# Income Gap and Carbon Emissions: Data from China's City Level

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**Abstract.**With the rapid advancement of industrialization and urbanization in China, carbon emissions and income inequality have become two major challenges that need to be addressed urgently.Although there have been many studies on the causal relationship and mechanism of action between the two, but the conclusion is not uniform, leaving room for further exploration of this issue; In addition，most of studies select provincial panel data on this issue of China, which may lead to biased research results. This paper studies the panel data of 203 cities in China from 2019 to 2019 at the municipal level, and examines the impact of income inequality on carbon emissions. Through empirical test,it is found that income inequality has a negative impact on carbon emissions, and the per capita carbon emissions and regional carbon emission intensity increase with the increase of income inequality. Accordingly, this study puts forward policy recommendations for China to achieve dual carbon goals and common prosperity.

**Keywords:**Income inequality; Carbon emissions; Environmental pollution

## 1 Introduction

Since the reform and opening up, with the rapid progress of industrialization and urbanization, energy demand in various industries has increased, and China's supply side carbon emissions have significantly increased. Reducing carbon emissions and improving environmental quality have become an urgent problem to be solved in China. The rapidly growing economy has greatly enriched the material wealth of the people, but its extensive development model has also brought about a large income gap among residents. According to the 2022 Carbon Dioxide Emissions Report released by the IEA, China's carbon emissions reached about 11.4 billion tons that year, approximately 3.43 times the carbon emissions in 2000. The sharp increase in carbon emissions not only poses many hazards to people's production and life, but also affects the health level of residents. Dong et al.'s research shows that carbon emissions will reduce the health level of Chinese residents. For every 1% increase in carbon emissions, outpatient patients in hospitals will increase by 0.298%, and hospitalized patients will increase by 0.162%[1].

At the same time, the issue of imbalanced and insufficient development in China remains prominent, with significant disparities in urban-rural regional development and income distribution. According to data from the National Bureau of Statistics of China, in 2022, the per capita disposable income of urban residents was 49283 yuan, as opposed to rural residents have only 20133 yuan, which is 2.45 times that of the latter. From the perspective of income Gini coefficient, in 2000, China exceeded the internationally recognized warning line for the first

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time by 0.4, climbed to 0.479 in 2003, and then fluctuated up and down in the following 22 years, but both were higher than 0.46. China implements an income distribution system in which distribution according to work is the mainstay and multiple distribution systems coexist. Due to the varying degrees of problems at the three levels of primary distribution, redistribution and tertiary distribution, the excessive gap in income distribution poses an unavoidable challenge in the process of achieving common prosperity. The large income gap is widespread in various regions and industries, and even causes social problems such as increased crime[7] and dissatisfaction with life[8], which affects social stability and development in all aspects.[19].

In summary, carbon emissions and income inequality are two major challenges that China urgently needs to solve, the relationship between the two should also be strengthened. To examine the relationship between them, based on the Panel data of 203 cities in China from 2010 to 2019, this paper explores the impact of income gap on carbon emissions, and then provides feasible policy recommendations for China to achieve low-carbon transformation.

## 2 Literature review

Against the backdrop of China vigorously stimulating consumption and expanding domestic demand, residents' carbon emissions from consumption have significantly increased, gradually increasing their proportion in carbon emissions[11]. Refer to the history of developed countries, the consumption carbon emissions of Chinese residents will gradually approach the industrial carbon emissions. This gradual increase is influenced by many factors, with current studies focusing on size, structure, efficiency, and income level[18].

In the role of income gap and carbon emissions, existing literature can be divided into following three categories according to different perspectives: first, a category believes that income inequality exacerbates carbon emissions. The income gap and carbon emissions in the United States were studied by Baek et al, they explored the change trend of the two with the autoregressive distributed lag model, and found that the former had a negative impact on the latter in both the long and short term[2]. Zhang et al. applied China's regional panel data and concluded that if income inequality Narrows, China's carbon emissions will also fall[3]. Jorgenson et al. found in their research that when income distribution becomes more equal and the class of the poor rises, they will increase their consumption of energy and other products, leading to an increase in total carbon emissions[4]. Liu et al. believe that rich people get less satisfaction from extra unit currency, so they will reduce their living consumption in the long run, resulting in lower carbon emissions. The poor have a relatively high monetary marginal effect, but their consumption power is low and they produce less carbon emissions[5]. In addition to the above two views, there is another view that income gap has different effects on carbon emissions when circumstanses change[9][10][13]. Jorgenson et al., based on the bidirectional fixed-effect model analysis, found that the relationship between the two is non-linear, and there are differences between different countries.[6]

In a word, although there have been multiple studies exploring the impact and mechanism between income inequality and carbon emissions, the conclusions are not uniform[14][17]. In addition, for the research within the Chinese region mostly selects provincial Panel data, which may lead to errors in the research results. Based on this, this paper selects Panel data of Chinese cities to empirically calculates the effect of income inequality on carbon emissions.

## 3 Empirical analysis

### 3.1 Econometric model

According to the actual investigation of variable relationship, we build the following econometric model:

$$\mathrm{lnco_2} = \alpha_0 + \alpha_1 \mathrm{T_{it}} + \beta \mathrm{lnControl_{it}} + \mathrm{c_{it}} + \mathrm{u_{it}} + \varepsilon_{it} \quad (1)$$

In the above equation, $i$ represents the region and $t$ represents the period; $co_2$ is a carbon emission indicator, measured by the per capita carbon emissions; $T_{it}$ for income inequality index by Thiel index; $Control_{it}$ represents the set of six control variables; $c_{it}$ is a fixed regional effect; $u_{it}$ is a fixed time effect; $\varepsilon_{it}$ is a random error term.

### 3.2 Data source and indicator selection

Following the principles of data accessibility and comparability, this article selects 203 cities in China from 2010 to 2019, with a total of 2019 sample data as the research object. The statistical data used in this paper come from China Urban Statistical Yearbook, China Urban and Rural Construction Database and other databases.

Drawing on relevant research[12], the explained variable of this paper adopts the carbon emission per capita, described by the carbon emission quantity of each urban population, to measure the carbon emission of the city. At the same time, carbon emission intensity, that is, the carbon emission corresponding to the urban unit GDP, was selected for testing. The core explanatory variable selected is the Thiel ($T_{it}$) as an index of income inequality, equation (2) shows the calculation formula:

$$\mathrm{T_{it}} = \sum_{\mathrm{j=1}}^{2} \left(\frac{\mathrm{y_{jt}}}{\mathrm{y_t}}\right) \ln\left(\frac{\mathrm{y_{jt}}}{\mathrm{y_t}} \Big/ \frac{\mathrm{z_{jt}}}{\mathrm{z_t}}\right) = \left(\frac{\mathrm{y_{1t}}}{\mathrm{y_t}}\right) \ln\left(\frac{\mathrm{y_{1t}}}{\mathrm{y_t}} \Big/ \frac{\mathrm{z_{1t}}}{\mathrm{z_t}}\right) + \left(\frac{\mathrm{y_{2t}}}{\mathrm{y_t}}\right) \ln\left(\frac{\mathrm{y_{2t}}}{\mathrm{y_t}} \Big/ \frac{\mathrm{z_{2t}}}{\mathrm{z_t}}\right) \quad (2)$$

Among them, $T_{it}$ represents the Thiel index of $i$ city t period; $j = 1$ stands for urban areas, and vice versa for rural areas; $y_{1t}$ represents the total urban income, $y_{2t}$ represents the total rural income, $y_t$ represents the sum of income; $z_{jt}$ represents the total population of different regions, $z_t$ represents the city's population of the corresponding period $t$.

This paper introduces the following indicators as control variables: (1) Per-capita income(*Income*), expressed as the annual per capita GDP of the city; (2) Technological Progress (*Tech*), measured by the number of authorized patents in cities; (3) Urbanization rate (*Urban*), expressed as the ratio of urban population to total urban population (4) Industrial structure (*Stru*), as measured by the ratio of tertiary to secondary industries; (5) Openness (Fdi), calculated by the contribution of the amount of foreign capital actually used in the current year to GDP; (6) Economic scale (*GDP*), measured in terms of urban gross domestic product.The descriptive statistics of each variable are shown in Table 1.

**Table 1.** Descriptive statistics

| Variable | N | Mean | Std | Max | Min |
|---|---|---|---|---|---|
| *$C0_2$_p* | 2019 | 2.516 | 22.261 | 0.033 | 903.248 |
| *Income* | 2019 | 50389.311 | 33415.873 | 5304 | 382410 |

| | | | | | |
|---|---|---|---|---|---|
| *GDP* | 2019 | 2670.571 | 3710.724 | 143.589 | 38156 |
| *Tech* | 2019 | 6065.315 | 12714.791 | 12.000 | 131716 |
| *T* | 2019 | 0.084 | 0.048 | 0.005 | 0.283 |
| *Urban* | 2019 | 0.537 | 0.142 | 0.197 | 0.950 |
| *Fdi* | 2019 | 0.020 | 0.041 | 0.000 | 0.741 |
| *Stru* | 2019 | 0.916 | 0.467 | 0.194 | 5.168 |

### 3.3 Analysis of empirical results

This paper uses OLS regression and clustering standard error to empirically test the econometric model, and Time fixed effect and city fixed effect are gradually added to the benchmark results to observe the robustness of the research results. Table 2 in the first three columns is income inequality (*T*) estimate of the per capita carbon emissions ($lnCO_2\_p$) results. Among them, column (1) added control variables, and then column (2) added time fixed effects, and column (3) further added regional fixed effects on top of column (2). Table2 shows that the estimated coefficients of *T* are significantly positive, which indicates the larger the Theil index, the greater income inequality, leading to higher per capita carbon emissions.

To test the above conclusion from another angle, this paper selects carbon emission intensity, that is, the carbon emission corresponding to the unit GDP of a city, as another carbon emission index to estimate. The other three columns in the table are the estimated results of carbon emission intensity (*lnCO2_i*) as the explained variable, which indicate the coefficient is also significantly positive.

**Table 2.** Empirical results

| Variable | $lnCO_2\_p$ | | | $lnCO_2\_i$ | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| *T* | 3.154$^{***}$ | 2.321$^{**}$ | 1.392$^{***}$ | 3.335$^{***}$ | 2.410$^{**}$ | 1.350$^{***}$ |
| | (2.868) | (2.152) | (3.058) | (3.063) | (2.264) | (3.057) |
| *LnUrb* | 6.324$^{***}$ | 5.499$^{***}$ | 0.837 | 6.236$^{***}$ | 5.313$^{***}$ | 0.685 |
| | (7.194) | (6.112) | (1.627) | (7.217) | (6.082) | (1.339) |
| *lnFdi* | 0.093 | -0.274 | 0.121 | 0.221 | -0.203 | 0.091 |
| | (0.237) | (-0.617) | (0.271) | (0.498) | (-0.483) | (0.213) |
| *lnTech* | 0.025 | 0.044 | 0.070$^{**}$ | 0.030 | 0.051 | 0.070$^{**}$ |
| | (0.507) | (0.875) | (2.465) | (0.591) | (1.013) | (2.448) |
| *lnIncome* | 0.970$^{***}$ | 1.144$^{***}$ | 0.025 | 0.064 | 0.258$^{**}$ | 0.026 |
| | (8.572) | (9.347) | (0.257) | (0.568) | (2.160) | (0.335) |
| *lnStru* | -0.478$^{**}$ | -0.102 | -0.162 | -0.467$^{**}$ | -0.048 | -0.151 |
| | (-2.571) | (-0.501) | (-1.323) | (-2.508) | (-0.238) | (-1.233) |
| *lnGDP* | -0.329$^{***}$ | -0.379$^{***}$ | 0.077 | -0.355$^{***}$ | -0.411$^{***}$ | -0.854$^{***}$ |
| | (-3.276) | (-3.737) | (0.607) | (-3.536) | (-4.075) | (-7.005) |
| _cons | -7.633$^{***}$ | -8.257$^{***}$ | -2.378 | 1.001 | 0.309 | 11.282$^{***}$ |
| | (-6.283) | (-6.807) | (-1.364) | (0.838) | (0.260) | (6.477) |
| Time | No | Yes | Yes | No | Yes | Yes |

| | | | | | | |
|---|---|---|---|---|---|---|
| Regional | No | No | Yes | No | No | Yes |
| *N* | 2019 | 2019 | 2019 | 2019 | 2019 | 2019 |
| *adj.*$R^2$ | 0.650 | 0.668 | 0.931 | 0.303 | 0.349 | 0.865 |
| *F-Value* | 88.599 | 48.535 | 730.949 | 12.364 | 23.849 | 400.445 |

### 3.4 Robustness test

To test the robustness of the conclusion, the Theil index was replaced by the urban-rural income gap index to further verify the empirical results. In this paper, the ratio of urban residents' disposable income to rural residents' net income is selected to reflect the interregional income gap (*gini*)[16]. Table 3 shows the estimated results of urban-rural income gap on carbon emissions. In the following table the estimated coefficient of Gini coefficient is significantly positive, indicating the robustness of the benchmark results.

**Table 3.** Robustness test

| Variable | $lnCO_2\ p$ | $lnCO_2\ i$ |
|---|---|---|
| *gini* | $0.173^{***}$ | $0.172^{***}$ |
| | (3.266) | (3.287) |
| _cons | $-2.986^{*}$ | $10.669^{***}$ |
| | (-1.730) | (6.202) |
| control variables | Yes | Yes |
| Time | Yes | Yes |
| Regional | Yes | Yes |
| *N* | 2019 | 2019 |
| adj.$R^2$ | 0.931 | 0.865 |
| *F-Value* | 726.352 | 394.625 |

## 4 Conclusions

Based on data from 203 cities in China from 2010 to 2019, this paper takes the per capita carbon emission from the perspective of population as the explained variable and the carbon emission intensity from the perspective of economic income as the explained variable, then explores the impact between the carbon emission and the income gap of the explanatory variable respectively. The study found that income inequality has a negative impact on carbon emissions, and the per capita carbon emissions and regional carbon emission intensity increase with the increase of income inequality.

Based on this, we propose the following policy recommendations: (1) The government should face up to widening income gap, which could lead to an increase in carbon emissions objective facts, improve the existing income distribution system and Integrate income distribution policies into carbon neutral strategies[15], reduce the proportion of low-income families, and strive to build a healthier economic environment. (2) The government should formulate differentiated carbon emission control policies based on income levels. For low-income groups, to increase environmental awareness, encourage energy efficiency and take part in environmental protection undertakings; For high income groups, to improve their environmental knowledge level, and undertake corresponding social responsibility. In addition, we will improve the efficiency of the tax adjustment mechanism, and link the responsibility for carbon emissions with the level of personal income, corporate responsibility, and government performance.

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