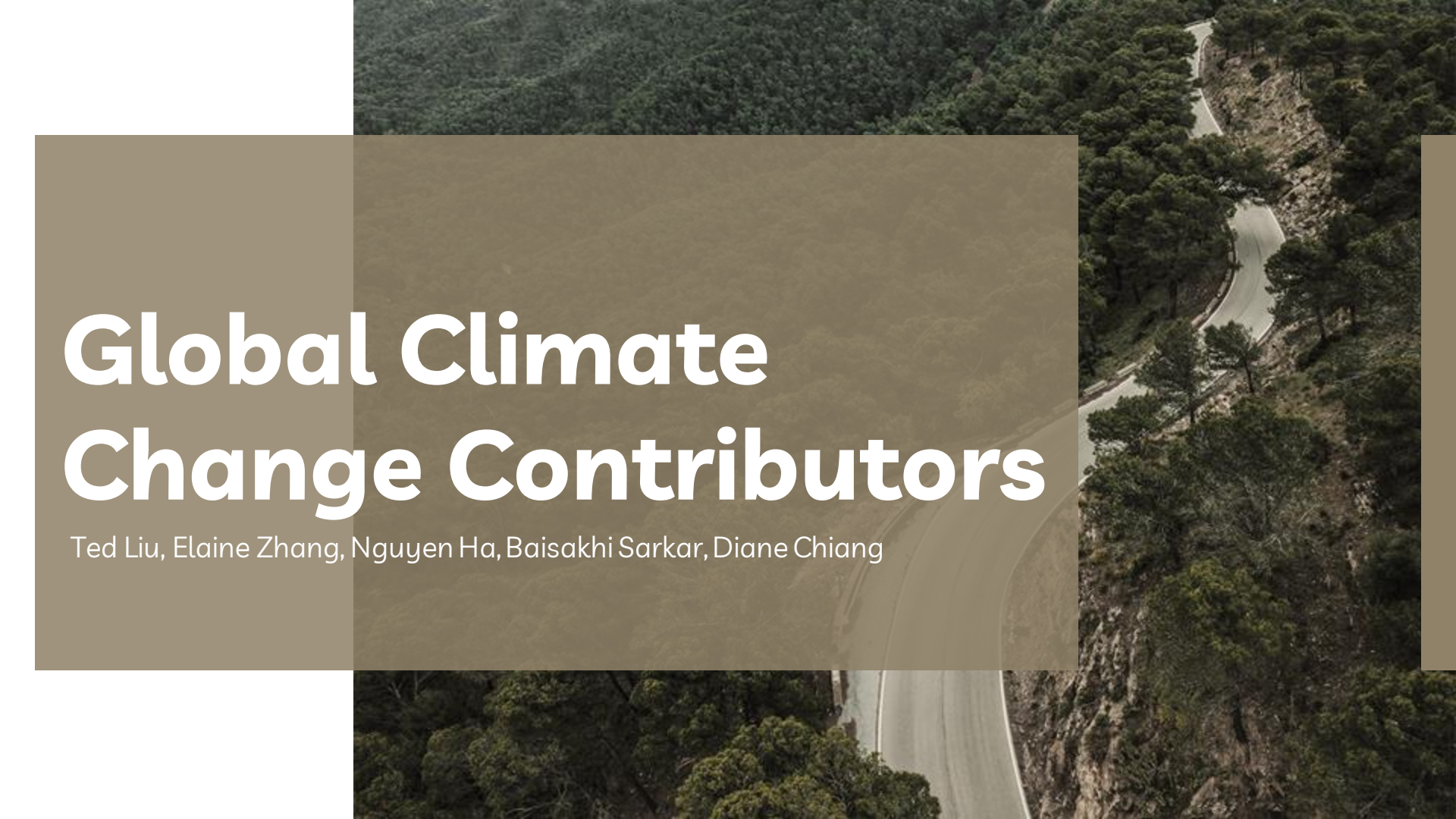

Global Climate Change Contributors

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Background

Climate change is an issue that will be relevant our entire lives.

To better understand how different factors are correlated with climate change, we focused on one of the most widely known contributors to the climate crisis – carbon dioxide emissions.

To see the effects of recent mitigation efforts, we explored the relationships between different natural and socioeconomic metrics and carbon dioxide emissions in recent years.

Data

Source	Dataset	Details
The World Bank	Environment, Social And Governance Data	Information on 17 key sustainability themes, CO2 emissions data
IMF	Forest and Carbon	Contains forestry indicators by country from 1990 to 2020
The World Bank	Energy Use	Contains energy consumption data from 1960 – 2022
The World Bank	Electricity Production from Renewable Resources	Contains energy production data from 1960 – 2022
The World Bank	Urban Development	Contains urban population data from 1960 – 2022

Research Questions

1. Has average CO2 emissions increased since the late 20th century and early 21st century?
2. Are CO2 emissions associated with any environment-related indicators and metrics?
    - Forestry-related metrics
    - Natural disaster metrics
3. Are CO2 emissions associated with any social or economic indicators and metrics?
    - Socioeconomic indicators
    - Electricity production and consumption
    - Urbanization metrics

Motivation

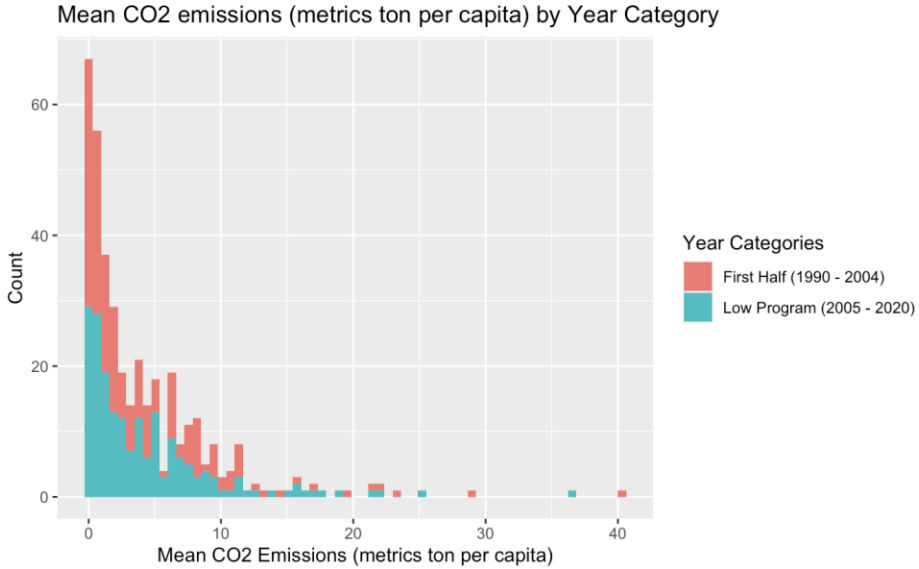
01

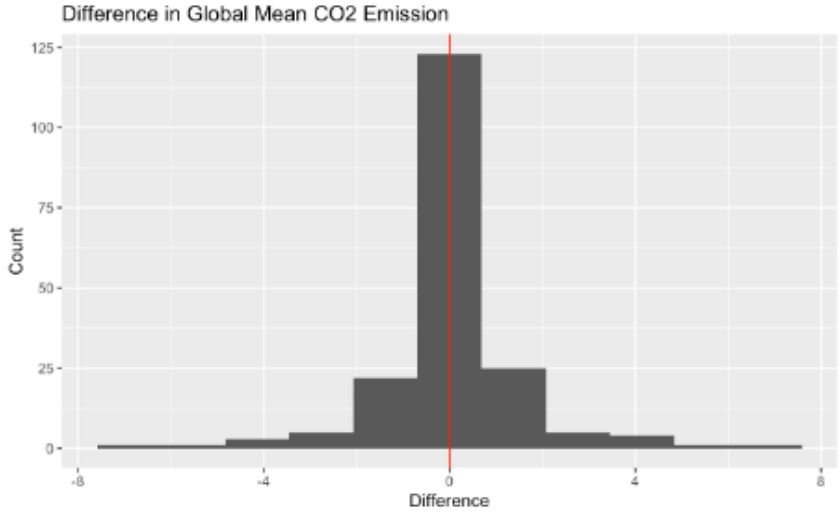
CO2 Emission

- The World Bank data includes info on 17 key sustainability themes spanning environmental, social, and governance categories.
- Interested in CO2 emissions (metric tons per capita) from 1990 – 2020
- Tested mean difference CO2 emissions from first half (1990 – 2005) and second half (2005 – 2020)
  - Global mean difference
  - 30 countries with highest CO2 emission vs. 30 countries with lowest CO2 emission
  - Individual countries of interest

T Test on Global Mean Difference

- H0: There is no difference in global mean CO2 emission (metric tons per capita) between the first half (1990 – 2005) and the second half (2006 – 2020)

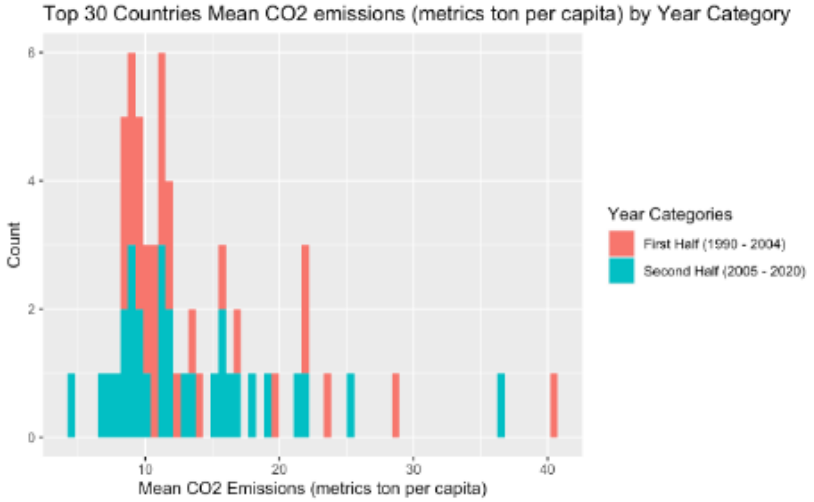


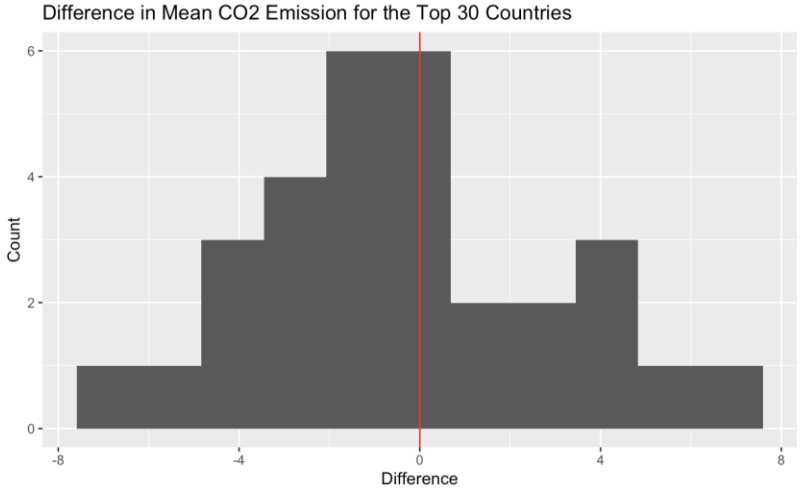


- The p value is around 0.7671 => insufficient evidence to conclude otherwise.

T Test on Top 30 Countries

- Picked top 30 countries with the most CO2 emission based on second half of the years (2005 – 2020)
- H0: There is no difference between the mean CO2 emission between the first half the years (1990 –

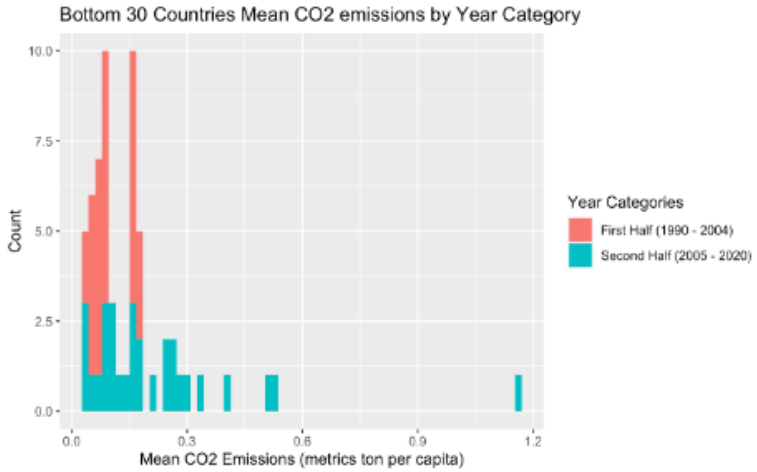


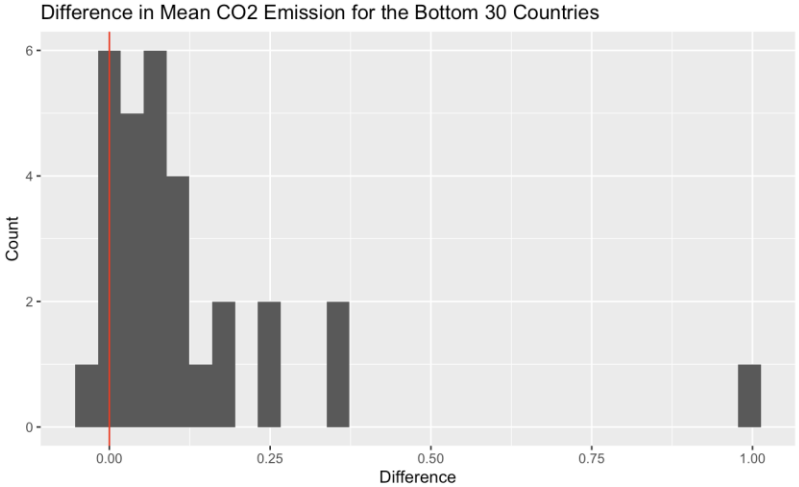


- The p-value is 0.3596 => fail to reject the null hypothesis that there is no difference

T Test on Bottom 30 Countries

- Picked 30 countries with the least CO2 emission based on second half of the years (2005 – 2020)
- H0: There is no difference between the mean CO2 emission between the first half the years (1990 – 2005) and the second half (2006 – 2020)





- The p-value is 0.0023 => reject the null hypothesis and conclude that there is a difference in mean CO2 emission (metrics ton per capita) between the first and second half the years in the 30 countries with the least CO2 emission.

Forestry

02

Forestry

- Forestry-related Metrics at the Country Level:
  - Forest Share (% of Land Area)
  - Agriculture, Forestry, Fishing Value Added (% of GDP)
- Data Used:
  - CO_2 emissions (metric tons per capita) from 1990 – 2020, World Bank
  - Forest and Carbon dataset from 1990 – 2020, IMF
- Multiple Linear Regression With Interaction
  - Explanatory Variables: mean forest share (% of land area), mean agriculture, forestry, fishing value added (% of GDP)
  - Response Variable: mean CO_2 emissions per capita
  - Adjustments for Assumptions:
    - Transformation of y-values
    - Jackknife estimation of standard errors

Forestry

Variable	Coefficients	P-value	Statistically significant (α = 0.05)
Mean Forest Share	0.0164943	0.0197152	✓
Mean Agriculture, Forestry, Fishing Value Added (% of GDP)	0.3056336	1.680996e-09	✓
Interaction Between Mean Forest Share and Mean Agriculture, Forestry, Fishing Value Added (% of GDP)	-0.0022125	0.009489029	✓

Socioeconomic Factors

03

Social and Economic Indicators

- For each country, from 1960 – 2022, but only look at 1990 – 2020
  - Only use complete cases for any instances of missing data
- Social Indicators:
  - Overweight prevalence in adults (% of adults)
  - Population Density
  - Proportion of Women in Government
  - Voice and Accountability Estimate
  - Government Spending on Education
  - Urban Population
- Economic Indicators:
  - GDP Growth
  - Industry (including construction), value added (% of GDP)
    - Value added in mining, manufacturing, construction, electricity, water, and gas.

Social and Economic Indicators

Statistically Significant: ($\alpha = 0.05$):

- Overweight (t=9.891)
- Population Density (t=3.36)
- Citizen Voice (t=3.503)
- Industry (t=9.560)
- Urban Population (t=5.560)

Practically Significant:

- Overweight
- Population Density
- Citizen Voice
- Industry
- Urban Population

Variable	**Raw Coefficient**	**% Change** $(e^{(\beta)}-1)\times 100$
Overweight	0.0467205 (0.0307, 0.0626)	4.78290633
GDP Growth	0.0025781 (0.0001, 0.0050)	0.25814119
Population Density	0.0006291 (0.000067, 0.00119)	0.06293371
Proportion Women Gov.	0.0019987 (0.000036, 0.00396)	0.20006876
Citizen Voice	0.0603953 (0.009100, 0.111689)	6.22564011
Education Spending	-0.0242037 (-0.04740, -0.00100)	-2.39131104
Industry	0.0131072 (0.0100, 0.0161)	1.31934334
Urban Population	0.0132841 (0.006249, 0.02031)	1.33727117

Energy Consumption

04

Electricity **Indicators**

- For each country, from 1960 – 2022, but only look at 1990 – 2020
  - Impute missing data with 0s.
- Energy production indicators:
  - Electricity production from coal sources (% of total)
  - Electricity production from hydroelectric sources (% of total)
  - Electricity production from natural gas sources (% of total)
  - Electricity production from nuclear sources (% of total)
  - Electricity production from oil sources (% of total)
  - Electricity production from renewable sources, excluding hydroelectric (% of total)
- Energy consumption Indicators:
  - Energy use (kg of oil equivalent per capita)
  - Electric power consumption (kWh per capita)
  - Fossil fuel energy consumption (% of total)
  - Combustible renewables and waste (% of total energy)
  - Alternative and nuclear energy (% of total energy use)
  - Electric power transmission and distribution losses (% of output)
- Multiple Linear Regressions
  - Explanatory Variables: all indicators in each group
  - Response Variable: CO_2 emissions

Electricity Production Indicators

Variable	Coefficients	P-value	Statistically significant (α = 0.05)
Electricity production from coal sources (% of total)	0.038	< 2e-16	✓
Electricity production from hydroelectric sources (% of total)	-0.018	< 2e-16	✓
Electricity production from natural gas sources (% of total)	0.089	< 2e-16	✓
Electricity production from nuclear sources (% of total)	0.097	< 2e-16	✓
Electricity production from oil sources (% of total)	-0.00009	0.967	
Electricity production from renewable sources, excluding hydroelectric (% of total)	0.063	1.57e-08	✓

Electricity Consumption Indicators

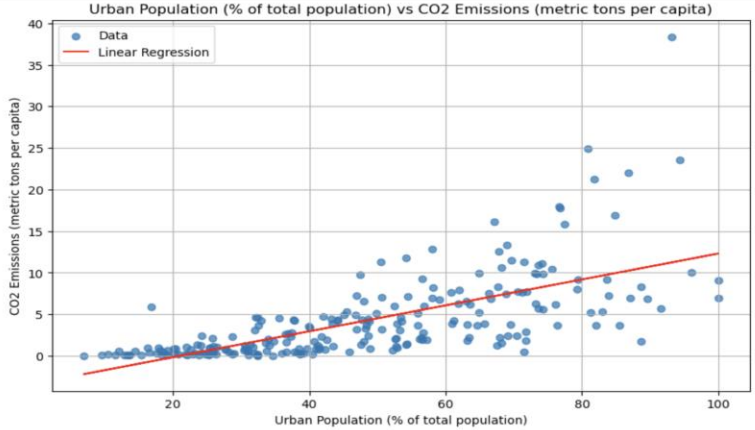
Variable	Coefficients	P-value	Statistically significant (α = 0.05)
Energy use (kg of oil equivalent per capita)	0.0014	< 2e-16	✓
Electric power consumption (kWh per capita)	0.0001	1.69e-11	✓
Fossil fuel energy consumption (% of total)	0.016	< 2e-16	✓
Combustible renewables and waste (% of total energy)	-0.032	< 2e-16	✓
Alternative and nuclear energy (% of total energy use)	-0.088	< 2e-16	✓
Electric power transmission and distribution losses (% of output)	-0.023	1.98e-05	✓

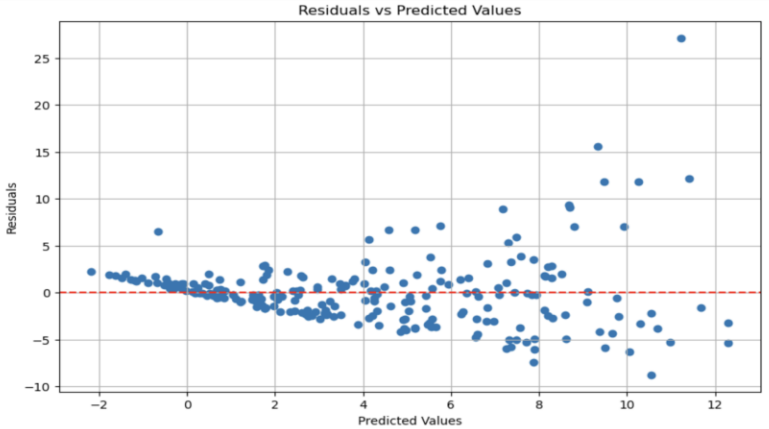
Urbanization

05

Urban Population (% of total Population) Indicator

- For each country, from 1960 – 2022, but we are only looking at 1990 – 2020 (due to unavailability of data points)
  - Impute missing data with 0s.
- Urban Population Indicators used:
  - Urban Population (% of population)
- Simple Linear Regressions
  - Explanatory Variables: Urban population (% of total population)
  - Response Variable: CO2 emissions
- Heteroscedasticity observed – Performed the analysis with standard errors and robust standard errors separately





Urban Population (% of total Population) Indicator

	Coefficient(Beta)	Test Statistic	P-value	Statistically significant ($\alpha = 0.05$)
Linear Regression Hypothesis Testing using Standard Error for Urban Population Indicator Variable	0.15572	0.901619	1.2046e-31	✓
Linear Regression Hypothesis Testing using Robust Standard Error for Urban Population Indicator Variable	0.15572	0.901619	8.16964e-19	✓


Questions