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Python for Data Science and AI

THE RELATIONSHIP BETWEEN CO_2 EMISSIONS AND SOCIO-ECONOMIC GROWTH

Countries develop

True?

Climate problems multiply

GDP PER CAPITA

- **Gross Domestic Product (current US$)**
- Measures the gross domestic product per capita of all countries within a specific years
- Source: World Bank

LITERACY VARIABLE

- **Adult literacy rate**
- Total % of people ages 15 and higher
- Capable to read and write a short, simple statement about their everyday life
- Source: World Bank

CO2 PER CAPITA

- **Emissions/population**
- Includes CO_2 released from human activities, especially from burning fossil fuels and industrial processes
- Source: Our World in Data

REASONING HYPOTHESIS

1. The economic growth of countries has a positive relationship to CO2 emissions rate
2. The social development of countries has a positive relationship to CO2 emissions rate

RESEARCH QUESTION 1

How is the CO_2 emission rate of countries related to their socio-economic development?

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NULL HYPOTHESIS ONE

There is no relationship between CO2 emissions and GDP of countries

GDP from World Bank, between 2000 and 2024

```
gdp = wb.data.DataFrame("NY.GDP.PCAP.CD", time=range(2000, 2025))
```

CO2 from World in Data, between 2000 and 2024

```
co = pd.read_csv("https://ourworldindata.org/grapher/co-emissions-per-capita.csv?v=1&csvT
co_filter = co[(co['Year'] >= 2000) & (co['Year'] <= 2024)]
```

Testing null hypothesis 1 using Pearson correlation coefficient

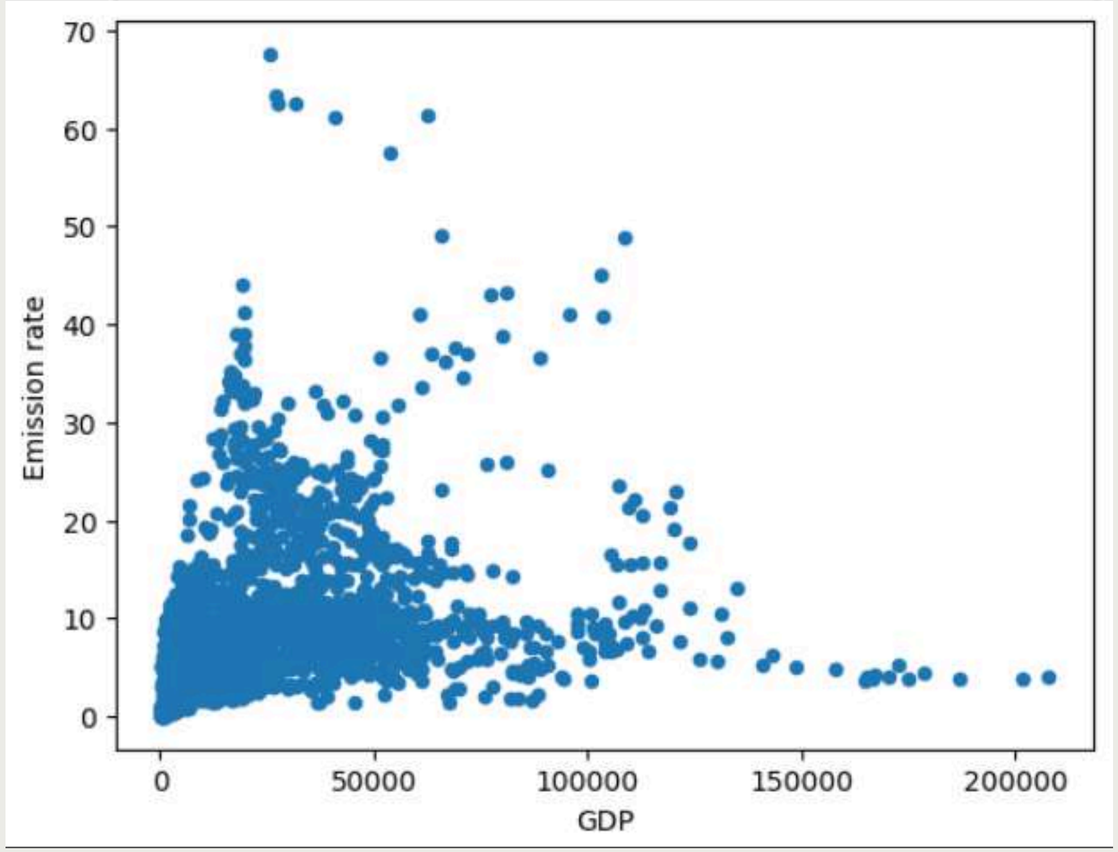
```
from scipy.stats import pearsonr
corr, p_value = pearsonr(merge_co_gdp['GDP'], merge_co_gdp['Emission rate'])
print("Correlation:", corr)
print("p-value:", p_value)
if p_value>=0.05:
  print("fail to reject the null hypothesis")
else:
  print("rejecting the null hypothesis")
```

```
Correlation: 0.49104457039263305
p-value: 2.7438351915934954e-289
rejecting the null hypothesis
```

The null hypothesis stating that there is no relationship between CO_2 emissions and GDP of countries was rejected.

ALTERNATIVE HYPOTHESIS ONE

Countries with higher GDP levels tend to exhibit higher CO_2 emissions.



- Low GDP countries cluster near the bottom, while high-GDP countries show various results.
- Positive upward trend that slows down at one point
- Overall the data supports alternative Hypothesis

NULL HYPOTHESIS TWO

There is no relationship between CO2 emission and level of literacy in different countries

Adult literacy rate from World Bank, between 2000 and 2024

```
edu = wb.data.DataFrame("SE.ADT.LITR.ZS", time=range(2000, 2025))
print(edu.head())
edu_long = edu.reset_index().melt(
    id_vars='economy',
    var_name='Year',
    value_name='Lit'
)
edu_long['Year'] = edu_long['Year'].str.replace('YR','').astype(int) #everything same as with GDP
edu_long = edu_long.rename(columns={'economy':'Code'})
```

Testing null hypothesis 2 using Pearson correlation coefficient

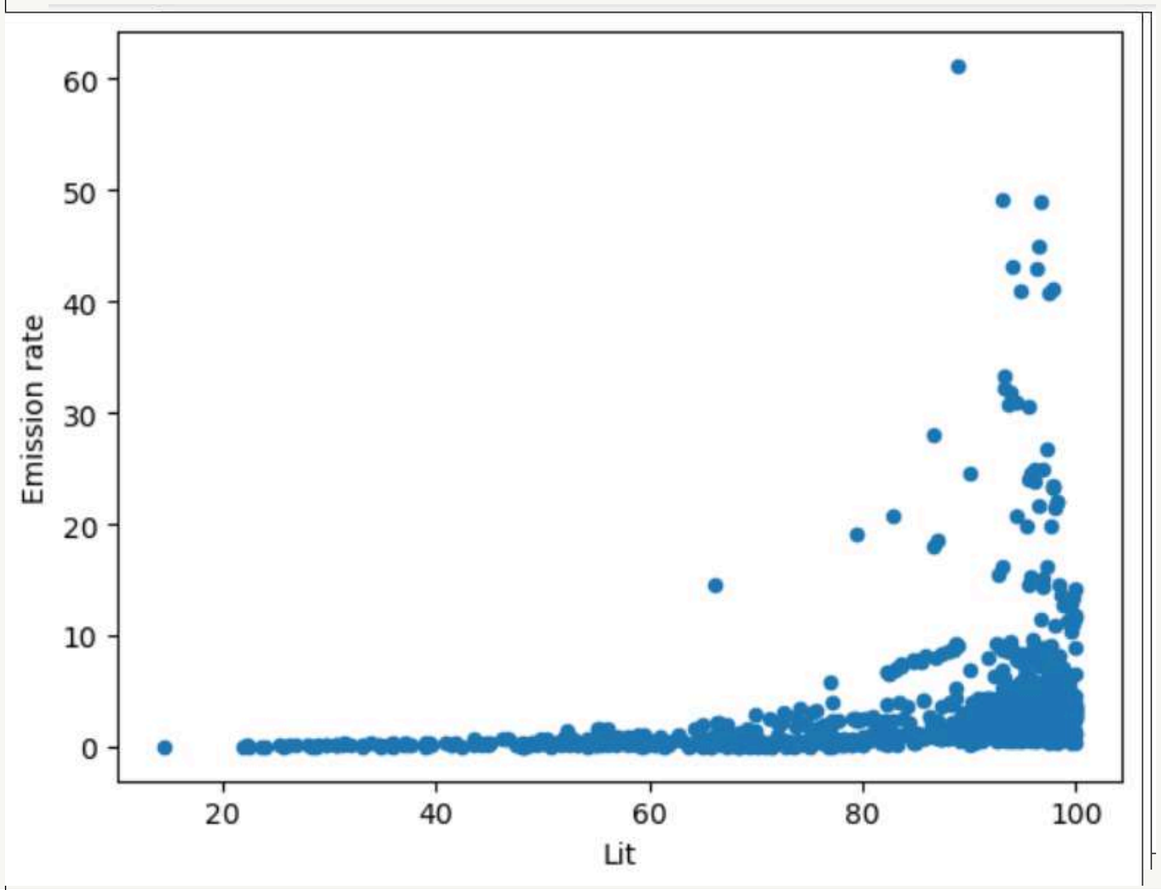
```
corr, p_value = pearsonr(merge_co_edu['Lit'], merge_co_edu['Emission rate'])
print("Correlation:", corr)
print("p-value:", p_value)
if p_value>=0.05:
  print("fail to reject the null hypothesis")
else:
  print("rejecting the null hypothesis")
```

```
Correlation: 0.3081595871723244
p-value: 7.405518536153116e-21
rejecting the null hypothesis
```

The null hypothesis stating that there is no relationship between CO_2 emissions and adult literacy rate of countries was rejected.

ALTERNATIVE HYPOTHESIS TWO

Countries with higher adult literacy rate tend to exhibit higher CO_2 emissions.



- Weak positive relationship
- As literacy rate approaches around 95% wider spread is shown
- Overall the data moderately supports alternative Hypothesis

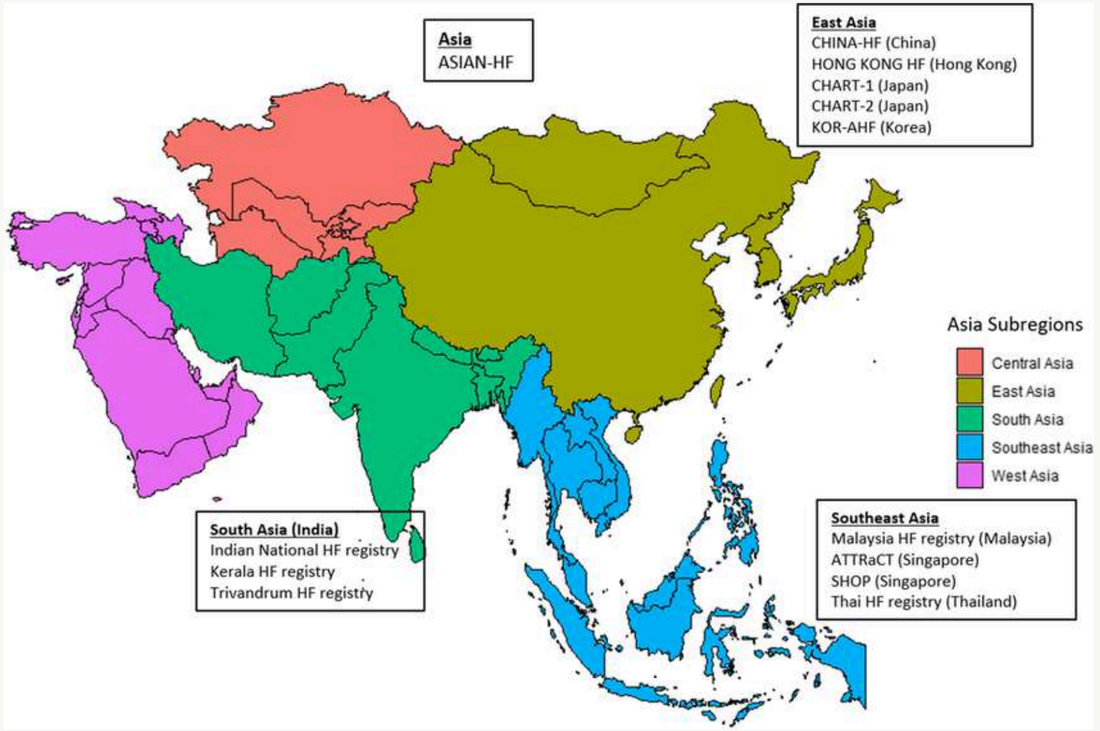
RESEARCH QUESTION 2

How is the CO2 emission rate of Asian countries related to their socio-economic development?

REGION VARIABLE

Asian Countries

Afghanistan, Bangladesh, Bhutan, India, Nepal, Pakistan, Sri Lanka, China, Hong Kong SAR (China), Japan, Macao SAR (China), Mongolia, North Korea, South Korea, Taiwan, Brunei Darussalam, Cambodia, Timor-Leste, Indonesia, Laos, Malaysia, Philippines, Singapore, Thailand, Vietnam, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan, Armenia, Azerbaijan, Bahrain, Cyprus, Georgia, Iraq, Israel, Jordan, Kuwait, Lebanon, Oman, Palestine, Qatar, Saudi Arabia, Syria, Turkey, United Arab Emirates



NULL HYPOTHESIS ONE AND TWO

There is no relationship between CO2 emissions and GDP of Asian countries

There is no relationship between CO2 emissions and adult literacy of Asian countries

Countries used to test this hypothesis

```
asian_countries = ['AFG', 'BGD', 'BTN', 'IND', 'NPL', 'PAK', 'LKA', 'CHN', 'HKG', 'JPN',
co_asia = co_filtered[co_filtered['Code'].isin(asian_countries)]
```

Testing null hypothesis 1&2 using Pearson correlation coefficient

```
corr, p_value = pearsonr(merge_co_gdp_asia['GDP'], me
print("Correlation:", corr)
print("p-value:", p_value)
if p_value>=0.05:
  print("fail to reject the null hypothesis")
else:
  print("rejecting the null hypothesis")
```

```
Correlation: 0.6329331080454598
p-value: 5.90483601277404e-122
rejecting the null hypothesis
```

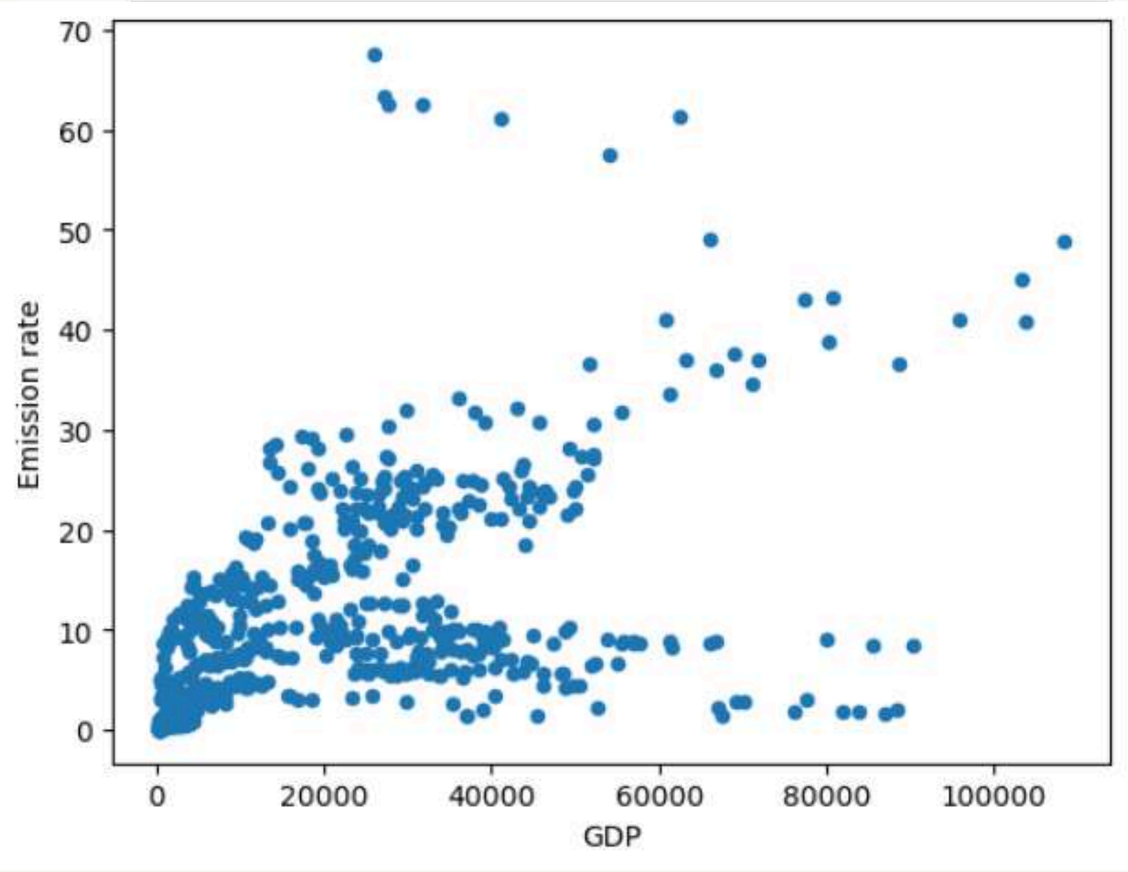
```
corr, p_value = pearsonr(merge_co_edu_asia['Lit'], m
print("Correlation:", corr)
print("p-value:", p_value)
if p_value>=0.05:
  print("fail to reject the null hypothesis")
else:
  print("rejecting the null hypothesis")
```

```
Correlation: 0.2696174986172553
p-value: 2.2398385898969844e-06
rejecting the null hypothesis
```

The null hypothesis stating that there is no relationship between CO_2 emissions and GDP/adult literacy rate of Asian countries was rejected.

ALTERNATIVE HYPOTHESIS ONE

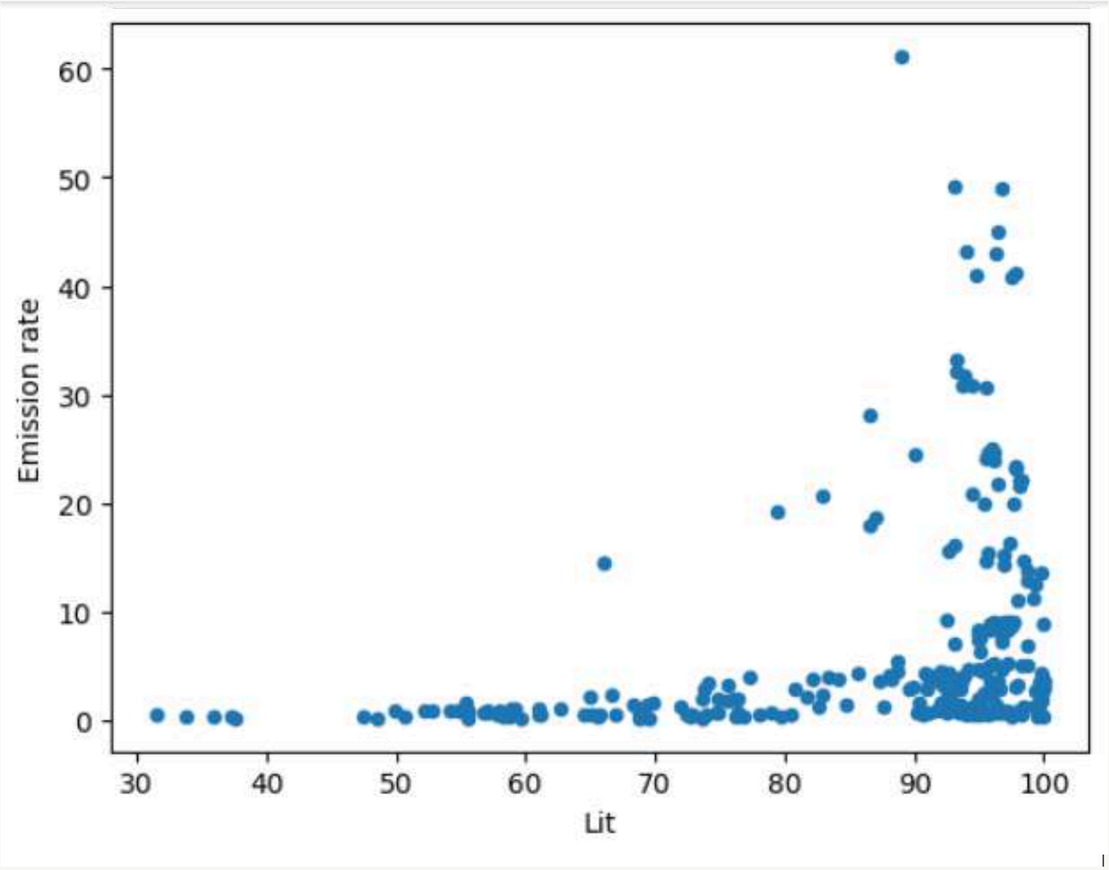
Higher GDP countries produce more CO2 emissions in Asian countries.



- Low GDP countries cluster near the bottom, while high GDP countries show greater variability and higher emission levels
- Positive upward trend that slows down at one point
- Overall the data supports alternative Hypothesis

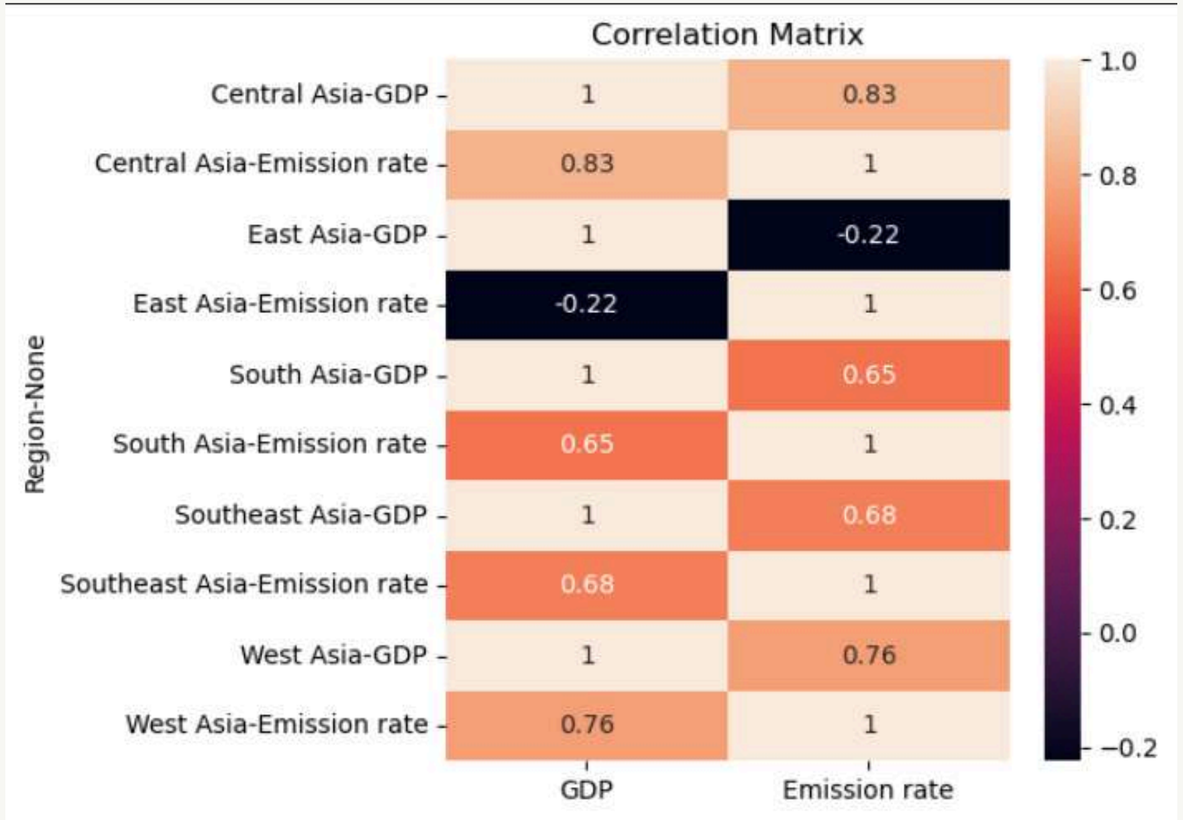
ALTERNATIVE HYPOTHESIS TWO

Higher GDP countries produce more CO2 emissions in Asian countries.



- Weak positive relationship
- As literacy rate approaches 90% wider spread is shown
- Overall the data supports alternative Hypothesis
- Not a lot of data below 50 on x-axis

FUTURE RESEARCH



- Central and West Asia show the highest correlation
- East Asia reduces emission with economic growth
- South and South-East Asian countries show similar correlation results

RESEARCH CONCLUSION

There is evidence to support that countries with greater socio-economic development output more CO_2 emissions

References

Florides, G. A., & Christodoulides, P. (2008). Global warming and carbon dioxide through sciences. *Environment International*, *35(2)*, 390–401. https://doi.org/10.1016/j.envint.2008.07.007

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