Gini coefficient

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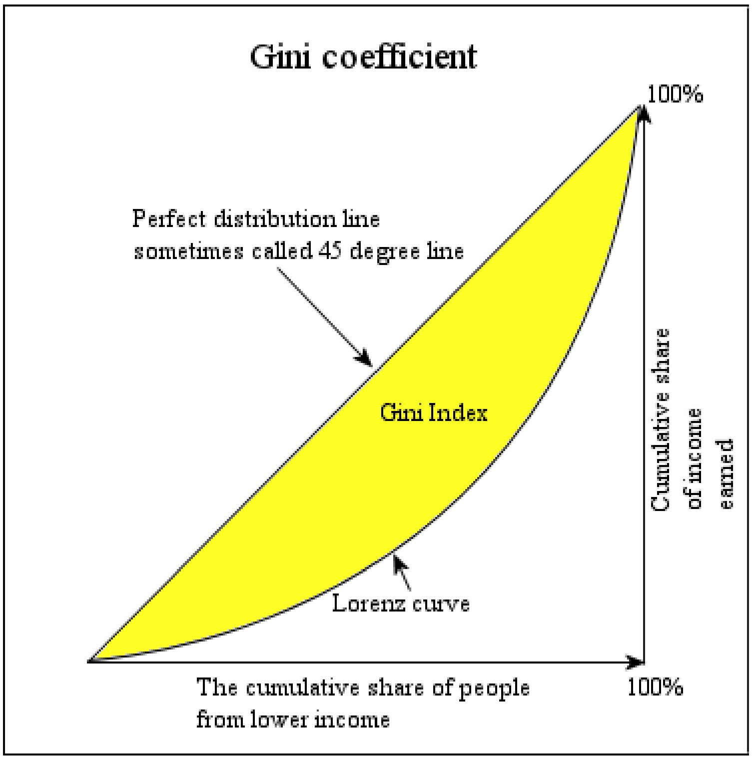


Graphical representation of the **Gini** coefficient

The **Gini coefficient** is a measure of inequality of a distribution. It is defined as a ratio with values between 0 and 1: the numerator is the area between the Lorenz curve of the distribution and the uniform distribution line; the denominator is the area under the uniform distribution line. It was developed by the Italian statistician Corrado **Gini** and published in his 1912 paper "Variabilità e mutabilità" ("Variability and Mutability"). The **Gini index** is the **Gini** coefficient expressed as a percentage, and is equal to the **Gini** coefficient multiplied by 100. (The **Gini** coefficient is equal to half of the relative mean difference.)

The **Gini** coefficient is often used to measure income inequality. Here, 0 corresponds to perfect income equality (i.e. everyone has the same income) and 1 corresponds to perfect income inequality (i.e. one person has all the income, while everyone else has zero income).

The **Gini** coefficient can also be used to measure wealth inequality. This use requires that no one has a negative net wealth. It is also commonly used for the measurement of discriminatory power of rating systems in the credit risk management.

Calculation

The Gini coefficient is defined as a ratio of the areas on the Lorenz curve diagram. If the area between the line of perfect equality and Lorenz curve is A, and the area under the Lorenz curve is B, then the Gini coefficient is A/(A+B). Since A+B = 0.5, the Gini coefficient, G = 2A = 1-2B. If the Lorenz curve is represented by the function Y = L(X), the value of B can be found with integration and:

$$G = 1 - 2\int_0^1 L(X)dX$$

In some cases, this equation can be applied to calculate the Gini coefficient without direct reference to the Lorenz curve. For example:

- For a population with values y_i, $i = 1$ to n, that are indexed in non-decreasing order ($y_i \leq y_{i+1}$):

$$G = \frac{1}{n}(n + 1 - 2\,\frac{\Sigma_{i=1}^{n}\,(n+1-i)y_i}{\Sigma_{i=1}^{n}y_i})$$

- For a discrete probability function $f(y)$, where y_i, $i = 1$ to n, are the points with nonzero probabilities and which are indexed in increasing order ($y_i < y_{i+1}$):

$$G = 1 - \frac{\Sigma_{i=1}^{n}\,f(y_i)(S_{i-1}+S_i)}{S_n}$$

where:

$S_i = \Sigma_{j=1}^{i}\,f(y_j)\,y_j$ and $S_0 = 0$

- For a cumulative distribution function $F(y)$ that is piecewise differentiable, has a mean μ, and is zero for all negative values of y:

$$G = 1 - \frac{1}{\mu}\int_0^\infty (1 - F(y))^2 dy$$

Since the Gini coefficient is half the relative mean difference, it can also be calculated using formulas for the relative mean difference.

For a random sample S consisting of values y_i, $i = 1$ to n, that are indexed in non-decreasing order ($y_i \leq y_{i+1}$), the statistic:

$$G(S) = \frac{1}{n-1}(n + 1 - 2\,\frac{\Sigma_{i=1}^{n}\,(n+1-i)y_i}{\Sigma_{i=1}^{n}y_i})$$

is a consistent estimator of the population Gini coefficient, but is not, in general, unbiased. Like the relative mean difference, there does not exist a sample statistic that is in general an unbiased estimator of the population Gini coefficient. Confidence intervals for the population Gini coefficient can be calculated using bootstrap techniques.

Sometimes the entire Lorenz curve is not known, and only values at certain intervals are given. In that case, the Gini coefficient can be approximated by using various techniques for interpolating the missing values of the Lorenz curve. If (X_k , Y_k) are the known points on the Lorenz curve, with the X_k indexed in increasing order ($X_{k-1} < X_k$), so that:

- X_k is the cumulated proportion of the population variable, for k = 0,...,n, with $X_0 = 0$, $X_n = 1$.
- Y_k is the cumulated proportion of the income variable, for k = 0,...,n, with $Y_0 = 0$, $Y_n = 1$.

If the Lorenz curve is approximated on each interval as a line between consecutive points, then the area B can be approximated with trapezoids and:

$$G_1 = 1 - \sum_{k=1}^{n} (X_k - X_{k-1})(Y_k + Y_{k-1})$$

is the resulting approximation for G. More accurate results can be obtained using other methods to approximate the area B, such as approximating the Lorenz curve with a quadratic function across pairs of intervals, or building an appropriately smooth approximation to the underlying distribution function that matches the known data. If the population mean and boundary values for each interval are also known, these can also often be used to improve the accuracy of the approximation.

While most developed European nations tend to have Gini coefficients between 0.24 and 0.36, the United States Gini coefficient is above 0.4, indicating that the United States has greater inequality. Using the Gini can help quantify differences in welfare and compensation policies and philosophies. However it should be borne in mind that the Gini coefficient can be misleading when used to make political comparisons between large and small countries (see criticisms section).

Correlation with per-capita GDP

Poor countries (those with low per-capita GDP) have Gini coefficients that fall over the whole range from low (0.25) to high (0.71), while rich countries have generally low Gini coefficient (under 0.40).

Advantages as a measure of inequality

- The Gini coefficient's main advantage is that it is a measure of inequality by means of a ratio analysis, rather than a variable unrepresentative of most of the population, such as per capita income or gross domestic product.

- It can be used to compare income distributions across different population sectors as well as countries, for example the Gini coefficient for urban areas differs from that of rural areas in many countries (though the United States' urban and rural Gini coefficients are nearly identical).

- It is sufficiently simple that it can be compared across countries and be easily interpreted. GDP statistics are often criticised as they do not represent changes for the whole population; the Gini coefficient demonstrates how income has changed for poor and rich. If the Gini coefficient is rising as well as GDP, poverty may not be improving for the majority of the population.

- The Gini coefficient can be used to indicate how the distribution of income has changed within a country over a period of time, thus it is possible to see if inequality is increasing or decreasing.

- The Gini coefficient satisfies four important principles:
    - *Anonymity*: it does not matter who the high and low earners are.

- *Scale independence*: the Gini coefficient does not consider the size of the economy, the way it is measured, or whether it is a rich or poor country on average.
- *Population independence*: it does not matter how large the population of the country is.
- *Transfer principle*: if income (less than the difference), is transferred from a rich person to a poor person the resulting distribution is more equal.

Disadvantages as a measure of inequality

- The Gini coefficient measured for a large economically diverse country will generally result in a much higher coefficient than each of its regions has individually. For this reason the scores calculated for individual countries within the EU are difficult to compare with the score of the entire US.

- Comparing income distributions among countries may be difficult because benefits systems may differ. For example, some countries give benefits in the form of money while others give food stamps, which may not be counted as income in the Lorenz curve and therefore not taken into account in the Gini coefficient.

- The measure will give different results when applied to individuals instead of households. When different populations are not measured with consistent definitions, comparison is not meaningful.

- The Lorenz curve may understate the actual amount of inequality if richer households are able to use income more efficiently than lower income households. From another point of view, measured inequality may be the result of more or less efficient use of household incomes.

- As for all statistics, there will be systematic and random errors in the data. The meaning of the Gini coefficient decreases as the data become less accurate. Also, countries may collect data differently, making it difficult to compare statistics between countries.

- Economies with similar incomes and Gini coefficients can still have very different income distributions. This is because the Lorenz curves can have different shapes and yet still yield the same Gini coefficient. As an extreme example, an economy where half the households have no income, and the other half share income equally has a Gini coefficient of ½; but an economy with complete income equality, except for one wealthy household that has half the total income, also has a Gini coefficient of ½.

- Too often only the Gini coefficient is quoted without describing the proportions of the quantiles used for measurement. As with other inequality coefficients, the Gini coefficient is influenced by the granularity of the measurements. For example, five 20% quantiles (low granularity) will yield a lower Gini coefficient than twenty 5% quantiles (high granularity) taken from the same distribution.

As one result of this criticism, additionally to or in competition with the Gini coefficient *entropy measures* are frequently used (e.g. the Atkinson and Theil indices). These measures attempt to compare the distribution of resources by intelligent players in the market with a maximum entropy random distribution, which would occur if these players acted like non-intelligent particles in a closed system following the laws of statistical physics.

A lower Gini coefficient tends to indicate a higher level of social and economic equality.

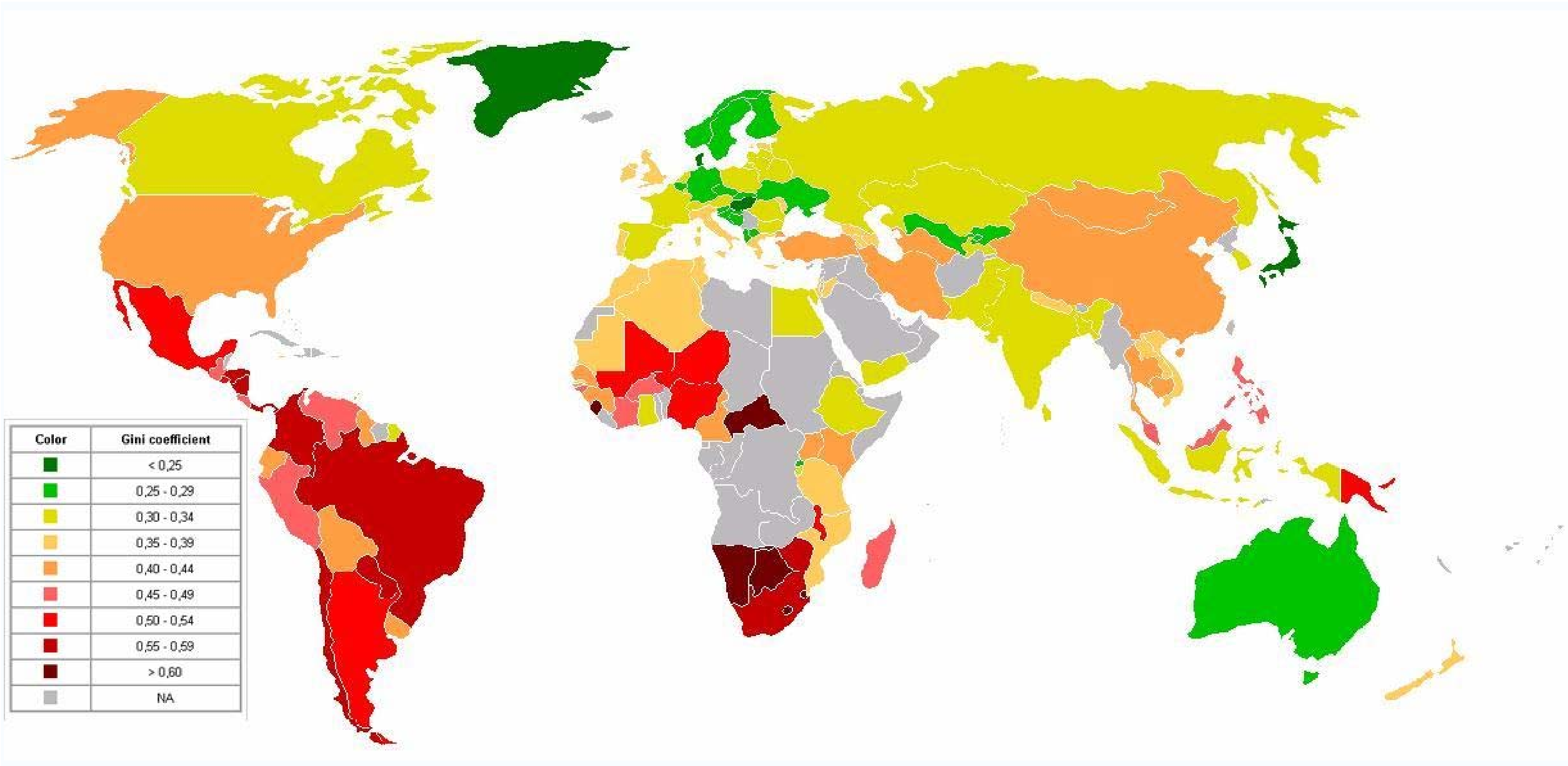
Rank	Country	Gini index	Richest 10% to poorest 10%	Richest 20% to poorest 20%	Survey year
1	Azerbaijan	19	3.3	2.6	2002
2	Denmark	24.7	8.1	4.3	1997
3	Japan	24.9	4.5	3.4	1993
4	Sweden	25	6.2	4	2000
5	Czech Republic	25.4	5.2	3.5	1996
6	Norway	25.8	6.1	3.9	2000
6	Slovakia	25.8	6.7	4	1996
8	Bosnia and Herzegovina	26.2	5.4	3.8	2001
9	Uzbekistan	26.8	6.1	4	2000
10	Hungary	26.9	5.5	3.8	2002
10	Finland	26.9	5.6	3.8	2000
12	Ukraine	28.1	5.9	4.1	2003
13	Albania	28.2	5.9	4.1	2002
14	Germany	28.3	6.9	4.3	2000
15	Slovenia	28.4	5.9	3.9	1998–99
16	Rwanda	28.9	5.8	4	1983–85
17	Croatia	29	7.3	4.8	2001
18	Austria	29.1	6.9	4.4	2000
19	Bulgaria	29.2	7	4.4	2003
20	Belarus	29.7	6.9	4.5	2002
21	Ethiopia	30	6.6	4.3	1999–00
22	Kyrgyzstan	30.3	6.4	4.4	2003
22	Mongolia	30.3	17.8	9.1	1998
24	Pakistan	30.6	6.5	4.3	2002
25	Netherlands	30.9	9.2	5.1	1999
26	Romania	31	7.5	4.9	2003
27	South Korea	31.6	7.8	4.7	1998
28	Bangladesh	31.8	6.8	4.6	2000
29	India	32.5	7.3	4.9	1999–00
30	Tajikistan	32.6	7.8	5.2	2003
30	Canada	32.6	9.4	5.5	2000
32	France	32.7	9.1	5.6	1995
33	Belgium	33	8.2	4.9	2000
34	Sri Lanka	33.2	8.1	5.1	1999–00
34	Moldova	33.2	8.2	5.3	2003

36	Yemen	33.4	8.6	5.6	1998
37	Switzerland	33.7	9	5.5	2000
38	Armenia	33.8	8	5	2003
39	Kazakhstan	33.9	8.5	5.6	2003
40	Indonesia	34.3	7.8	5.2	2002
40	Ireland	34.3	9.4	5.6	2000
40	Greece	34.3	10.2	6.2	2000
43	Egypt	34.4	8	5.1	1999–00
44	Poland	34.5	8.8	5.6	2002
45	Tanzania	34.6	9.2	5.8	2000–01
45	Laos	34.6	8.3	5.4	2002
47	Spain	34.7	10.3	6	2000
48	Australia	35.2	12.5	7	1994
49	Algeria	35.3	9.6	6.1	1995
50	Estonia	35.8	10.8	6.4	2003
51	Lithuania	36	10.4	6.3	2003
51	Italy	36	11.6	6.5	2000
51	United Kingdom	36	13.8	7.2	1999
54	New Zealand	36.2	12.5	6.8	1997
55	Benin	36.5	9.4	6	2003
56	Vietnam	37	9.4	6	2002
57	Latvia	37.7	11.6	6.8	2003
58	Jamaica	37.9	11.4	6.9	2000
59	Portugal	38.5	15	8	1997
60	Jordan	38.8	11.3	6.9	2002–03
61	Republic of Macedonia	39	12.5	7.5	2003
61	Mauritania	39	12	7.4	2000
63	Israel	39.2	13.4	7.9	2001
64	Morocco	39.5	11.7	7.2	1998–99
64	Burkina Faso	39.5	11.6	6.9	2003
66	Mozambique	39.6	12.5	7.2	1996–97
67	Tunisia	39.8	13.4	7.9	2000
68	Russia	39.9	12.7	7.6	2002
69	Guinea	40.3	12.3	7.3	1994
69	Trinidad and Tobago	40.3	14.4	8.3	1992
71	Georgia	40.4	15.4	8.3	2003
71	Cambodia	40.4	11.6	6.9	1997
73	Ghana	40.8	14.1	8.4	1998–99
73	United States	40.8	15.9	8.4	2000

73	Turkmenistan	40.8	12.3	7.7	1998
76	Senegal	41.3	12.8	7.5	1995
77	Thailand	42	12.6	7.7	2002
78	Zambia	42.1	13.9	8	2002–03
79	Burundi	42.4	19.3	9.5	1998
80	Singapore	42.5	17.7	9.7	1998
80	Kenya	42.5	13.6	8.2	1997
82	Uganda	43	14.9	8.4	1999
82	Iran	43	17.2	9.7	1998
84	Nicaragua	43.1	15.5	8.8	2001
85	**Hong Kong, China (SAR)**	**43.4**	**17.8**	**9.7**	**1996**
86	Turkey	43.6	16.8	9.3	2003
87	Nigeria	43.7	17.8	9.7	2003
87	Ecuador	43.7	44.9	17.3	1998
89	Venezuela	44.1	20.4	10.6	2000
90	Côte d'Ivoire	44.6	16.6	9.7	2002
90	Cameroon	44.6	15.7	9.1	2001
92	**People's Republic of China**	**44.7**	**18.4**	**10.7**	**2001**
93	Uruguay	44.9	17.9	10.2	2003
94	Philippines	46.1	16.5	9.7	2000
95	Guinea-Bissau	47	19	10.3	1993
96	Nepal	47.2	15.8	9.1	2003–04
97	Madagascar	47.5	19.2	11	2001
98	Malaysia	49.2	22.1	12.4	1997
99	Mexico	49.5	24.6	12.8	2002
100	Costa Rica	49.9	30	14.2	2001
101	Zimbabwe	50.1	22	12	1995
102	Gambia	50.2	20.2	11.2	1998
103	Malawi	50.3	22.7	11.6	1997
104	Niger	50.5	46	20.7	1995
104	Mali	50.5	23.1	12.2	1994
106	Papua New Guinea	50.9	23.8	12.6	1996
107	Dominican Republic	51.7	30	14.4	2003
108	El Salvador	52.4	57.5	20.9	2002
109	Argentina	52.8	34.5	17.6	2003
110	Honduras	53.8	34.2	17.2	2003
111	Peru	54.6	40.5	18.6	2002
112	Guatemala	55.1	48.2	20.3	2002
113	Panama	56.4	54.7	23.9	2002

114	Chile	57.1	40.6	18.7	2000
115	Paraguay	57.8	73.4	27.8	2002
115	South Africa	57.8	33.1	17.9	2000
117	Brazil	58	57.8	23.7	2003
118	Colombia	58.6	63.8	25.3	2003
119	Haiti	59.2	71.7	26.6	2001
120	Bolivia	60.1	168.1	42.3	2002
121	Swaziland	60.9	49.7	23.8	1994
122	Central African Republic	61.3	69.2	32.7	1993
123	Sierra Leone	62.9	87.2	57.6	1989
124	Botswana	63	77.6	31.5	1993
125	Lesotho	63.2	105	44.2	1995
126	Namibia	74.3	128.8	56.1	1993

United Nations 2006 Development Programme Report (p. 335).

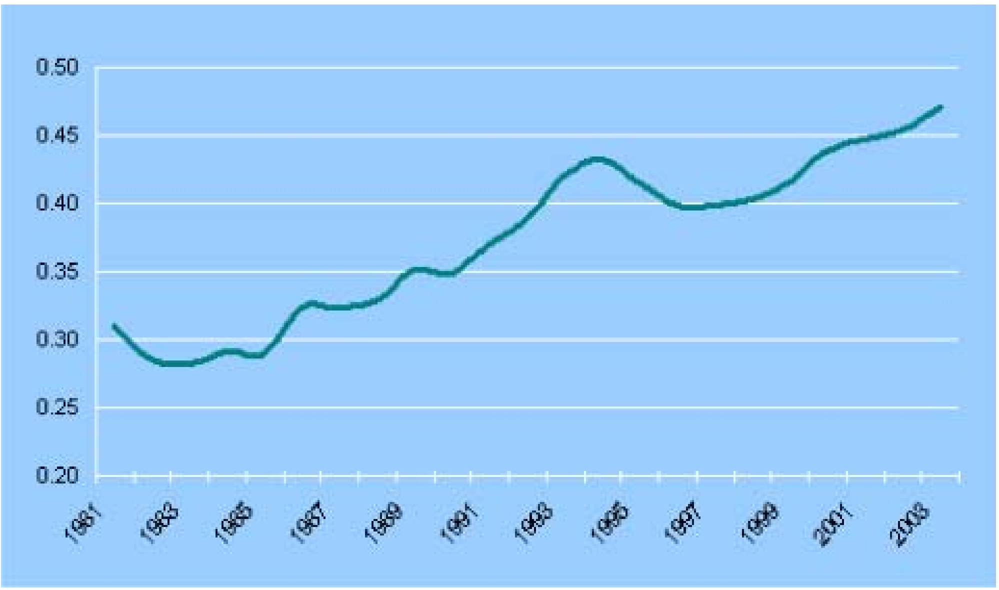


Color
Gini coefficient
< 0,25
0,25 - 0,29
0,30 - 0,34
0,35 - 0,39
0,40 - 0,44
0,45 - 0,49
0,50 - 0,54
0,55 - 0,59
> 0,60
NA

year	China's Gini Coefficient
1991	0.38
1992	0.4
1993	0.4
1994	0.41
1995	0.41
1996	0.41
1997	0.41
1998	0.41
1999	0.42
2000	0.46
2001	0.45
2002	0.447
2003	0.447
2004	0.447

Source: Ravallion and Chen, 2004. China Statistical Yearbook (State Statistical Bureau, 1992 1996 and 1997 2001).
http://www3.nccu.edu.tw/~jthuang/inequality.pdf

Gini Coefficient for China's Income Distribution, 1981-2003



Source: Ravallion and Chen, Measuring Pro-Poor Growth, World Bank Policy Research Working Paper 2666. August, 2001; The World Bank: Biannual on China's Economy. Business Weekly: No. 9, 2004

http://www.cdrf.org.cn/2006cdf/news_Harmony.htm