for 1978 to 1984 has not been estimated due to the unavailability of the living cost index for this period.

![Real income in 1990 yuan vs Nominal income](image)

**Figure 2. Changes in China’s Rural per Capita Income, 1978–2002**

*China’s Urban-Rural Income Gap*

While China’s market-oriented economic reform has been quite successful in terms of average income growth in both urban and rural areas, as shown in Figures 1 and 2, respectively, it has caused socioeconomic concerns that are related to the widening income gap between rural and urban residents and, as well, the increasing income inequality in both urban and rural areas (Zhang and Tam 1990, Khan et al. 1993, Carter 1997). Although several reports have suggested that China’s income inequality has shown an upward trend since the early 1980s (e.g., Zhang and Tam 1990, Khan et al. 1993), most of the studies were based on limited data from the early 1980s to mid 1990s.

As a country with a long history of agriculture and more than 70 percent of its population living in rural areas, China has always had a significant gap between urban
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and rural income. The problem, however, is that the gap has become larger in recent years. As shown in Figure 3, China’s urban to rural average income ratio has changed significantly since 1978: it decreased from 2.57 in 1978 to the lowest level of 1.85 in 1983, increased continuously during the next 11 years, reaching 2.87 in 1994, receded back to 2.48 in 1997, but has then increased steadily since 1997, reaching a peak 3.11 in 2002. The decline in the urban-rural income ratio from 1978 to 1983 was largely due to China’s economic reform started in the rural sector in 1978 and then expanded to urban areas in the mid 1980s.

As a key component of the rural reform, the commune system adopted nationally in the late 1950s was gradually replaced by the household responsibility system (HRS) during 1978 to 1984. Under HRS, collectively owned land was contracted to individual households, and farmers had much more flexibility in making production and marketing decisions to maximize their net return. The improvement in incentives and efficiency along with increased use of agricultural inputs brought about remarkable growth in agricultural production and rural income in the early 1980s. Since the income distribution in the urban sector was basically under the central planning system until the mid 1980s, the significant increase in rural income gradually reduced the urban-rural income ratio over the period 1978 to 1983. As China’s economic reform expanded from rural to urban sectors in the mid 1980s, however, growth in urban income was significantly faster than that in rural regions. See Carter (1997) for a comprehensive review and discussion on how China’s policy bias against agriculture contributed to the widening urban-rural income gap during the 1983 to 1995 period. As a result of several policy changes implemented in the mid

![Figure 3. Ratio of Urban to Rural per Capita Income in China, 1978–2002](image-url)
1990s to boost agricultural production and farm income, the urban-rural income ratio reduced significantly from 1994 to 1997. One of the major policy changes during that period was the remarkable increase in state purchasing price for major grain products: the average grain price increased more than 20 percent in 1994, more than 15 percent in 1995, and almost 10 percent in 1996.

Unfortunately, prices received by farmers for grain and other major farm products declined continuously and significantly from 1997 through the fall of 2003. For example, the average grain price in 2001 was only about 90 percent of the price in 1996. On the other hand, major farm expenses, such as agricultural tax and fees imposed by state and local government and expenditures for fertilizer and other farm inputs, have increased significantly. At the same time, urban residents, who have enjoyed many more opportunities during the economic transition than have their rural counterparts, have experienced a steady increase in average income. As a result, the urban-rural income gap has increased steadily since 1997, and reached the highest level of 3.11 in 2002.

While the urban-rural income gap in China has increased steadily since 1997, how is the urban-rural income gap related to the average rural income across regions? To address this question, the regional urban-to-rural average income ratio ($Y$) and the average rural per capita income ($X$), from the lowest to the highest, for the 31 regions (23 provinces, 4 autonomous regions, and 4 municipalities) in 2002 are plotted in Figure 4. The plot clearly shows that the urban-rural income ratio is negatively correlated to the average rural income among the 23 regions with relatively low

![Figure 4. China’s Urban-Rural per Capita Income Ratio by 31 Regions in 2002](image_url)
income, suggesting that rural residents in low income regions not only have lower income as compared to rural residents in more developed regions, but also have a larger income gap with urban residents in their own regions. However, the data for the eight regions with relatively high per capita rural income in Figure 4 do not show any significant correlation between $Y$ and $X$. Figure 4 suggests that rural income growth may reduce the urban-rural income gap among low income regions but may not contribute to a reduction in the income gap in the regions with relatively high per capita rural income.

**China's Urban Income Inequality**

While several reports have suggested that China’s income inequality has increased since the early or mid 1980s (e.g., Zhang and Tam 1990, Khan et al. 1993, Griffin and Zhao 1993, World Journal 1998), most of the studies were based on data from the 1980s; few quantitative estimations have been reported for the 1990s. This study estimates Lorenz curves and Gini coefficients using the most recently available data from the NBSC. NBSC has conducted the nationwide annual urban household survey since 1981. Sample households were selected by using a three-stage stratified sample scheme: cities were first selected from each province, enterprises and institutions were then selected from each city, and finally households were selected from each enterprise and institution. The participating households were requested to keep detailed records of their daily income and expenditures by using the account books provided by the NBSC. The account books were collected, examined, aggregated, and reported by local statistical agencies every month. Although the NBSC has not published the survey data by households, it has published the average income, number of households, and average household size by seven income groups from the urban household survey.

Because the grouped data published by NBSC are not detailed enough to permit accurate construction of Lorenz curves, the interpolation method proposed by Kakwani (1980) is used to construct Lorenz curves and then estimate the Gini coefficients. This method involves constructing a continuous and differentiable function within each income range and fitting a Pareto function for the first income range and the last income range (Kakwani 1980, Lambert 1989). As compared to the traditional linear interpolation method of constructing Lorenz curves from grouped data, this approach generates smooth Lorenz curves and therefore more accurate estimates of Gini coefficients through integration.

While the mathematical method is discussed in Kakwani (1980) and Lambert (1989), the major procedures are presented in the appendix to this chapter. A computer program is developed to estimate Gini coefficients from the Chinese data by seven income groups for the period of 1981 to 2002. The results, presented in Figure 5, suggest that the income inequality in urban China has increased significantly since the early 1980s, and especially since the early 1990s.
China’s Rural Income Inequality

Similar to the urban household survey, the NBSC has conducted a nationwide rural household survey every year since 1978. The selection of sample households is similar to that in the urban household survey: a certain number of counties were first selected from each province, then sample villages were selected from each selected county, and finally sample households were selected from each sample village. As with the urban survey, the sample households were requested to keep detailed records of their daily income and expenditures by using the account books provided by the NBSC. The account books were collected, examined, aggregated, and reported by local statistical agencies every month. Again, the NBSC has not published the household level survey data; instead, sample means by income groups have been published in China’s Statistical Yearbook. In contrast to the urban income distribution data, which has always had seven income groups each year since 1981, the number of income groups in the rural income distribution data has changed over time. For example, the number of groups has increased to 20 in recent years. The Gini coefficients estimated from such grouped data are also presented in Figure 5, together with the urban Gini coefficients.

As shown in Figure 5, China’s rural Gini coefficients fluctuated around 0.23 from 1980 to 1985, increased significantly in the next four years, showed a downward trend from 1989 to 1995, then increased steadily since 1995 and reached the highest...
level of 0.32 in 2002. Note that the Gini coefficient in 2002 is the highest value since 1980 but only slightly above the level in 1989. A comparison of the urban and rural Gini coefficients from 1980 to 2002 in Figure 5 suggests that China’s rural income inequality level has been significantly higher than the urban inequality level but that the difference has reduced steadily since 1995. Indeed, the urban and rural Gini coefficients were very close by 2002.

As a limitation of this study, we have not estimated the national Gini coefficient for China due to at least two considerations: First, in addition to their higher income, urban households have received a lot of subsidies such as health care, education, and housing that are not available to rural households, and such subsidies are hard to quantify. Second, the measurement of rural income is quite different from that of urban income due to the fact that a significant proportion of rural households’ food consumption derives directly from their own home production. Regarding the latter, there has always been some question about how such consumption was counted in rural income. More importantly, both the subsidies in urban areas and the income measurement in rural areas have changed significantly in the past two decades and it is therefore difficult to pool urban and income distributions together to estimate the national Gini coefficients.

### An Analysis of Welfare Changes in Urban China

While the Lorenz curves and Gini coefficients provide useful information on changes in income inequality, or how the cake is divided, they do not reflect the size of the cake, that is, the actual welfare of the population in each income group. In this section, a welfare approach developed by Atkinson (1970), Shorrocks (1983), and Lambert (1989) is used to examine changes in social welfare in urban China. As a major component of this approach, a generalized Lorenz curve is constructed by multiplying the ordinary Lorenz curve by mean income (Lambert 1989). The rationale of this approach is to assign a level of utility $U(x)$ to each income level $(x)$, and the average utility across the distribution is then used as an indicator of “social welfare.”

Lambert (1989) stated that, given two income distributions (A and B), the generalized Lorenz curves can by constructed by multiplying the ordinary Lorenz curves by mean incomes. Social welfare can then be compared according to the generalized Lorenz curves. If the generalized Lorenz curve for distribution A dominates the corresponding curve for distribution B without any intersection (except at the starting point), it can be concluded that distribution A will be ranked as welfare superior to distribution B under the assumption of a concave utility function for the population. The rationale of this approach is to assign a level of utility to each income group, and the average utility across the distribution is then used as an indicator of the population’s social welfare. However, when the generalized Lorenz curves intersect
each other, the conclusion will be different for different income groups. Considering that the economic theory and mathematical framework of this approach are directly available in Lambert (1989), we do not reproduce the technical details in this chapter.

Following this welfare approach, we have constructed a generalized Lorenz curve for each of the 22 years according to the real mean income and ordinary Lorenz curves estimated in the previous section. Because there is no obvious intersection between any two generalized Lorenz curves (except at the starting point), we are able to make conclusions about changes in welfare for the population: with the exception of 1988 and 1989, social welfare has increased continuously since 1981.

To provide a quantitative measure of the changes, a social welfare index is constructed based on the area under the generalized Lorenz curves. We first estimated the area under each generalized Lorenz curve and then constructed an index with the area under the 1981 curve set to 100. Results presented in Figure 6 indicate that the social welfare in urban China improved continuously from 1981 to 2002, except for 1988 and 1989 when lower average real incomes were caused by high inflation rates. The procedures and computer programs to derive generalized Lorenz curves and estimate the welfare index are available from the authors upon request. Together Figures 5 and 6 may suggest that the rise in real average income in urban China has more than compensated for the increase in inequality and has therefore brought about continuous improvement in social welfare since 1981, excepting 1988 and 1989. Again, we have not estimated the welfare index for rural China due to data limitations (e.g., the rural consumer price index is not available for 1981 to 1984); however, the rural real income presented in Figure 2 and the rural Gini coefficients presented in

Figure 6. An Estimated Welfare Index for Urban China, 1981–2002
Figure 5 together suggest that rural average welfare has also improved significantly over the study period. Even so, this improvement has been slower than that in urban areas.

Income Inequality and Food Consumption

While the previous sections have analyzed the changes in China’s urban and rural average income and income inequality since its economic transition started in the early 1980s, this section examines the changes in Engel coefficients (i.e., the proportion of total expenditure allocated to food) in both urban and rural China since 1978 along with the variation in food consumption across income groups in urban China. As shown in Figure 7, the Engel coefficient has reduced significantly for both urban and rural residents since 1978, with the decline in urban China being more notable than that in rural China. Figure 7 along with the average real income data presented in Figure 1 and Figure 2 together suggest that there is a negative correlation between the Engel coefficient and real per capita income for both rural and urban China. This result is, of course, quite consistent with the predictions of economic theory.

Because income has been identified as an important factor of China’s changing food consumption patterns and because both urban and rural households still spend a large percentage of their income on food, it is interesting to examine the variation in...

Figure 7. Engel Coefficient in Urban and Rural China, 1978–2002
food consumption across income groups. Due to data limitations, the following analysis is limited to the urban data. Information on the relation between income distribution and food consumption in urban China is also useful for analyzing China’s food market and trade behavior because urban households are the primary buyers of imported food products, especially high value products such as meats and fruits. See Carter (1997) for a discussion on China’s urban-rural income gap and implications for the global food market.

As shown in Table 1, food consumption patterns in urban China are significantly different across income groups. While high-income households consumed significantly less grain and much more dairy products, meats, fruits and melons, fish, and shrimp, low-income households purchased more grains and significantly less high-value products in 2002. An analysis of the changes in the variation in per capita food consumption across income groups over the past decade suggests that the variation for some high value products such as milk, fish, and shrimp has increased remarkably, but that the variation for vegetable oil across income groups has decreased significantly. See Figure 8 for the changes in per capita milk consumption across income groups in 1998 and 2002. The relatively slow increase in per capita vegetable oil consumption in urban China and the significant decrease in the variation across income groups in the past several years may suggest that urban per capita consumption of vegetable oil has reached a stable level and that the major source for the increase in China’s demand for vegetable oils in the future is likely from rural residents and the immigrants from rural to urban areas. The dramatic increase in per capita dairy consumption and its close correlation with per capita income in urban China in the past several years suggest that the demand will continue to increase at a significant rate as the per capita income continues to increase in urban China, and this may bring about opportunities for dairy-exporting nations like the U.S.

Conclusions and Policy Implications

This chapter has examined changes in China’s average income and income inequality in its transition toward a market economy. While the estimated Gini coefficients indicate that the level of income inequality in both urban and rural China has increased significantly since 1981, welfare comparisons based on generalized Lorenz curves for urban China suggest that the rise in real average income has more than compensated for the increase in inequality and has therefore brought about continuous improvement in welfare since 1981. As suggested by Lambert (1989), the inequality and welfare analyses compensate each other because Gini coefficients reflect the changes in inequality, or how a cake is divided, and the welfare analysis provides information on changes in the overall social welfare, or the size of the cake.

While Adelman and Sunding (1988) predicted that a new inverted U-shaped relationship between inequality and per capita GNP should be observed when China’s
Table 1. Per Capita Food Consumption in Urban China by Income Groups in 2002 (kilogram)

<table>
<thead>
<tr>
<th>Products</th>
<th>Lowest</th>
<th>Low</th>
<th>Lower middle</th>
<th>Middle</th>
<th>Upper middle</th>
<th>High</th>
<th>Highest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grains</td>
<td>83.32</td>
<td>82.28</td>
<td>79.58</td>
<td>77.67</td>
<td>77.76</td>
<td>76.75</td>
<td>71.36</td>
</tr>
<tr>
<td>Vegetable oil</td>
<td>8.18</td>
<td>8.81</td>
<td>8.80</td>
<td>8.71</td>
<td>8.46</td>
<td>8.45</td>
<td>7.79</td>
</tr>
<tr>
<td>Pork</td>
<td>15.65</td>
<td>18.28</td>
<td>19.98</td>
<td>20.84</td>
<td>21.57</td>
<td>22.79</td>
<td>22.38</td>
</tr>
<tr>
<td>Beef</td>
<td>1.24</td>
<td>1.61</td>
<td>1.80</td>
<td>2.08</td>
<td>2.20</td>
<td>2.19</td>
<td>2.18</td>
</tr>
<tr>
<td>Poultry</td>
<td>5.17</td>
<td>6.99</td>
<td>8.06</td>
<td>9.23</td>
<td>10.38</td>
<td>11.87</td>
<td>13.34</td>
</tr>
<tr>
<td>Eggs</td>
<td>8.37</td>
<td>9.82</td>
<td>10.48</td>
<td>10.72</td>
<td>11.08</td>
<td>11.56</td>
<td>11.06</td>
</tr>
<tr>
<td>Fish</td>
<td>5.67</td>
<td>7.010</td>
<td>8.06</td>
<td>9.43</td>
<td>10.65</td>
<td>12.44</td>
<td>14.52</td>
</tr>
<tr>
<td>Shrimp</td>
<td>0.4</td>
<td>0.59</td>
<td>0.93</td>
<td>1.24</td>
<td>1.70</td>
<td>2.35</td>
<td>2.72</td>
</tr>
<tr>
<td>Vegetables</td>
<td>102.66</td>
<td>109.08</td>
<td>112.73</td>
<td>116.06</td>
<td>121.98</td>
<td>127.16</td>
<td>126.56</td>
</tr>
<tr>
<td>Sour milk</td>
<td>0.51</td>
<td>0.98</td>
<td>1.35</td>
<td>1.76</td>
<td>2.30</td>
<td>2.74</td>
<td>3.31</td>
</tr>
<tr>
<td>Milk</td>
<td>4.83</td>
<td>8.39</td>
<td>11.78</td>
<td>15.79</td>
<td>19.99</td>
<td>23.63</td>
<td>26.46</td>
</tr>
<tr>
<td>Melons &amp; fruits</td>
<td>31.67</td>
<td>44.45</td>
<td>51.02</td>
<td>57.88</td>
<td>64.18</td>
<td>70.66</td>
<td>74.69</td>
</tr>
<tr>
<td>Beer</td>
<td>3.44</td>
<td>5.00</td>
<td>5.68</td>
<td>6.20</td>
<td>6.63</td>
<td>7.49</td>
<td>6.36</td>
</tr>
</tbody>
</table>
reform spread to the urban area, our results suggest that, while such a relationship is possible, China is still in the heading-up period. Also, our results are quite different from those of Zhang and Tam (1990), who argued that the social welfare in both rural and urban China in the late 1980s was not significantly better than that in the early 1980s.

Because of the socialist economic system that was in place in China for many years, China’s subsequent market-oriented economic reforms have resulted in a new set of socioeconomic problems and challenges. For example, the ongoing reform in state-owned enterprises has significantly increased the unemployment rate and resulted in difficulties for many families. While living costs have been increasing and state subsidies in housing and health care have been decreasing, it is critical for China to develop welfare programs and a social security system to provide a guaranteed living standard for low-income households.

China’s widening urban-rural income gap has recently become a major economic and political issue in China. As a result the central government has announced several measures to increase farm income and attain more balanced economic growth. For example, the central government announced in March 2004 that the agricultural tax will be cut by at least one percentage point per year and will be totally eliminated in five years. While this policy action represents an encouraging step aimed at increasing rural income and reducing the urban-rural income gap, the question of whether the objective can be attained and whether the agricultural tax will be replaced
by other forms of taxes and charges in some rural areas, especially in the poor and disadvantaged regions, remains.

Historically, property taxes are used as an effective way of redistributing income and funding public education in many other nations. A property tax scheme should therefore also be considered in China, especially in urban areas. As more and more urban households have purchased their own houses, the difference in home ownership has become a major reflection of income and wealth inequality across China. Revenues from property taxes can be used to fund public education and affordable housing for low-income households. Also, establishing a minimum wage, improving welfare programs for unemployed workers, increasing state investment in rural education and health care, and enhancing the incentives to attract investment in disadvantaged regions are among the policy options for China to reduce income inequality and the urban-rural income gap and attain balanced economic growth.

References


Appendix

EVALUATION OF INCOME INEQUALITY MEASURES FROM GROUPED OBSERVATIONS

The Gini index has been used as a measure of income inequality for grouped observations in many studies. Suppose the population is grouped into \((T + 1)\) income classes, \((x_0, x_1), (x_1, x_2), \ldots, (x_t, x_{t+1}), \ldots, (x_T, x_{T+1})\), where \(x_t < x_{t+1}\), and both are income levels. A widely used formula to estimate the Gini index from grouped observations is

\[
GL = 1 - \sum_{t=1}^{T+1} f_t(q_t + q_{t-1}),
\]

where \(q_t\) is the sum of the shares of income received by groups that have an income less than or equal to \(x_t\), and \(f_t\) is the fraction of population in group \((x_{t-1}, x_t)\). However, this formula gives an estimate of inequality only between the income classes, and ignores the inequality within the income classes. Kakwani’s (1980) interpolation method addresses this underestimation issue by treating total inequality as the sum of both inequality between income classes \((GL)\) and inequality within income classes \((G_t)\).

To derive the estimation of inequality within each income class, a polynomial of the third degree is fitted to represent the Lorenz curve within each income class. For the first and the last open-ended income ranges, a Pareto function is fitted as a refinement. To fit the third-degree polynomial, four data points are needed: the estimated curve must pass through the two end-points of the income class \((p_{t-1}, q_{t-1})\) and \((p_t, q_t)\), where \(p_t\) is the share of people receiving an income less than or equal to \(x_t\). The estimated curve is continuously differentiable, and the slope at these points must be equal to \(x_{t-1}/\mu\) and \(x_t/\mu\), where \(\mu\) is the overall mean income. Thus, we express the Lorenz curve for the \(t\)th income class as

\[
q = q_{t-1} + \alpha_{1t}(p - p_{t-1}) + \alpha_{2t}(p - p_{t-1})^2 + \alpha_{3t}(p - p_{t-1})^3,
\]

where the parameters \(\alpha_{1t}, \alpha_{2t},\) and \(\alpha_{3t}\) are

\[
\alpha_{1t} = \frac{x_{t-1}}{\mu},
\]

\[
\alpha_{2t} = \frac{(3\delta_t - 1)(\Delta x_t)}{\mu^2 f'_t},
\]

and

\[
\alpha_{3t} = \frac{(1 - 2\delta_t)(\Delta x_t)}{\mu^3 f''_t},
\]

where \(\delta_t = (\mu_t - x_{t-1})/\Delta x_t\), \(\Delta x_t = x_t - x_{t-1}\), and \(\mu_t\) is the mean income in group \((x_{t-1}, x_t)\).
The Pareto distribution functions for the lowest and highest income ranges are

- lowest: \( p = A_t q^{\alpha_t}, \) and
- highest: \( (1 - p) = A_{r+1} (1 - q)^{\alpha_{r+1}}. \)

Using the condition \( dq/dp = x/\mu, \) we obtain the following parameter values:

\[
A_t = f_t \left[ \frac{\mu}{\mu_t f_t} \right]^{\alpha_t}, \quad \alpha_t = \frac{\mu_t}{x_t}, \quad A_{r+1} = f_{r+1} \left[ \frac{\mu}{\mu_{r+1} f_{r+1}} \right]^{\alpha_{r+1}}, \quad \text{and} \quad \alpha_{r+1} = \frac{\mu_{r+1}}{x_{r+1}}.
\]

The equations for the Lorenz curve given above can be used to compute any percentile of the distribution. The inequality within income classes, denoted by \( G_t, \) will be estimated from the density functions which are derived from the functions of the Lorenz curve,

\[
G_t = \frac{1}{6} \frac{(\Delta x_t)}{\mu_t},
\]

and for the first and last open-ended income ranges, where the Pareto density function was fitted, the Gini index is derived as

\[
G_t = \frac{x_t - \mu_t}{x_t + \mu_t}
\]

and

\[
G_{r+1} = \frac{\mu_{r+1} - x_{r+1}}{\mu_{r+1} + x_{r+1}}.
\]

Therefore, as Kakwani proposed, the Gini index \( G \) is expressed as the sum of two components,

\[
G = GL + \frac{1}{\mu} \sum_{t=1}^{r+1} f_t^2 \mu_t G_t,
\]

in which the first component \( GL \) is the inequality between the income classes, and the second one, the inequality within income classes (the weighted sum of the Gini indexes within each income class \( G_t \)).