ECON 0150 | Economic Data Analysis

The economist's data analysis skillset.

Part 2.1 | Relationships Between Numerical Variables

Bivariate Relationships

Let's summarize what we know about four datasets.

Bivariate Relationships

Let's summarize what we know about four datasets.

Summary Statistics: Four Datasets

Dataset	*Mean(x)*	*Mean(y)*	*Std(x)*	*Std(y)*	*Corr(x,y)*
I	*9.0*	*7.5*	*3.32*	*2.03*	*0.82*
II	*9.0*	*7.5*	*3.32*	*2.03*	*0.82*
III	*9.0*	*7.5*	*3.32*	*2.03*	*0.82*
IV	*9.0*	*7.5*	*3.32*	*2.03*	*0.82*

> same means, same standard deviations, same correlation between x and y…

> are these datasets the same?

Bivariate Relationships

Are these the same datasets?

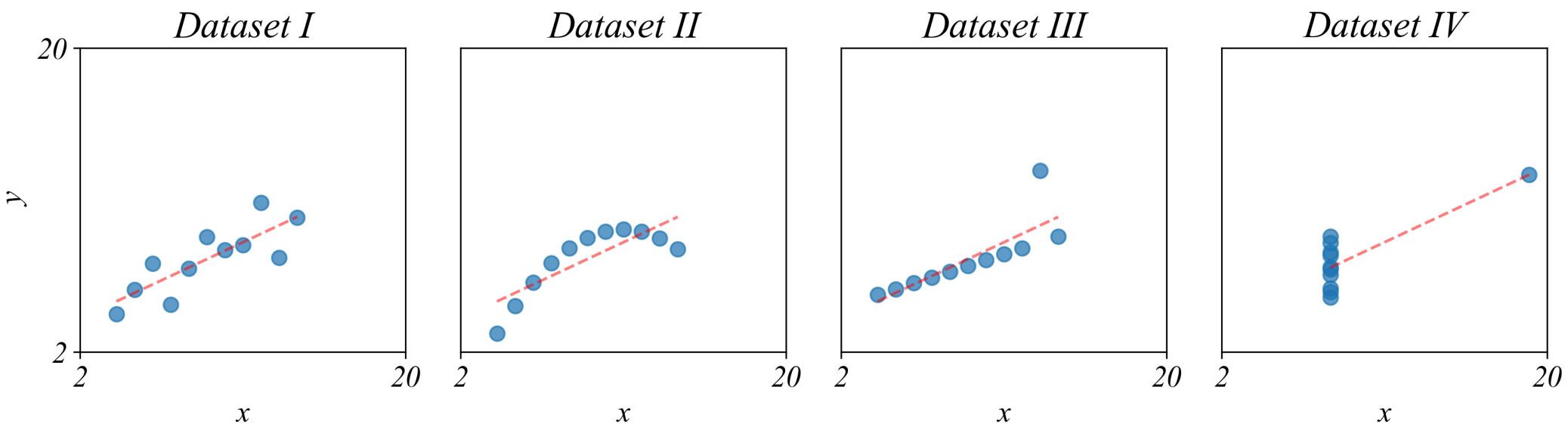
Lets take a look at the data in a Notebook!

```
# Visualize all four datasets
sns.relplot(anscombe, x='x', y='y', col='dataset')
```

Bivariate Relationships

Are these the same datasets?

Anscombe's Quartet: Same Statistics, Different Patterns



> very different! summarizing variables isn't enough

Bivariate Relationships

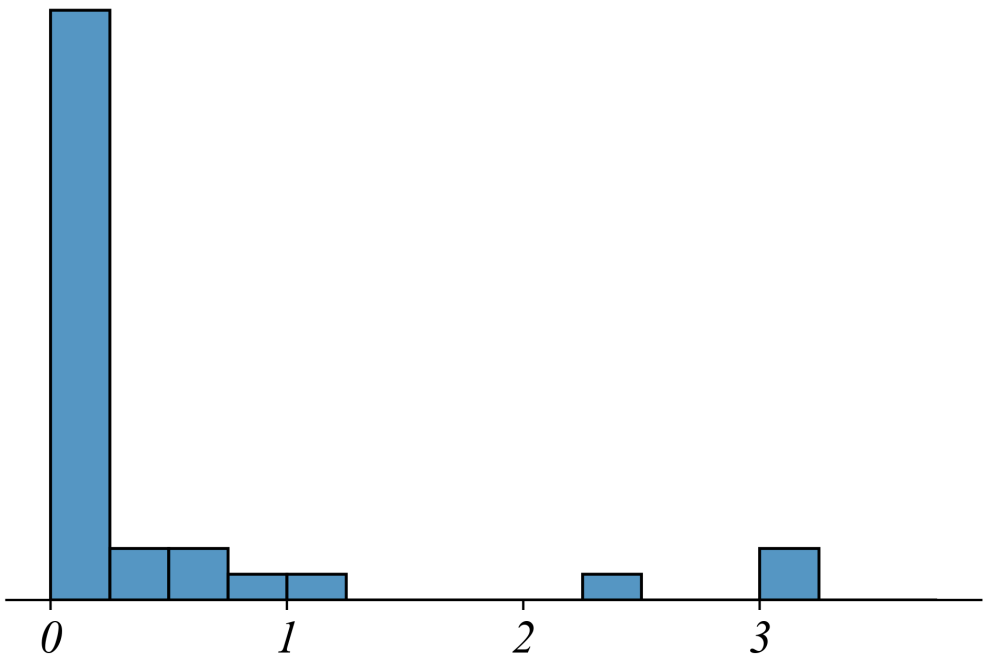
Summary statistics can hide important patterns

- *The same mean, variance, and correlation can describe **very different** data*
- ***Visualizing relationships** between variables allows us a clearer understanding*
- *Part 2 is about exploring relationships in this way*

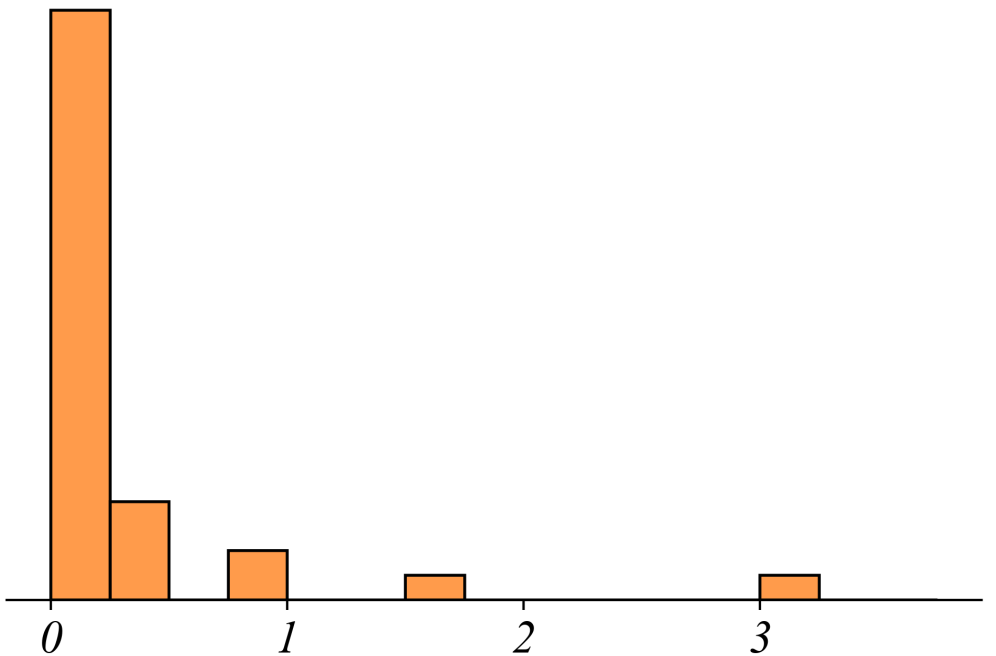
Bivariate Relationships in Cross-Section

Q. Is there a relationship between GDP and coffee production?

Gross Domestic Product (GDP)



Coffee Production (tonnes)



> maybe, but it's hard to see

> lets use a two dimensional graph

Bivariate Relationships in Cross-Section

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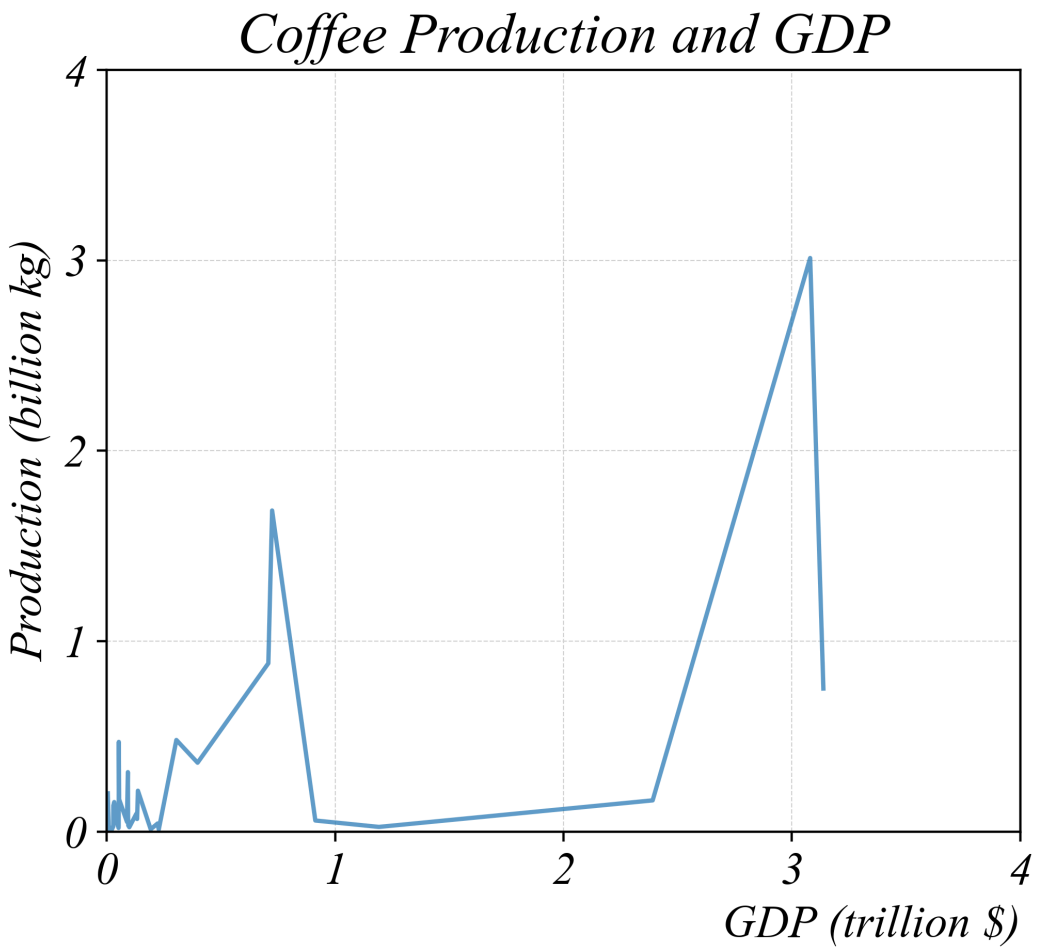

> *two dimensions is nice, but the points have no meaningful relationships*

Bivariate Relationships in Cross-Section

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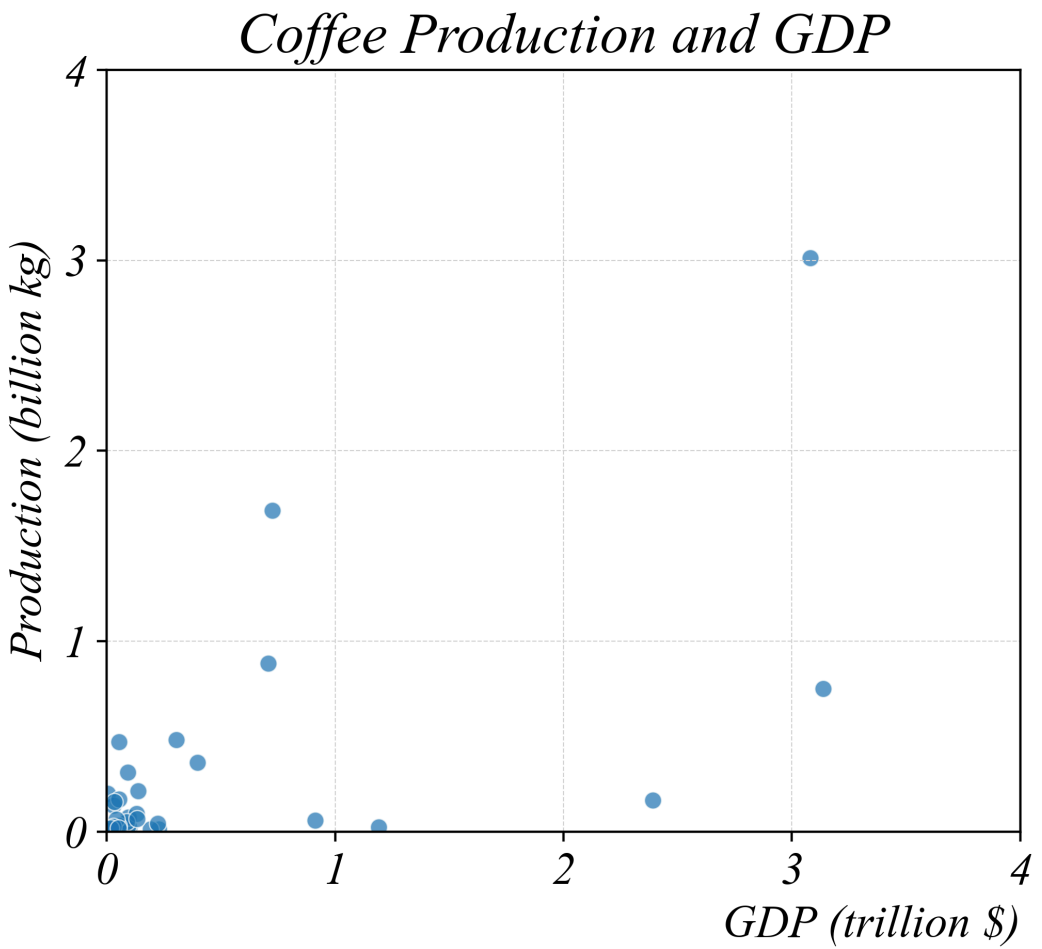
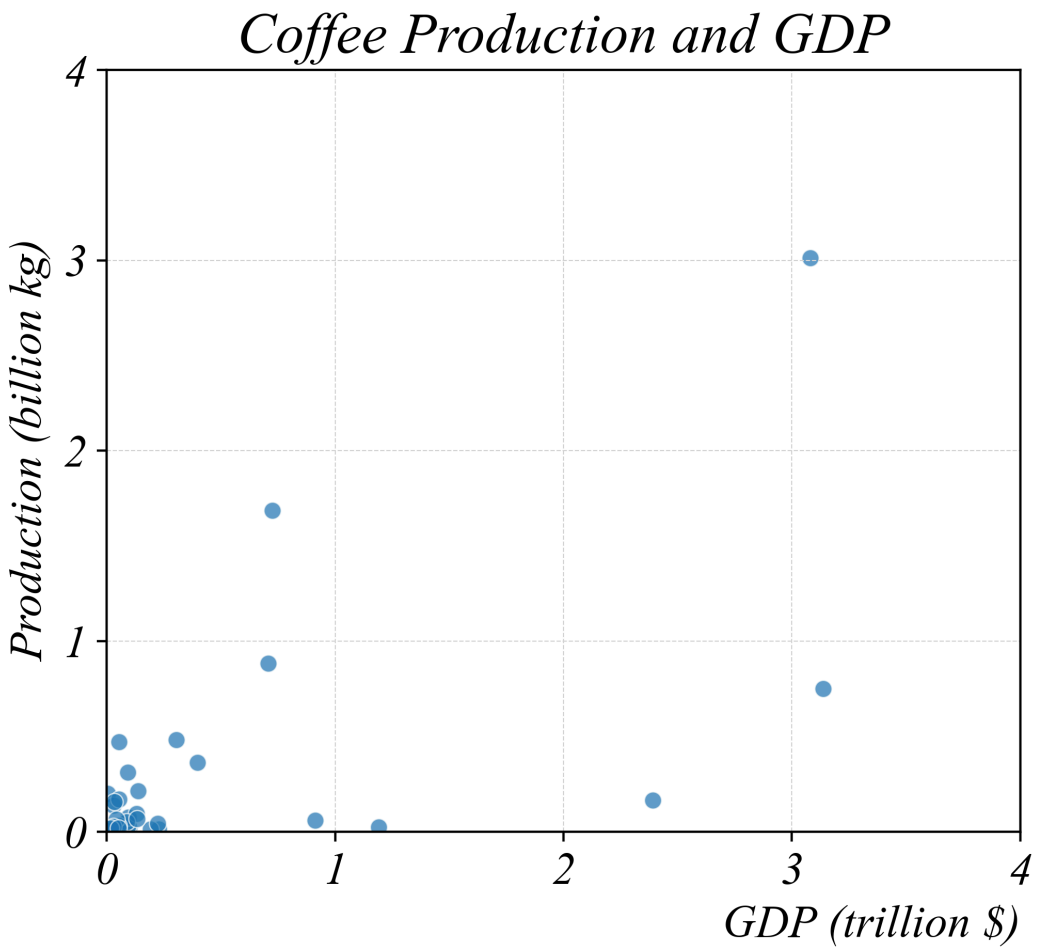


> a scatterplot effectively visualizes scross sectional data with two dimensions

Bivariate Relationships in Cross-Section

Which countries have a GDP above $2 trillion?



> look at the horizontal axis and select all that are greater than 2

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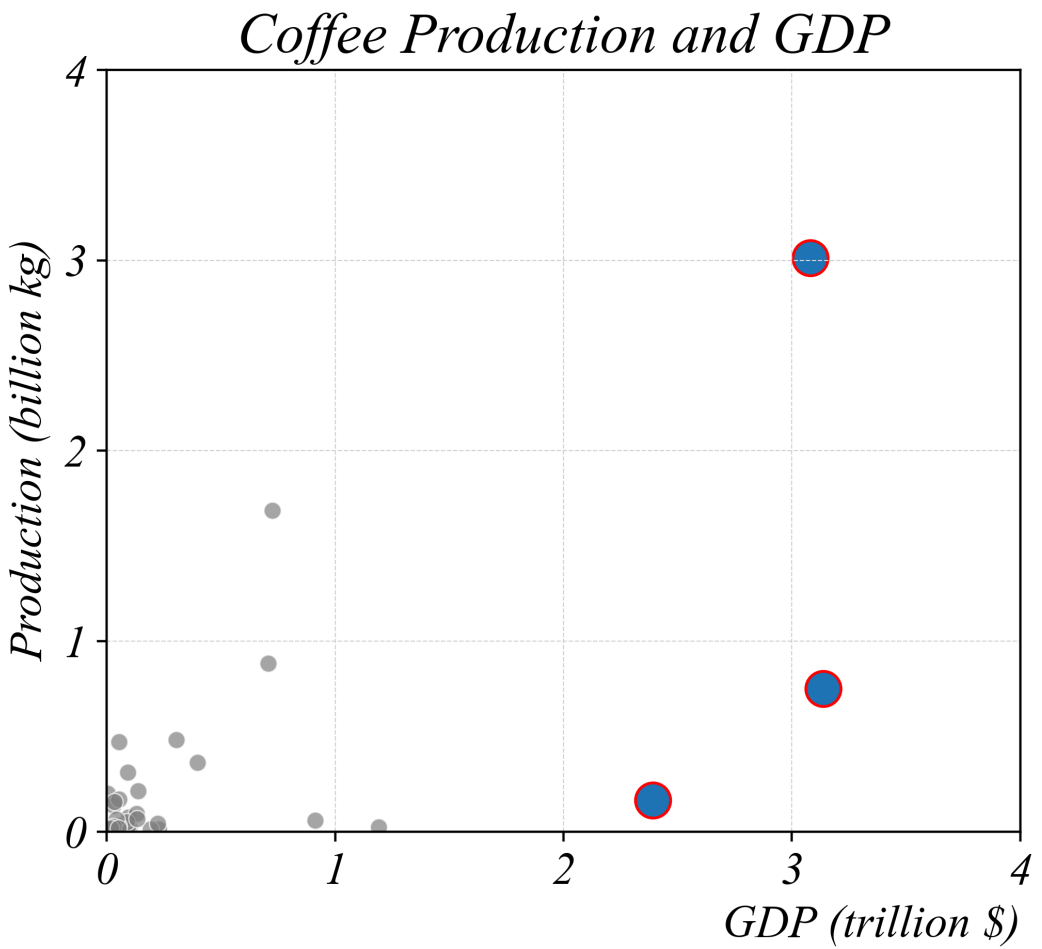

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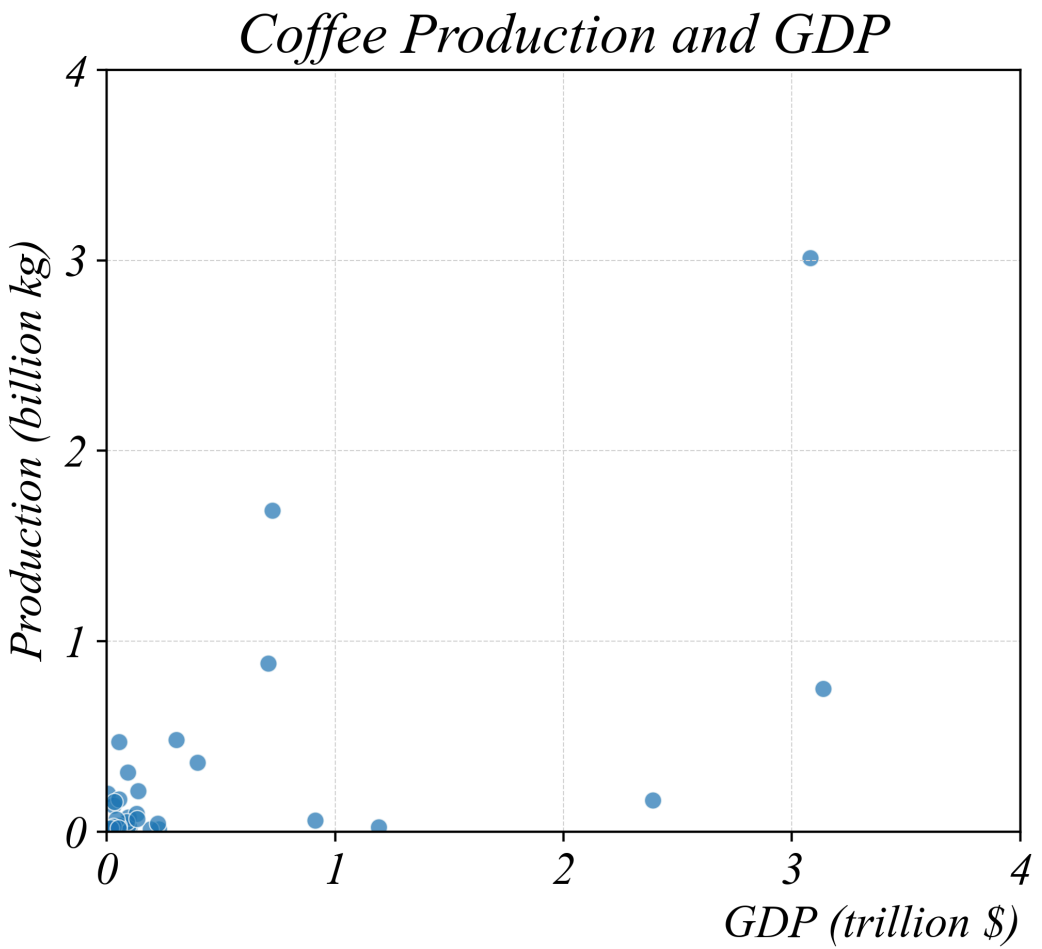
Bivariate Relationships in Cross-Section

Which countries have a production above ½ billion kg?



> *and we can use either axis*

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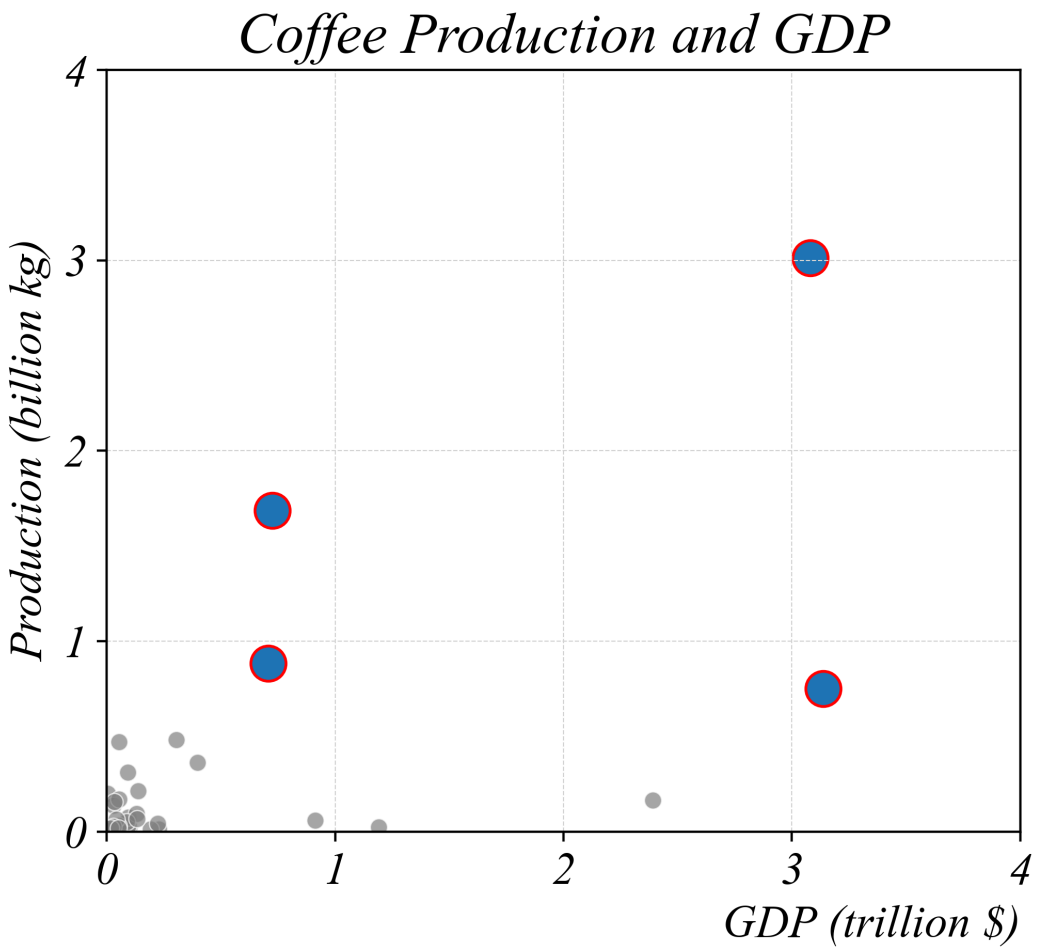

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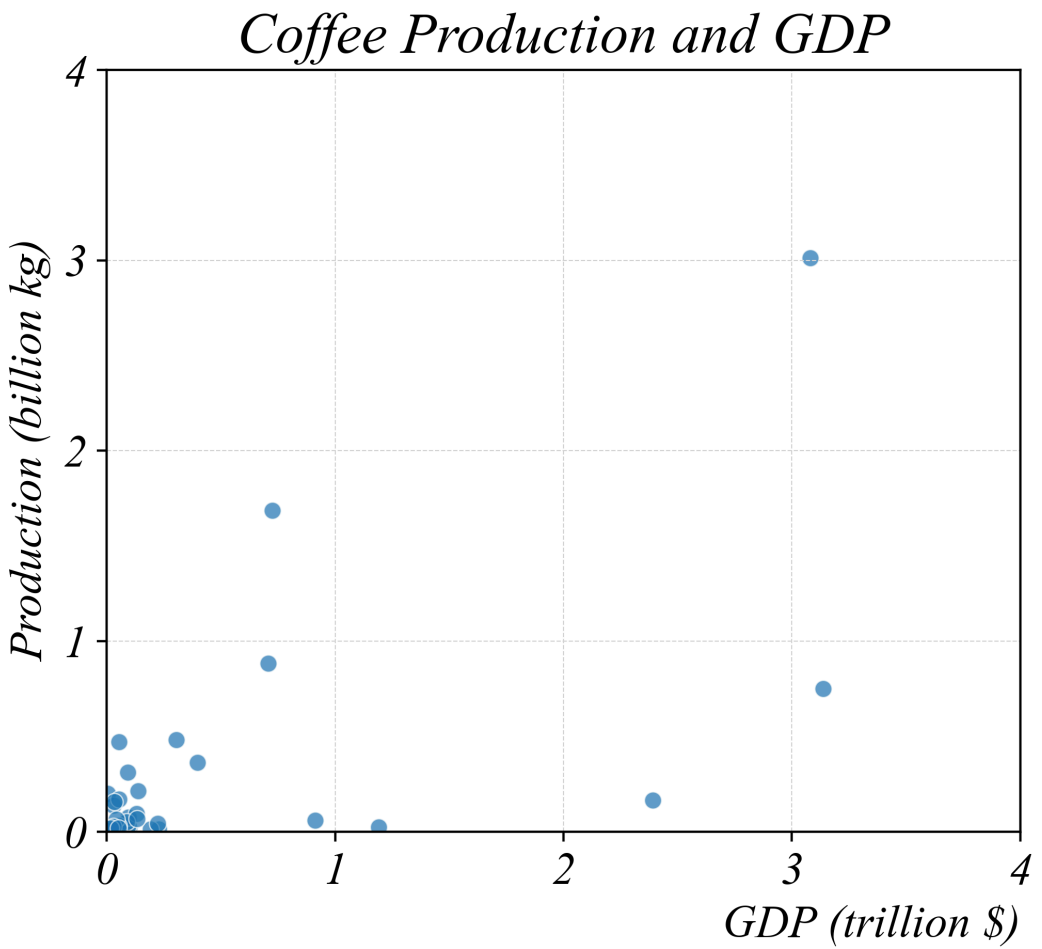
Bivariate Relationships in Cross-Section

Which countries produce less coffee per dollar than Brazil?



> *we can also compare BETWEEN data points*

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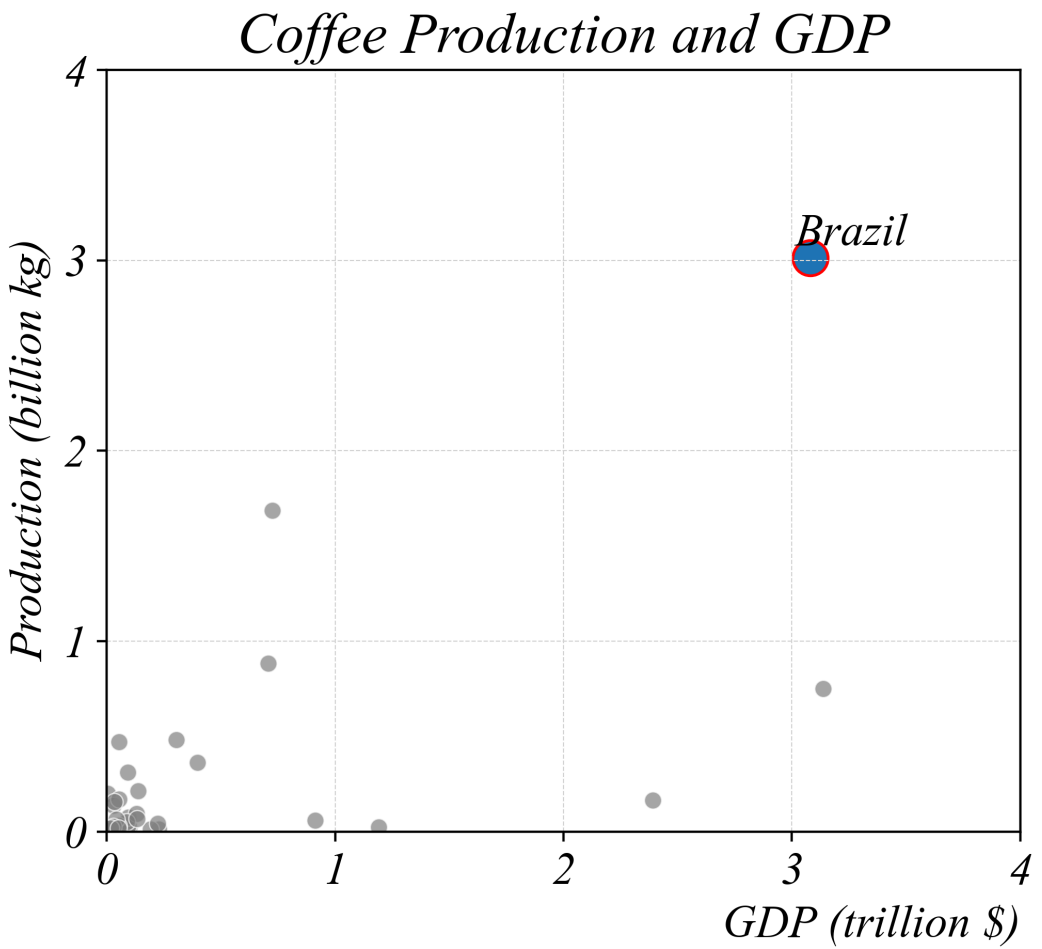

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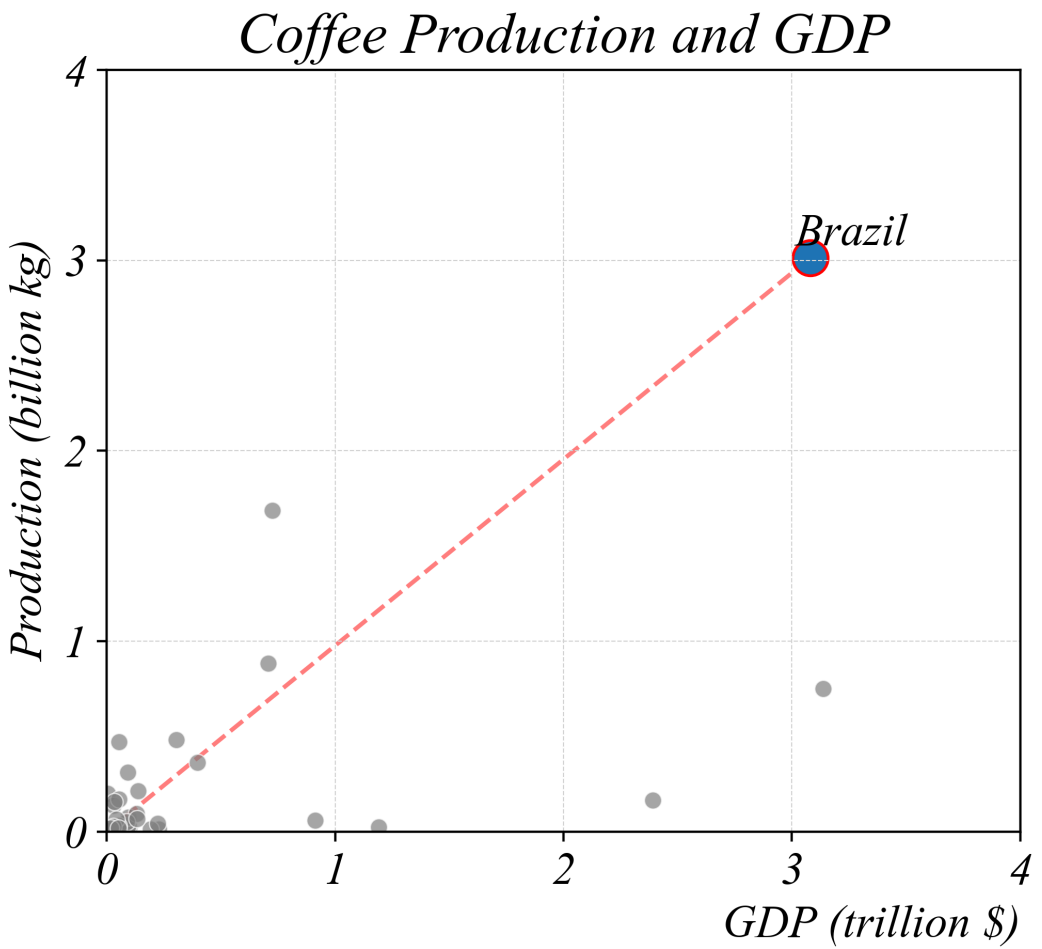

> *separating lines can help make comparisons between ratios*

Bivariate Relationships in Cross-Section

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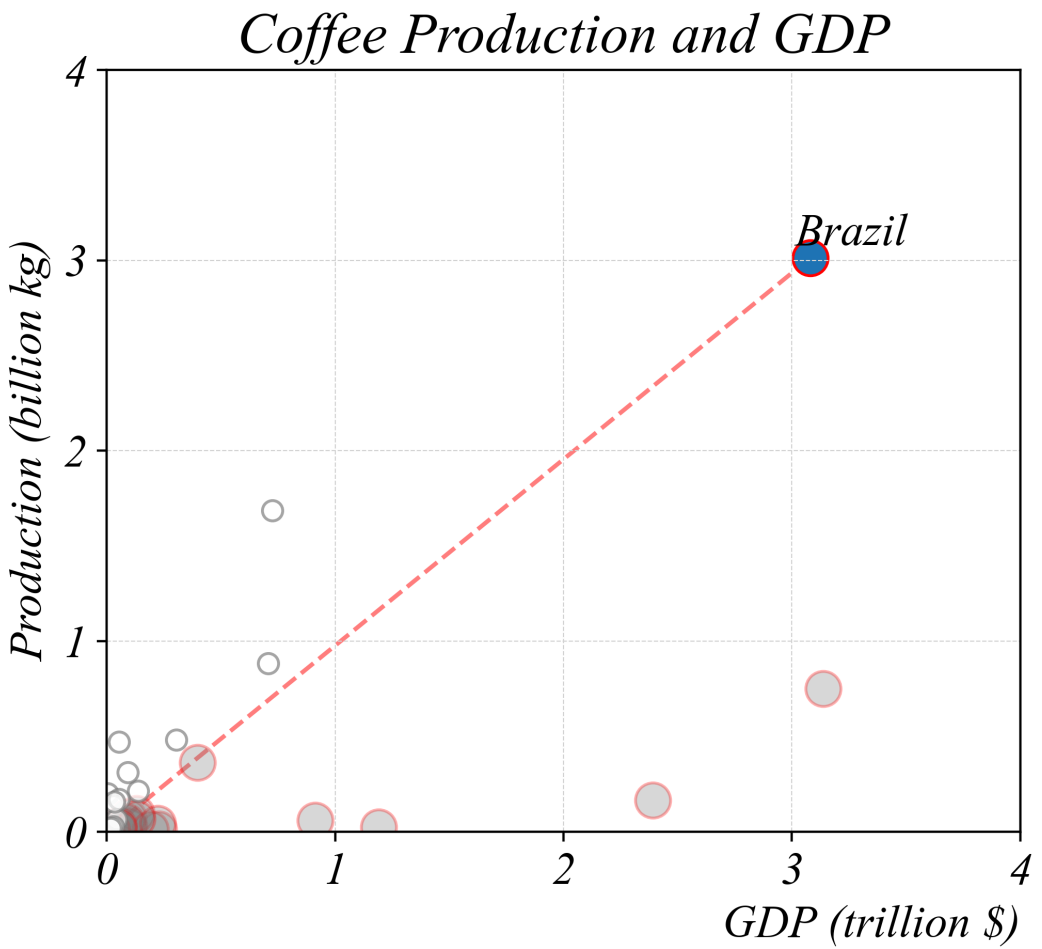

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Bivariate Relationships in Cross-Section

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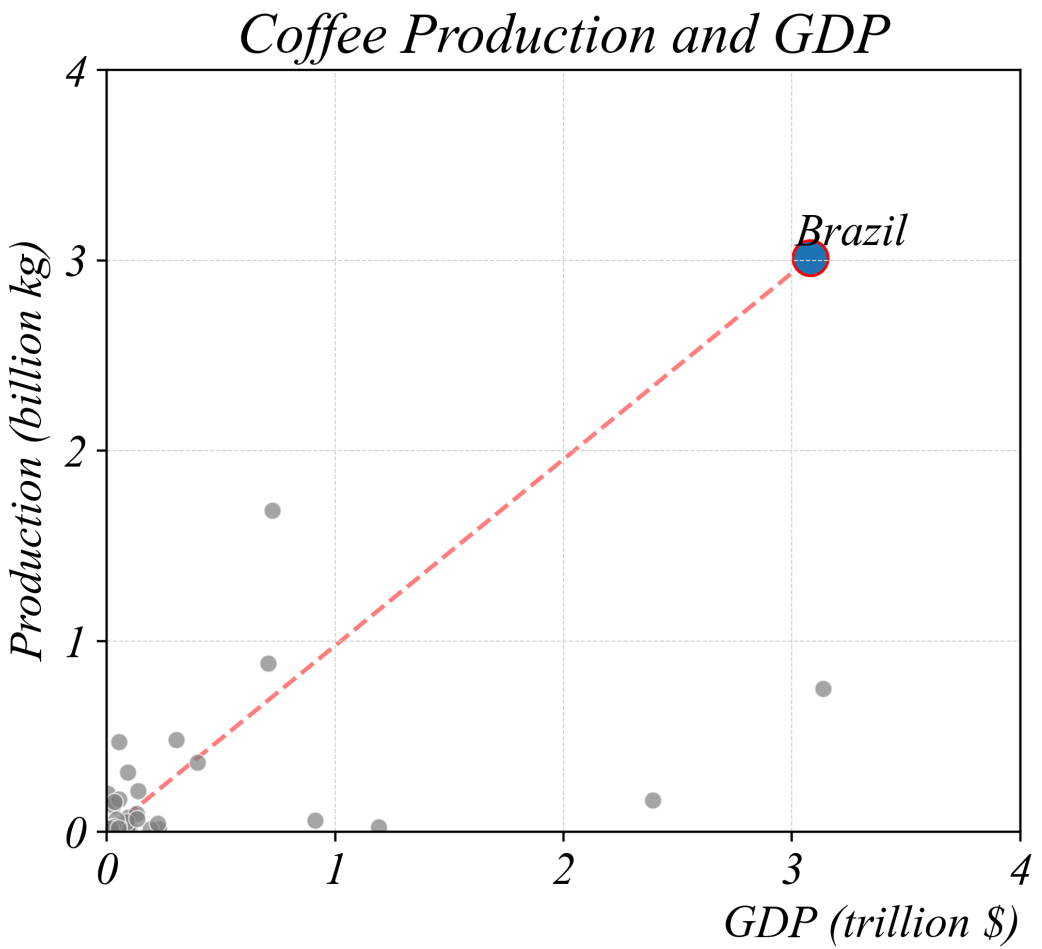

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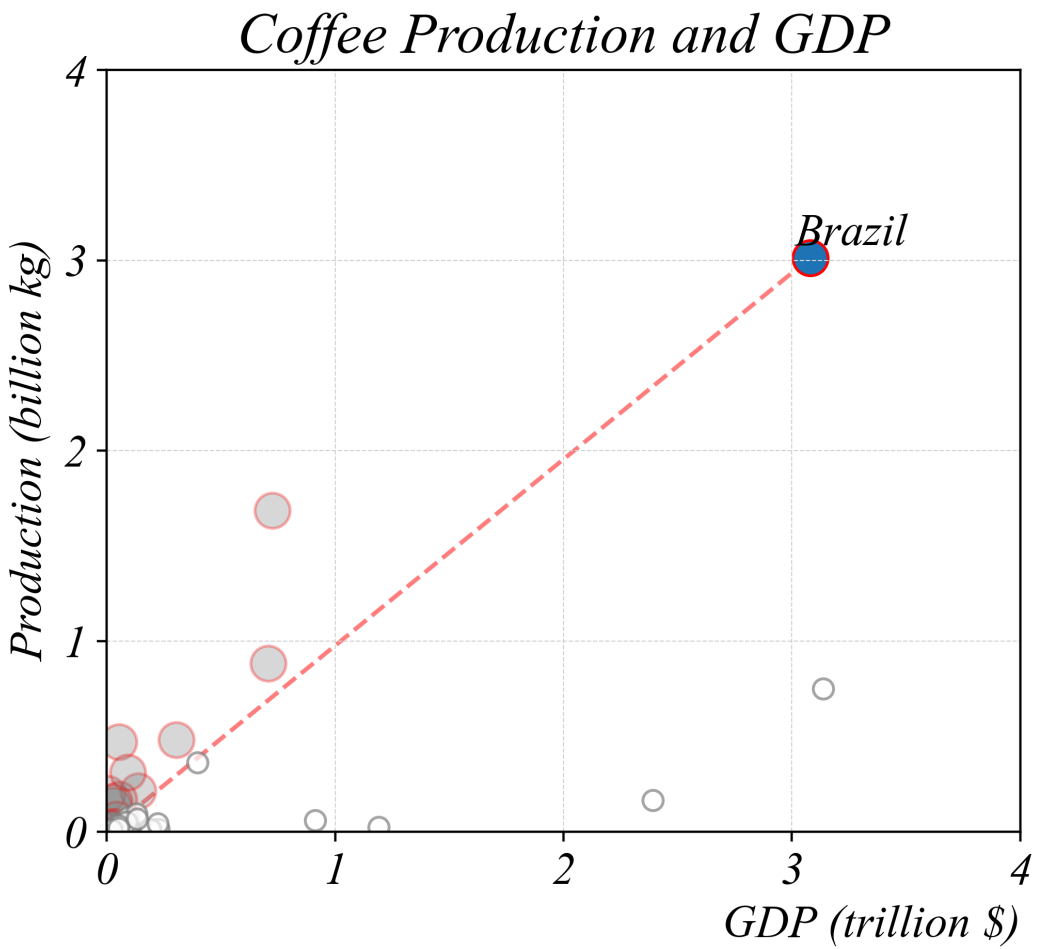
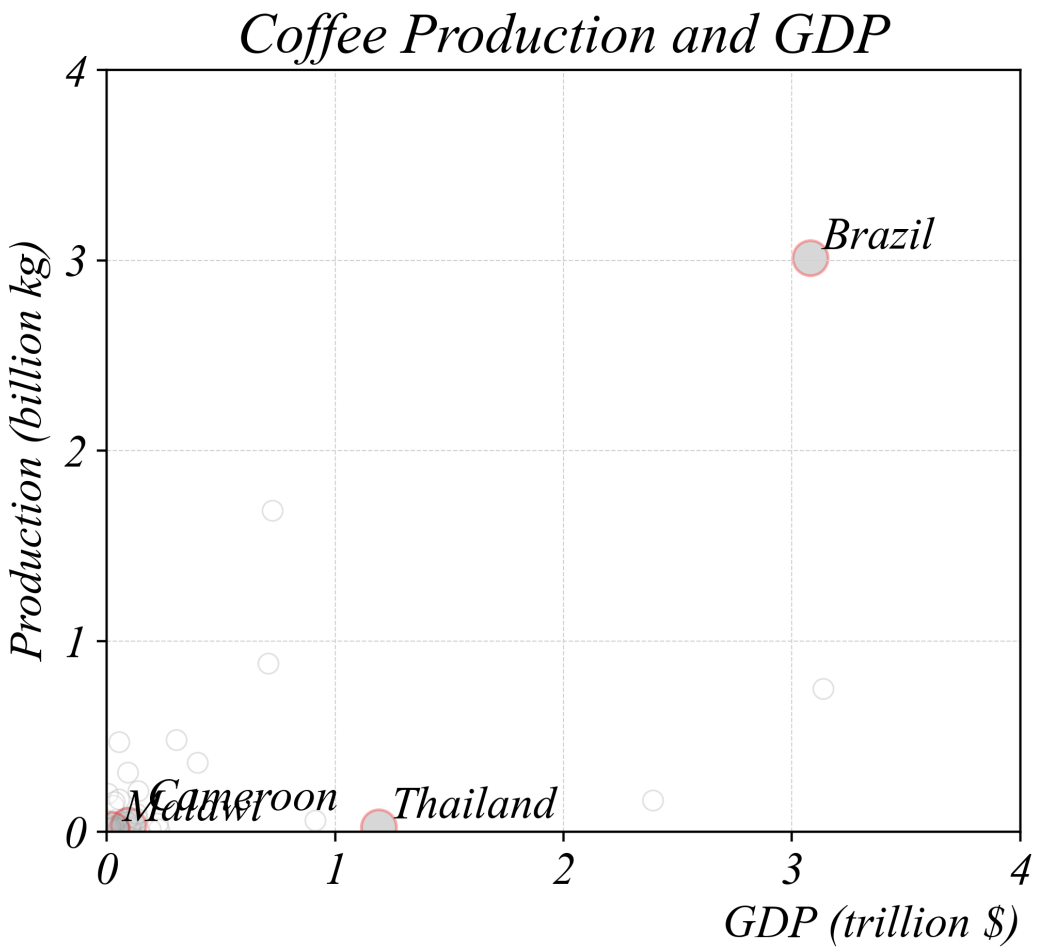


> *separating lines can help make comparisons between ratios*

Bivariate Relationships in Cross-Section

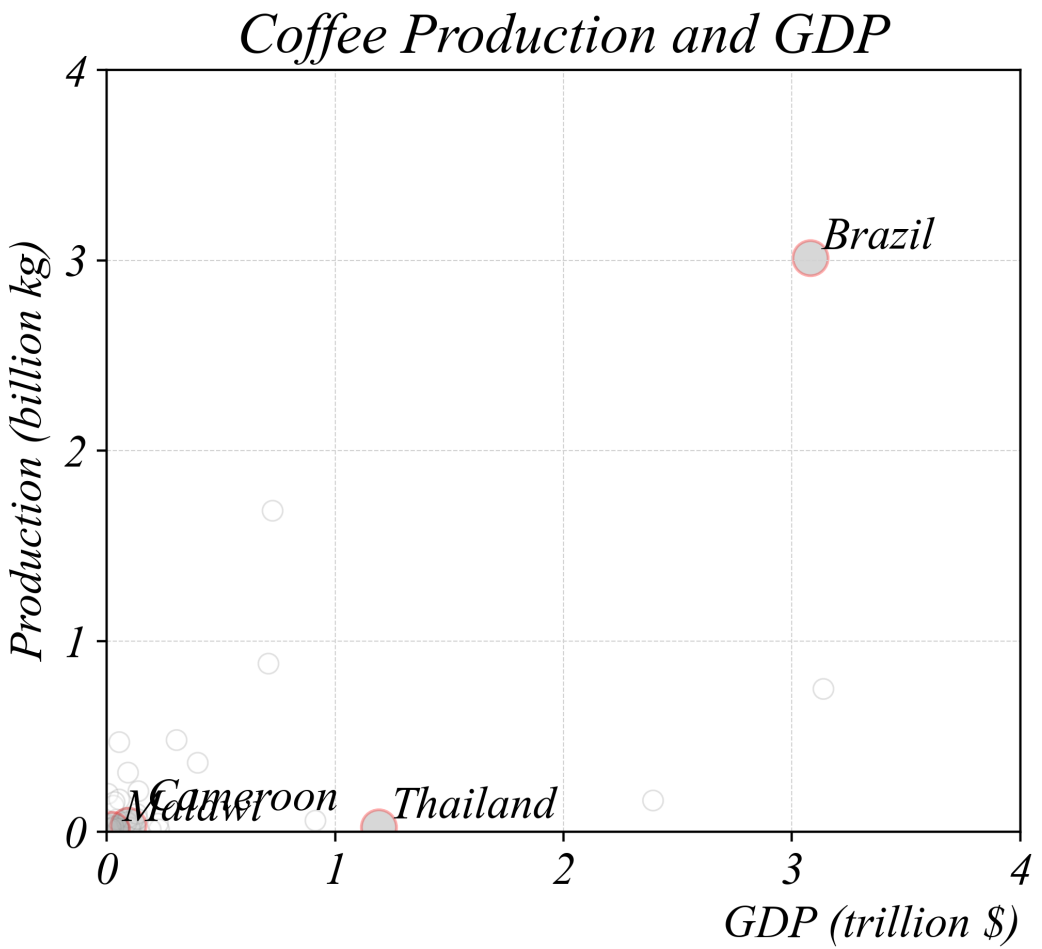
Do the GDPs of the upper or lower pair differ by a larger amount?



> *use the differences on the horizontal axis to measure differences*

Bivariate Relationships in Cross-Section

Which is larger: the ratio of GDPs of the upper or lower pair?



> *this question is difficult to answer with this scale*

Bivariate Relationships in Cross-Section

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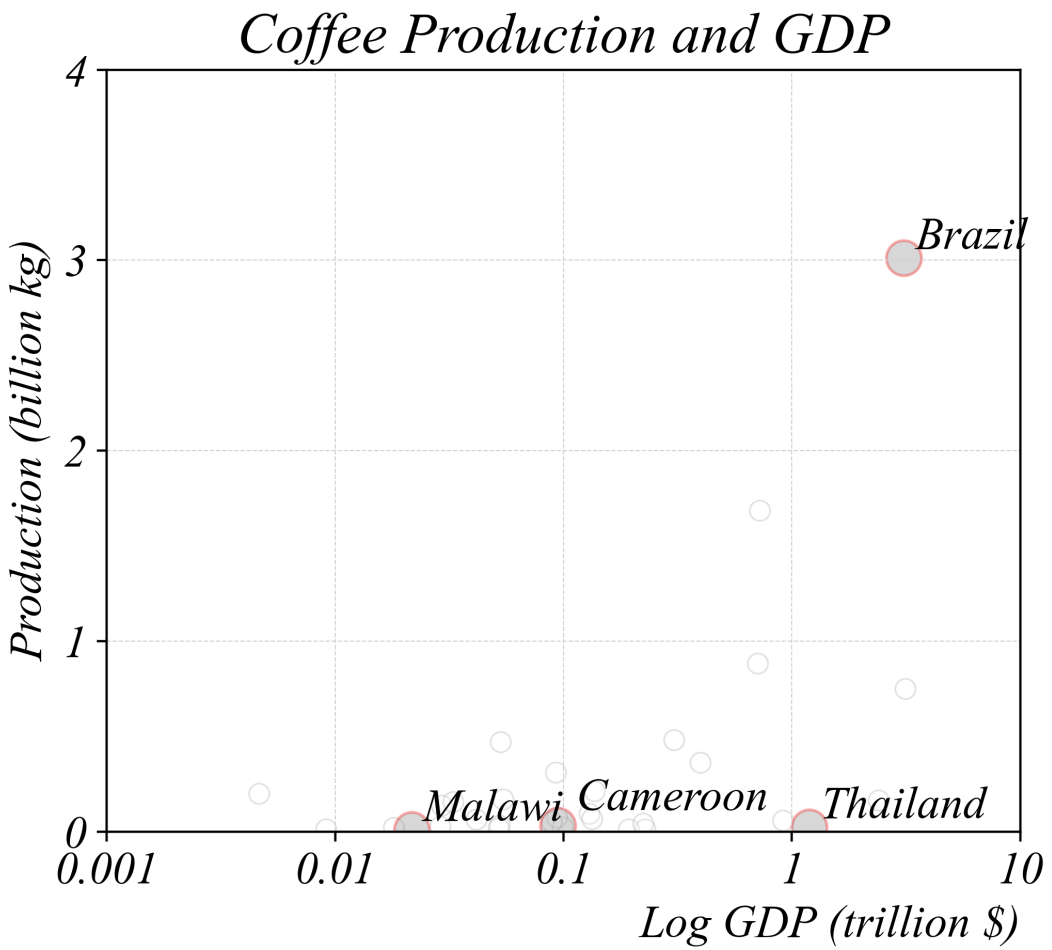
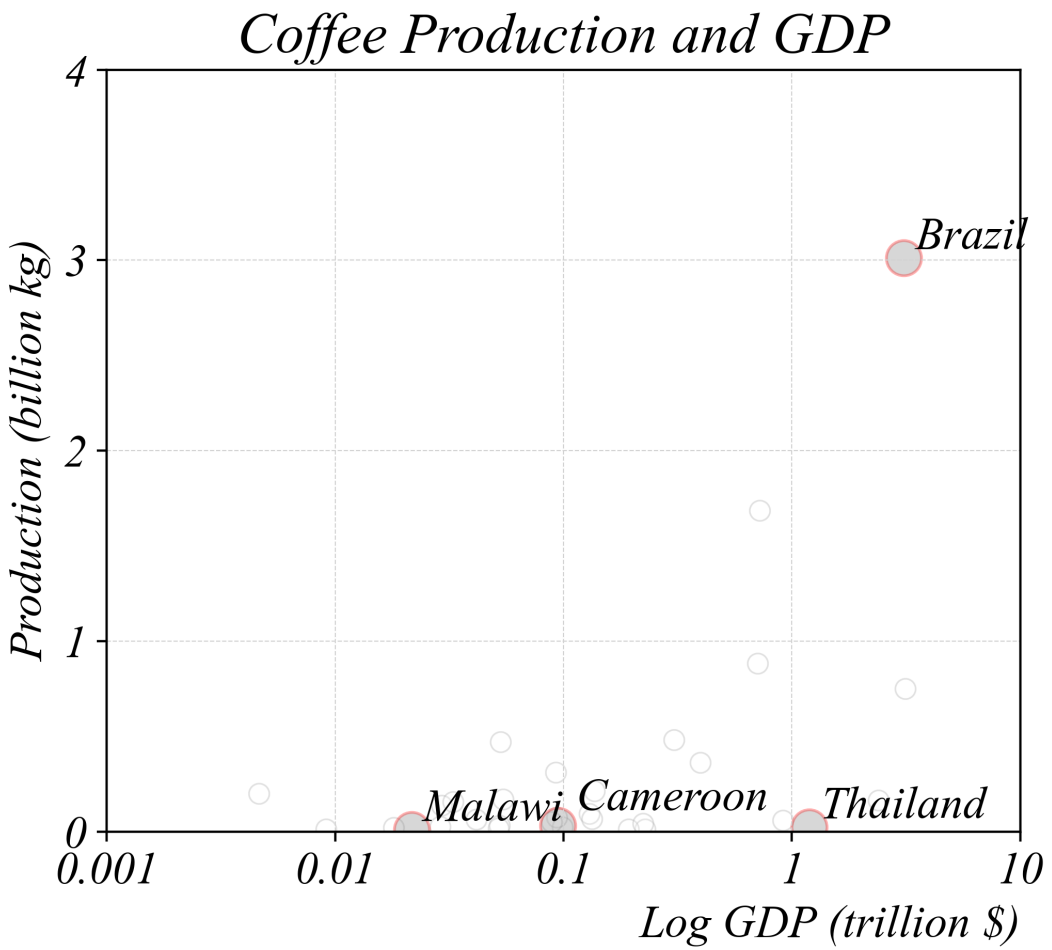


> a log scale makes RATIOS easier to visualize: each tick is 10x larger

Bivariate Relationships in Cross-Section

Which country produces the second highest output of coffee?



> a log scale also makes it easier to see SCALING

Bivariate Relationships in Cross-Section

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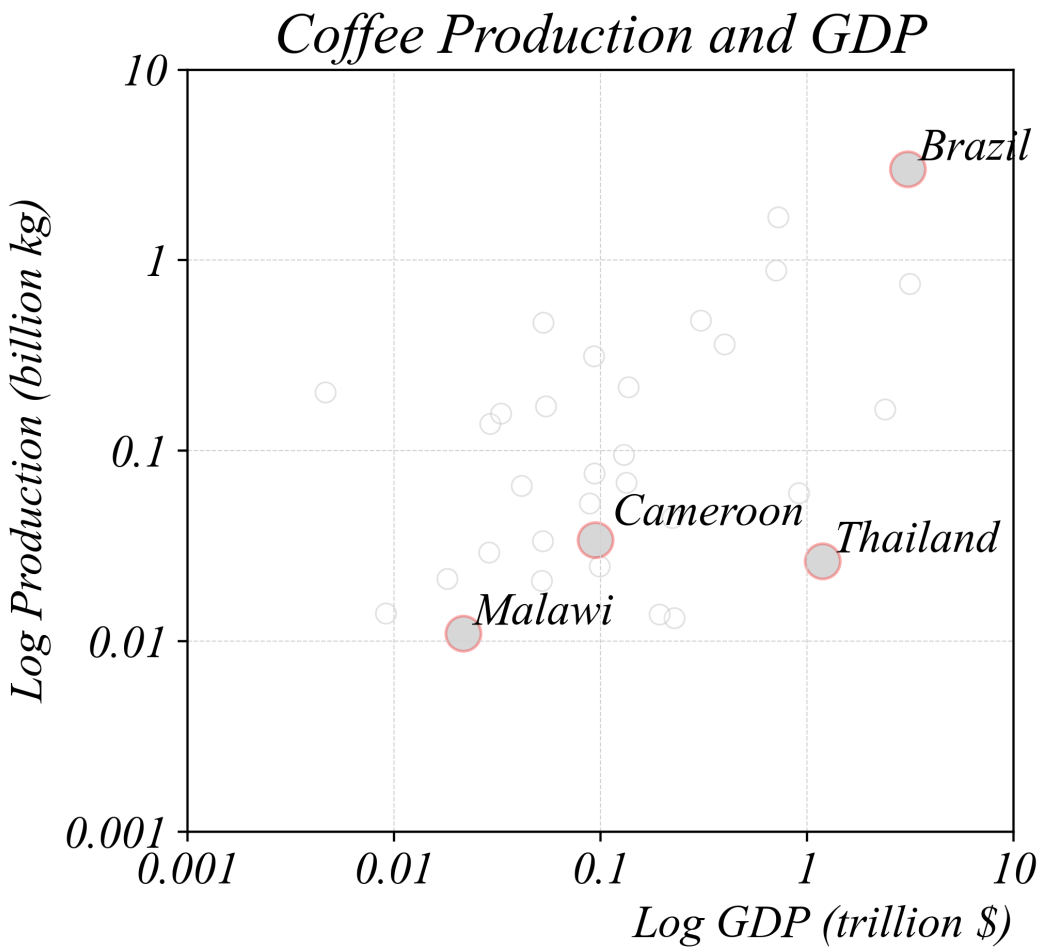
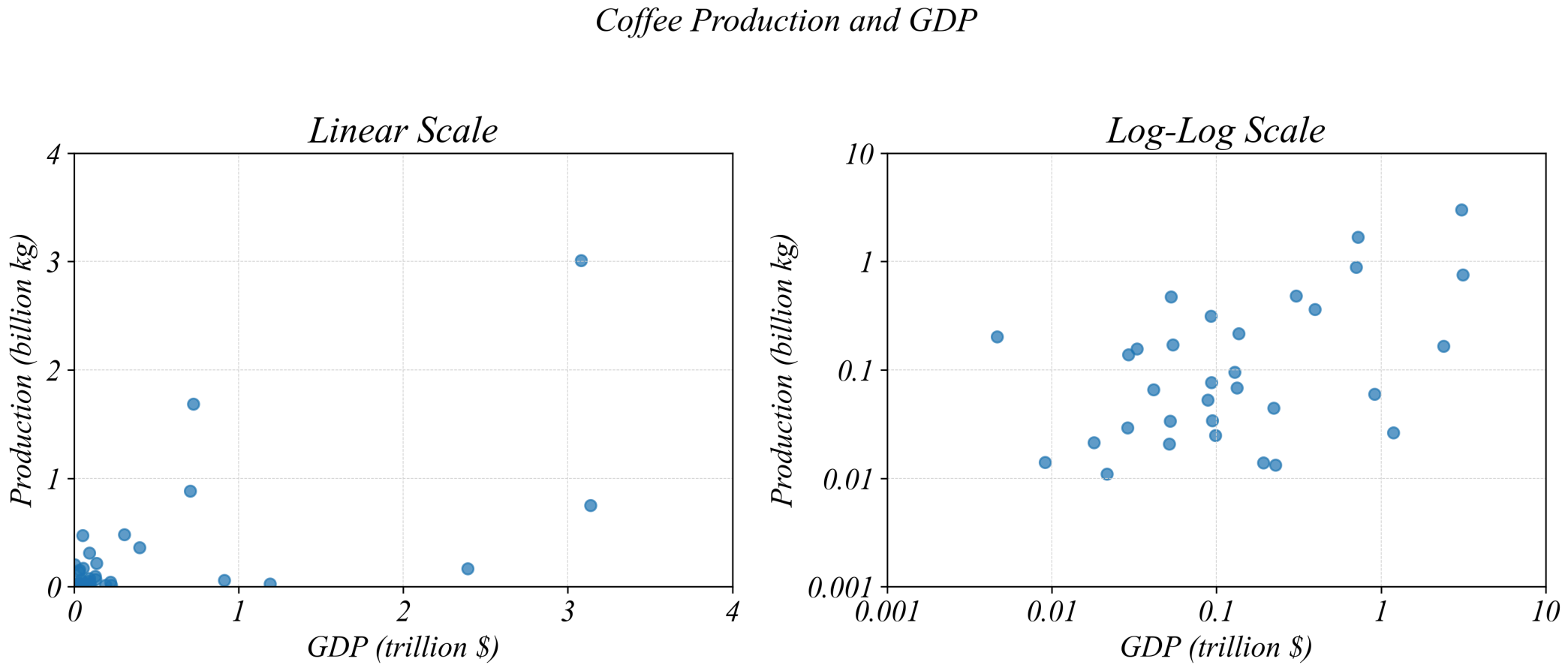


> *scaling the vertical axis in logs clarifies both small and large variation*

Bivariate Relationships in Cross-Section

Linear vs Log Scale: Same data, different views



> *log scales reveal patterns hidden by outliers in linear scale*

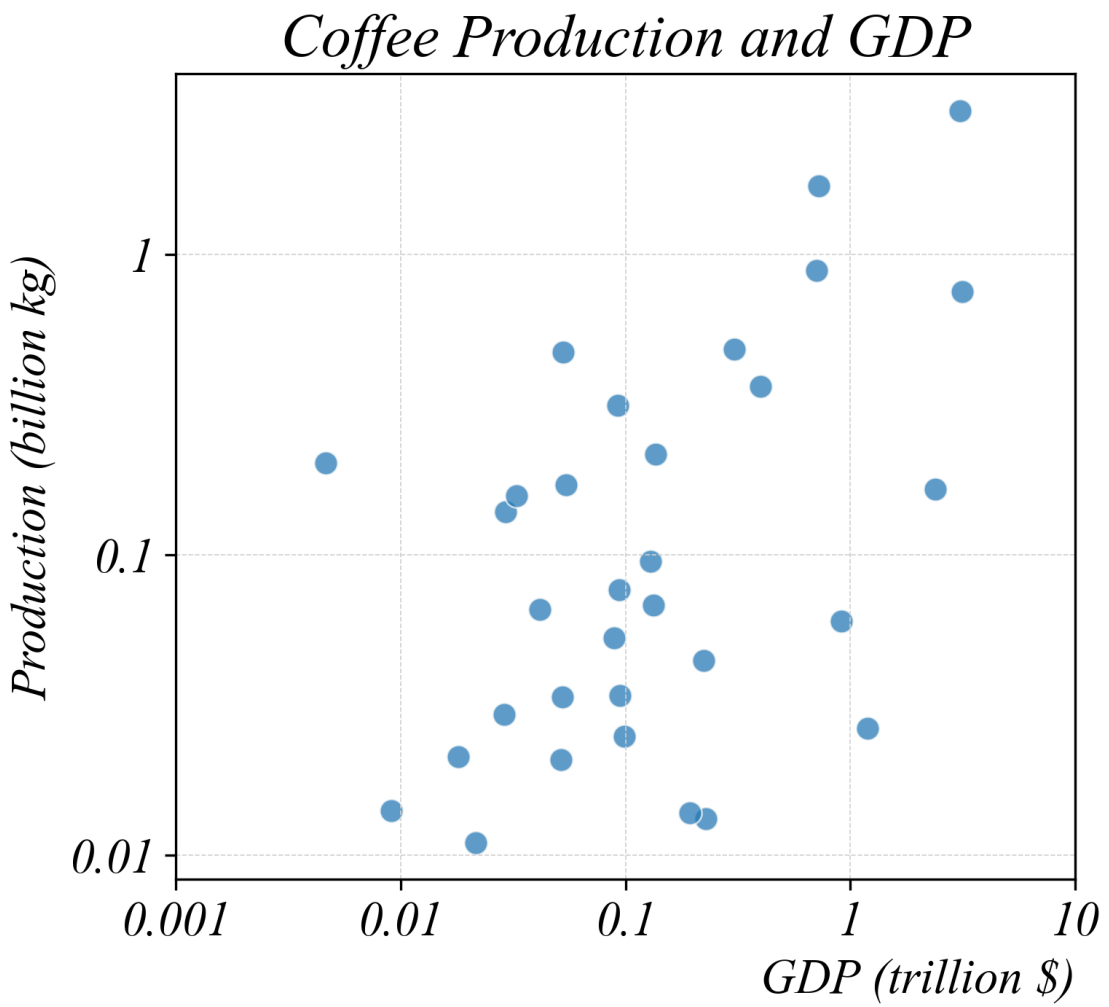
Adding More Variables

So far we've encoded two variables using position

- ***x-position*** → *GDP*
- ***y-position*** → *Coffee Production*
- *What if we want to show a* ***third variable****?*

Trivariate Relationships: Size

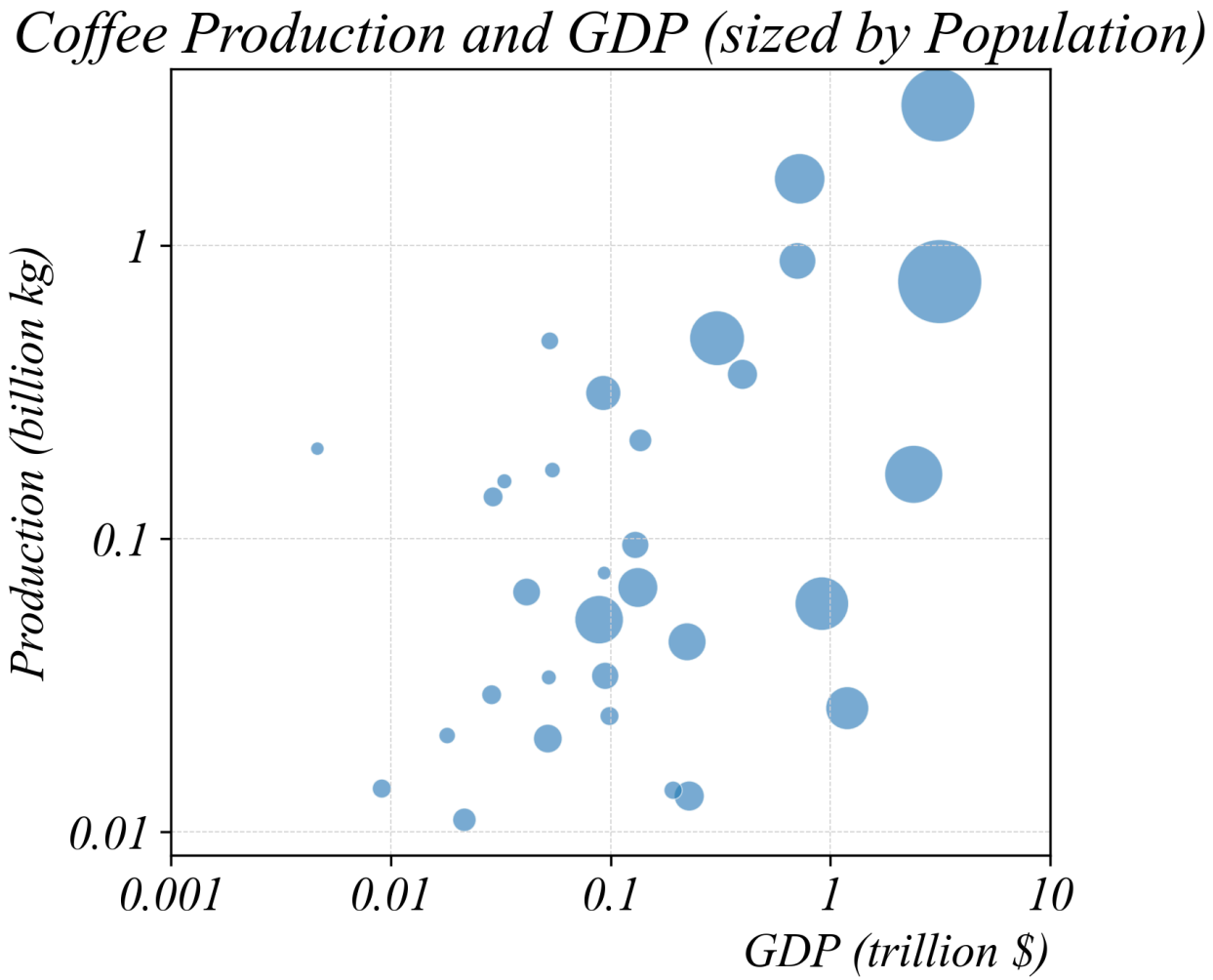
We can use SIZE to encode a third numerical variable



> *our standard scatterplot with position encoding*

Trivariate Relationships: Size

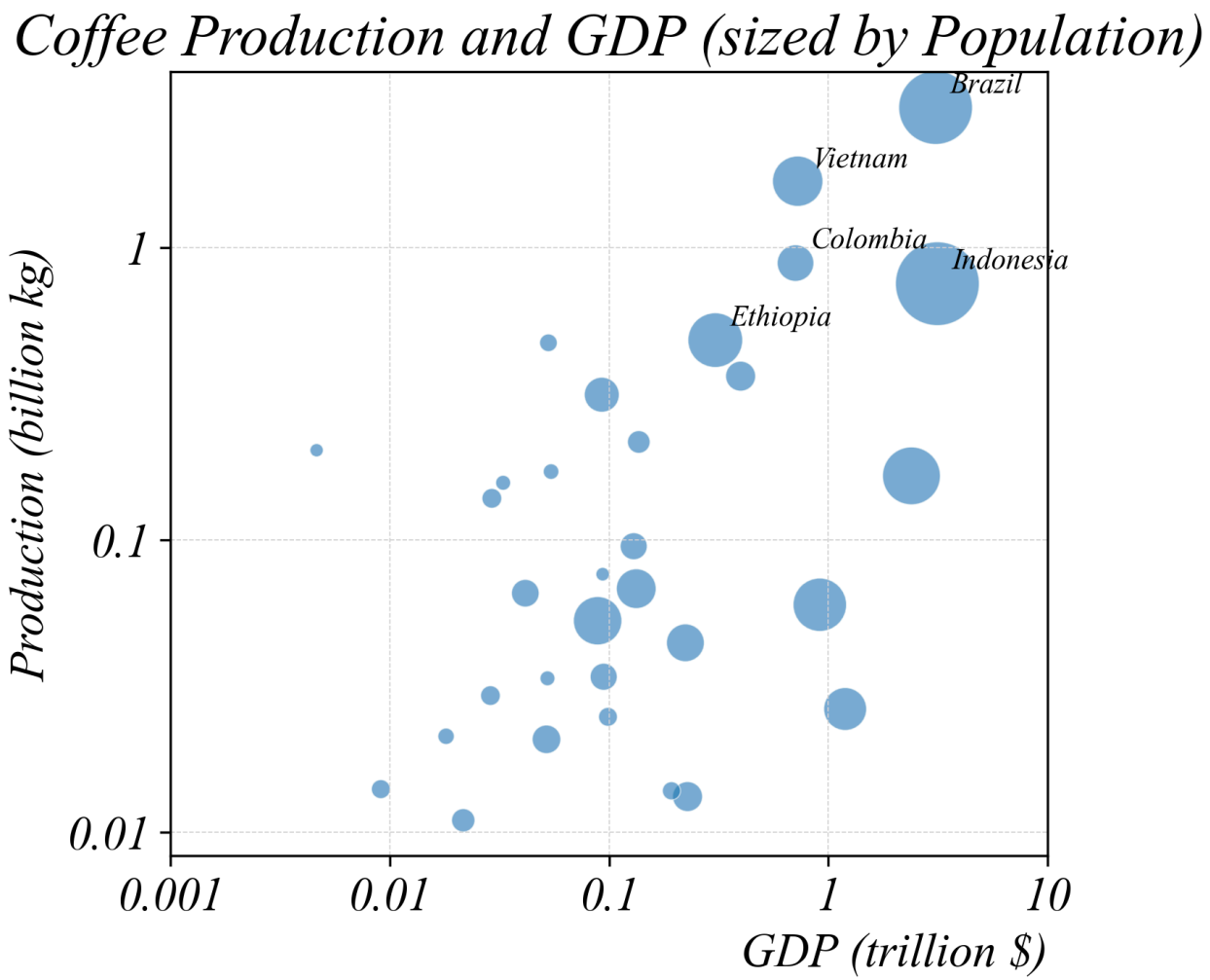
Each point's SIZE now represents population



> *larger bubbles = larger population*

Trivariate Relationships: Size

Indonesia and Brazil stand out — large countries with high production



> *we can now see three variables at once: GDP, production, AND population*

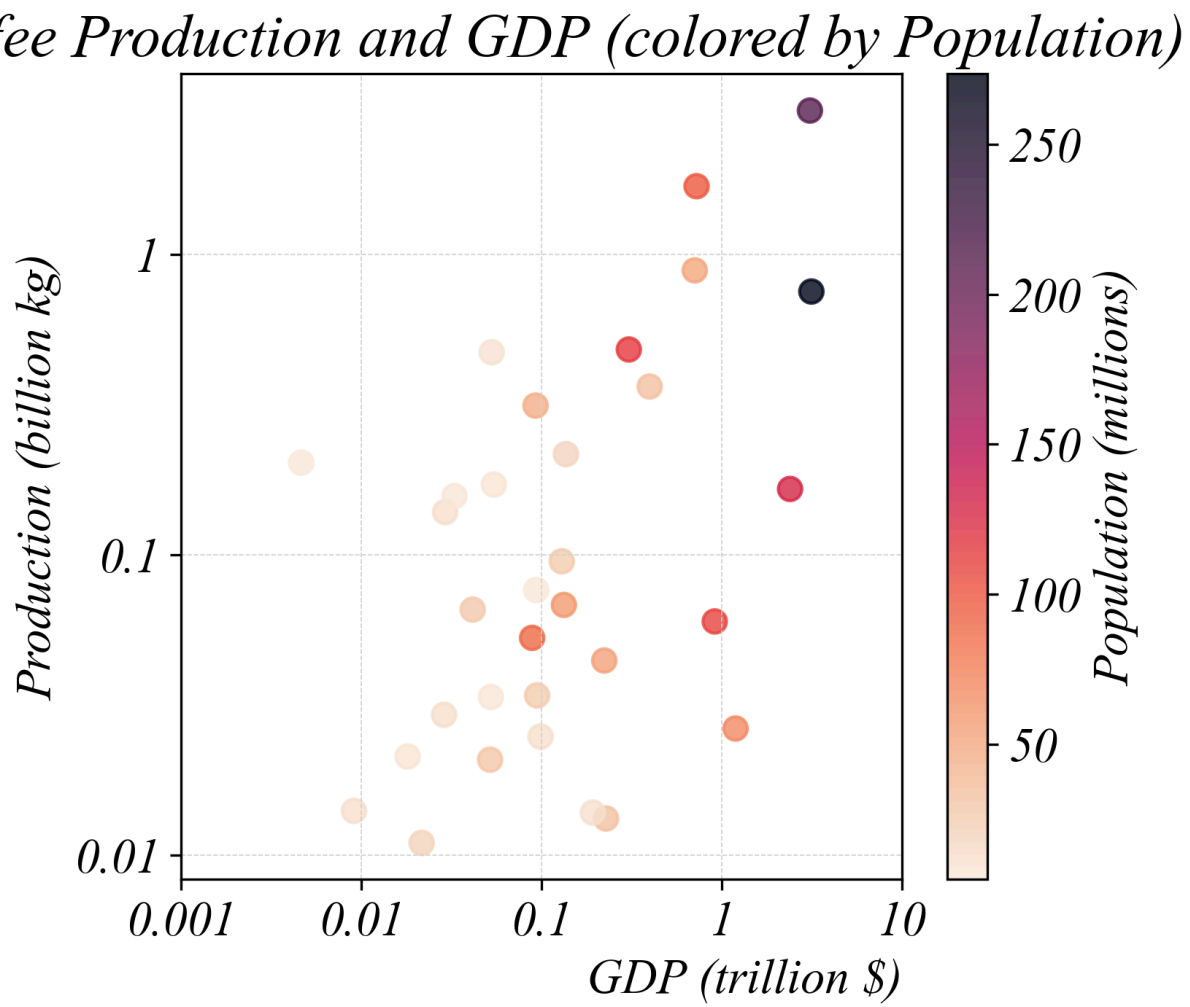
Trivariate Relationships: Color

We can also use COLOR to encode a third numerical variable

- *A **continuous color scale** maps values to shades*
- *Lighter → lower values, Darker → higher values*
- *Works well when size would be hard to compare*

Trivariate Relationships: Color

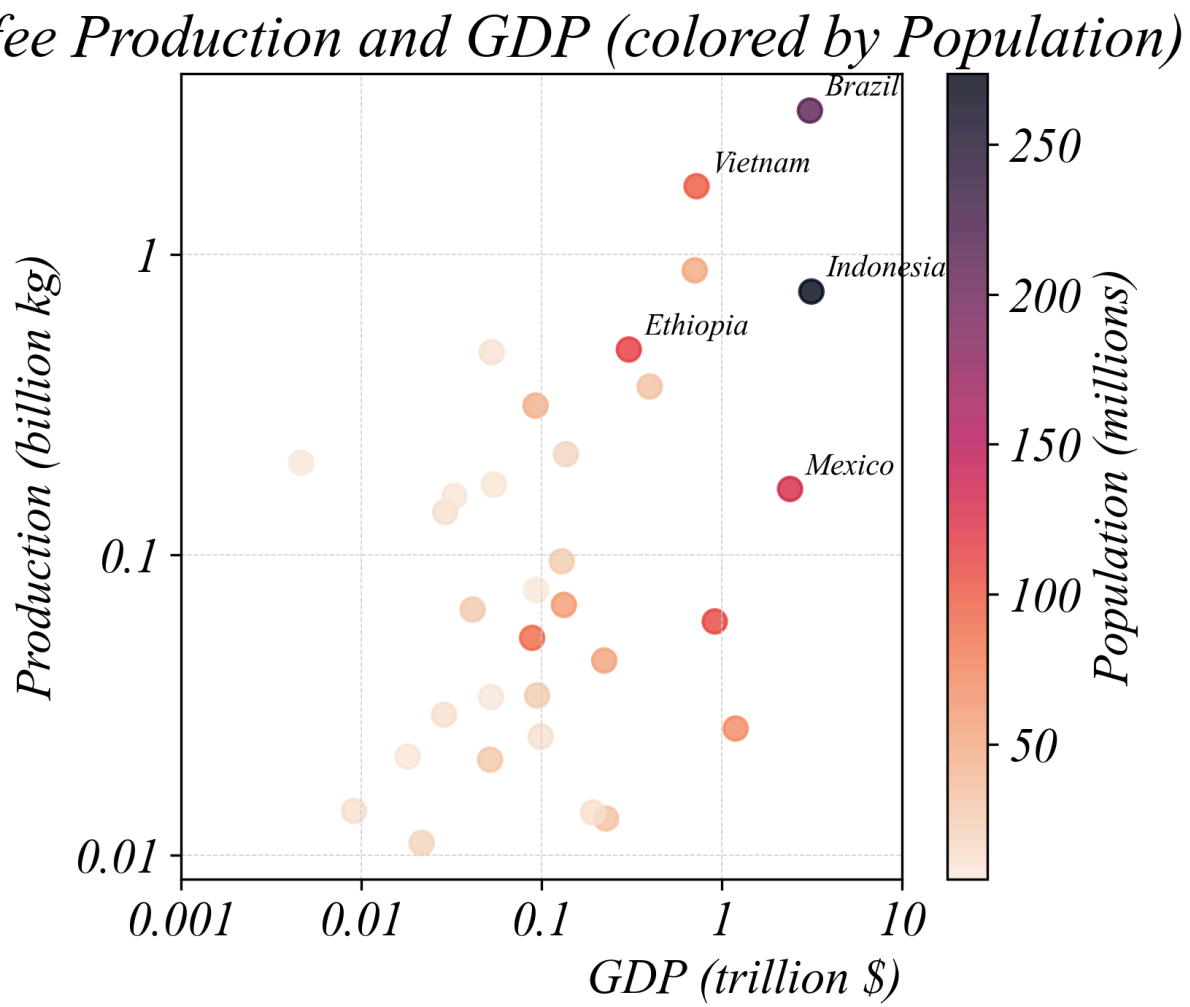
Each point's COLOR now represents population



> *darker points = larger population*

Trivariate Relationships: Color

Color makes it easy to spot high-population countries



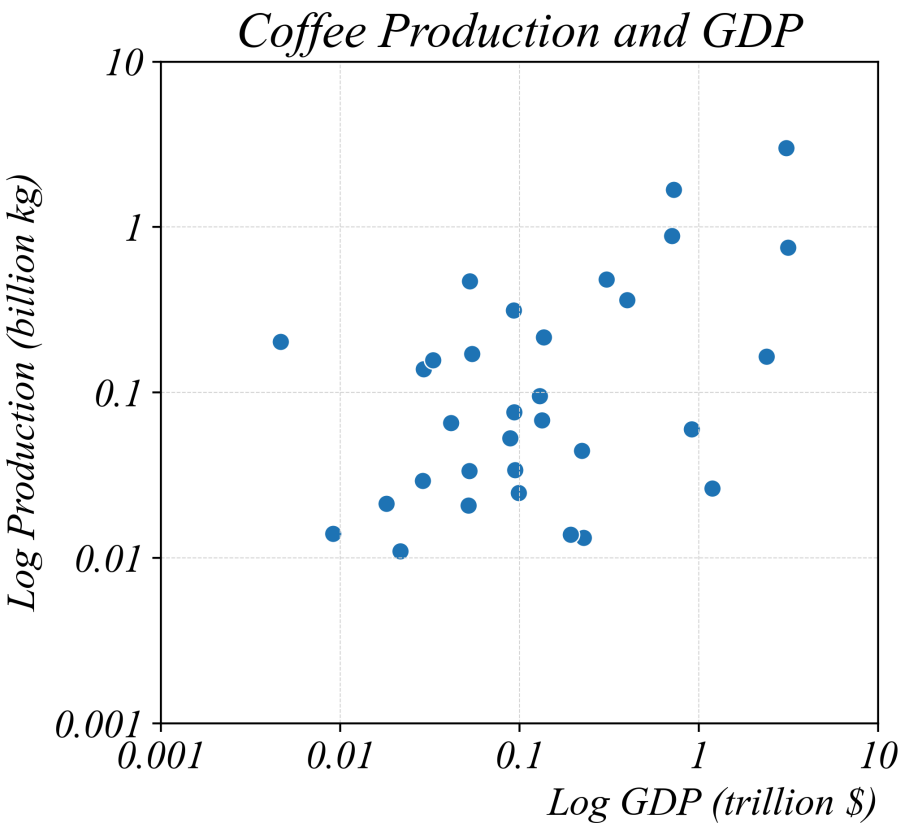
> *Brazil, Indonesia, and Ethiopia stand out as darker points*

Summary

- ***Scatterplots*** *show relationships between two numerical variables*
- ***Log scales*** *help compare ratios and see variation across orders of magnitude*
- ***Size encoding*** *adds a third numerical variable (bubble charts)*
- ***Color encoding*** *adds a third numerical variable (continuous color scale)*

Exercise 2.1 | Cross-Sectional Scatterplots

Visualizing GDP and Coffee Production Relationships



Was the relationship between coffee production and GDP different in 1980?

- ***Data:*** `Beans_GDP_1980.csv`

Exercise 2.1 | Cross-Sectional Scatterplots

How does GDP relate to coffee production?

```
# Log both x and y variables
gdp['log_GDP'] = np.log(gdp['GDP'])
gdp['log_prod'] = np.log(gdp['coffee_prod'])
```

```
# Plot the log variables
sns.scatterplot(gdp, x='log_GDP', y='log_prod')
```

Exercise 2.1 | Log Transformation

Alternative: use log scale without transforming

```
# Use a log scale without transforming the variable
sns.scatterplot(gdp, x='GDP', y='coffee_prod')
plt.xscale('log')
plt.yscale('log')
```

Exercise 2.1 | Cross-Sectional Scatterplots

How does GDP relate to coffee production?

```
# Encode population size as bubble size
sns.scatterplot(gdp, x='GDP', y='coffee_prod', size='population', sizes=(10,200))
```

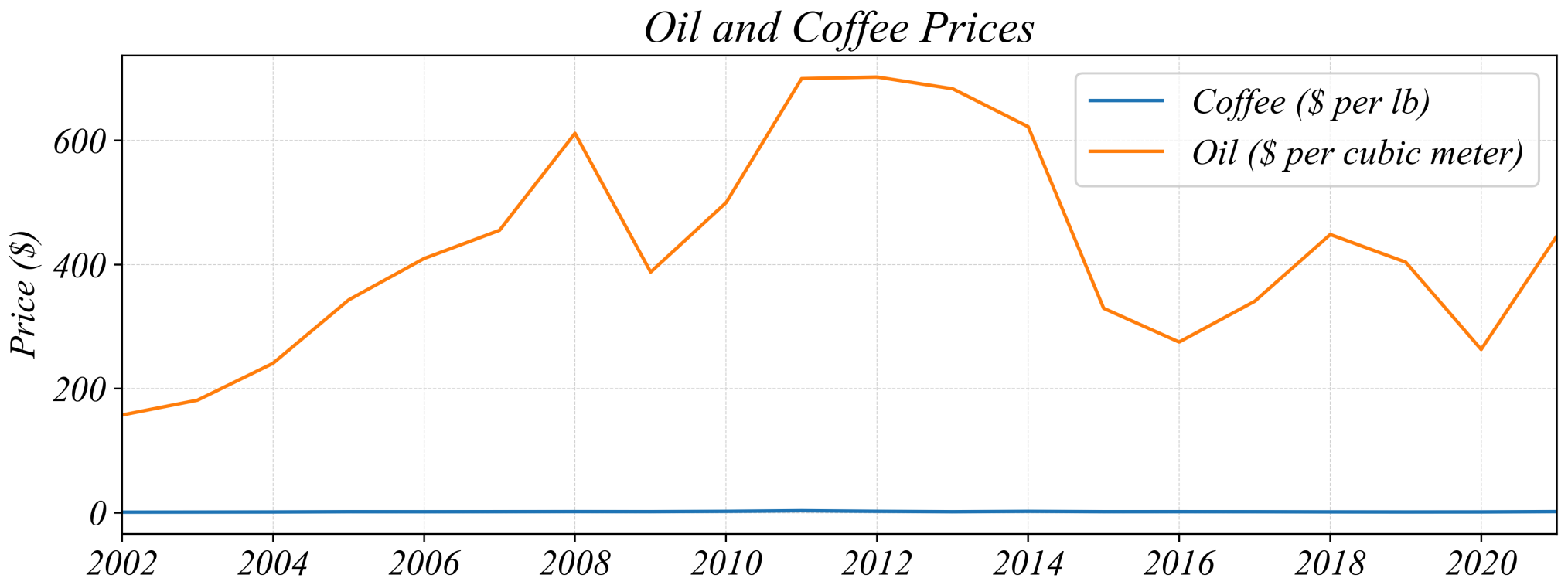
Exercise 2.1 | Cross-Sectional Scatterplots

How does GDP relate to coffee production?

```
# Encode population size as color
sns.scatterplot(gdp, x='GDP', y='coffee_prod', hue='population')
```

Bivariate Relationships: Timeseries

How do the two commodity prices relate to each other?



> *difficult to tell because of the axis scale*

Bivariate Relationships: Timeseries

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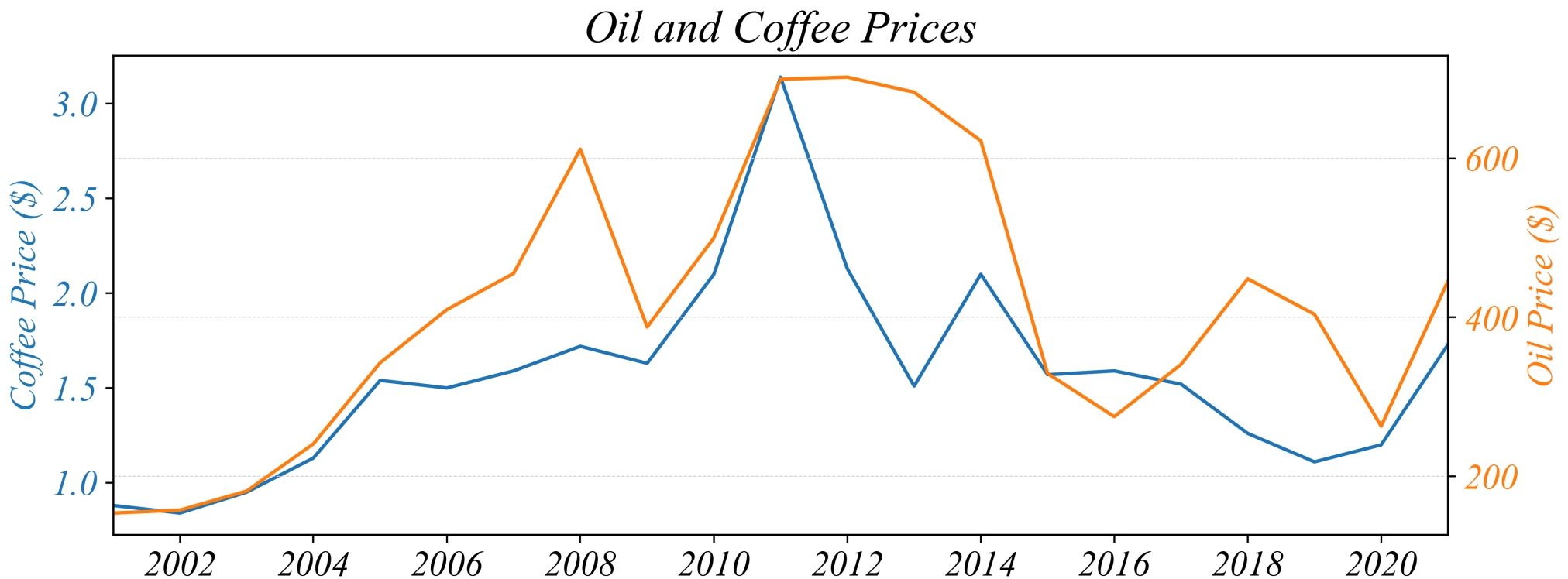
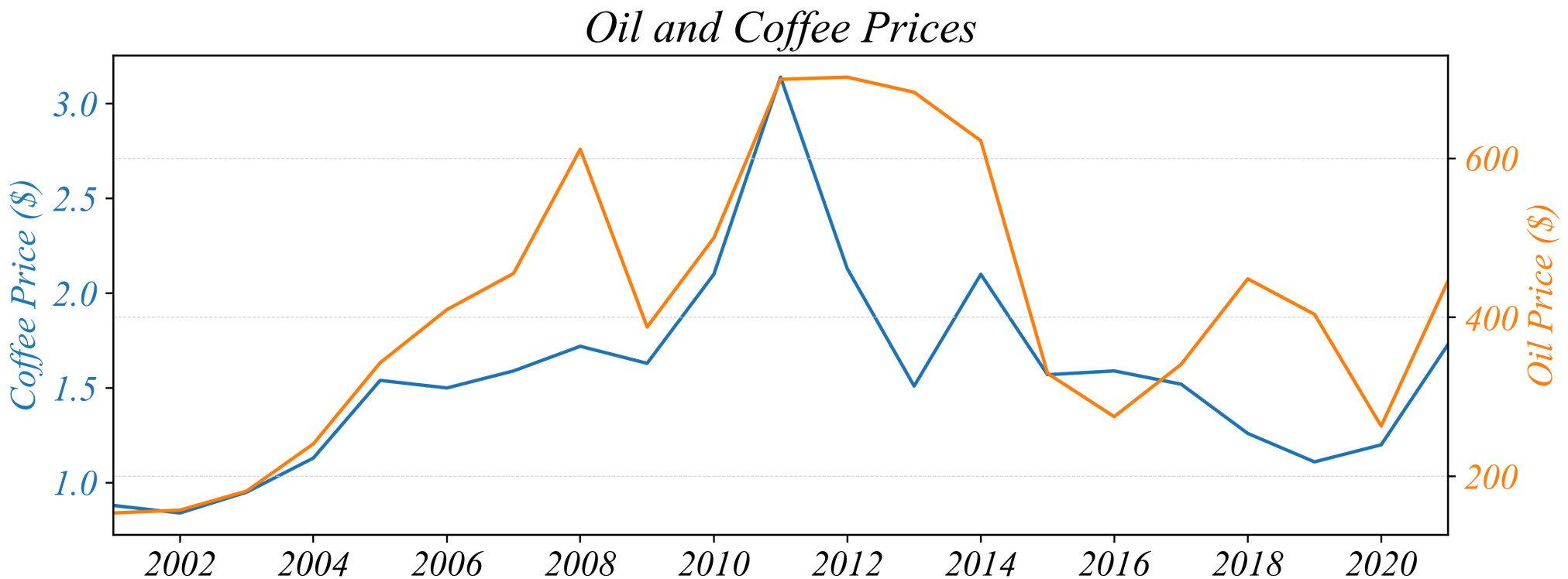


Bivariate Relationships: Timeseries

*In which years did oil and coffee prices move in **opposite** directions?*



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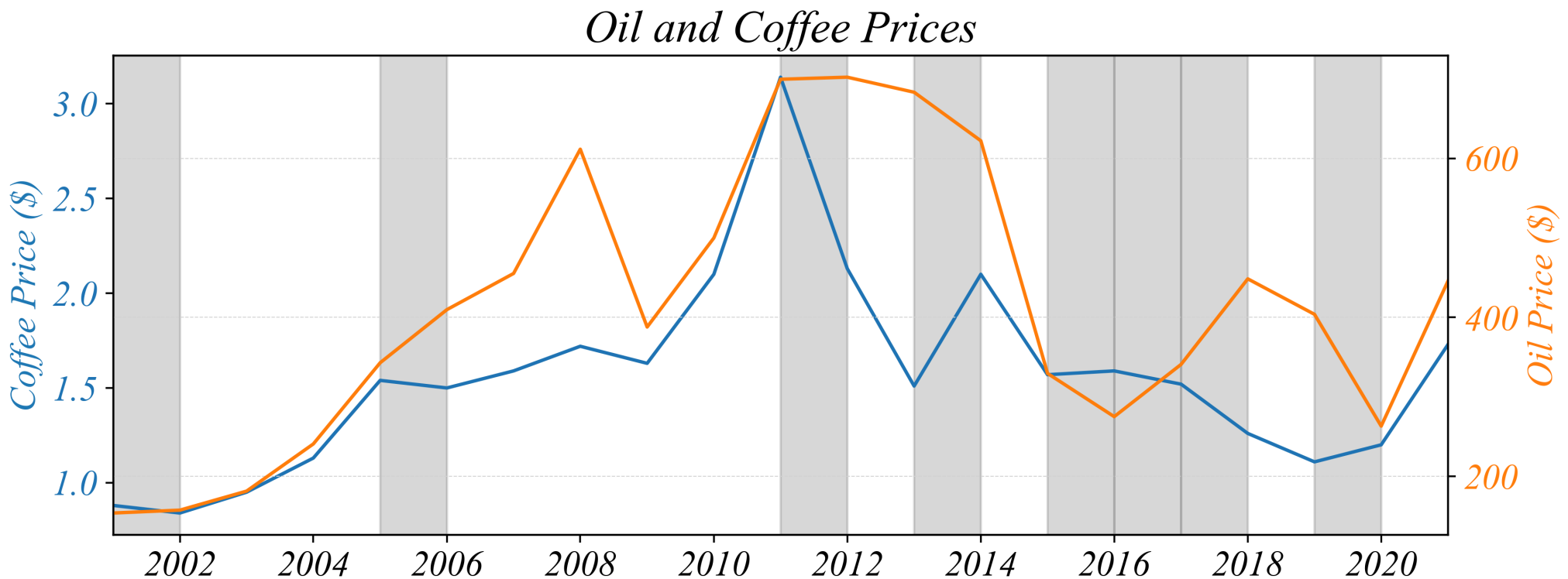
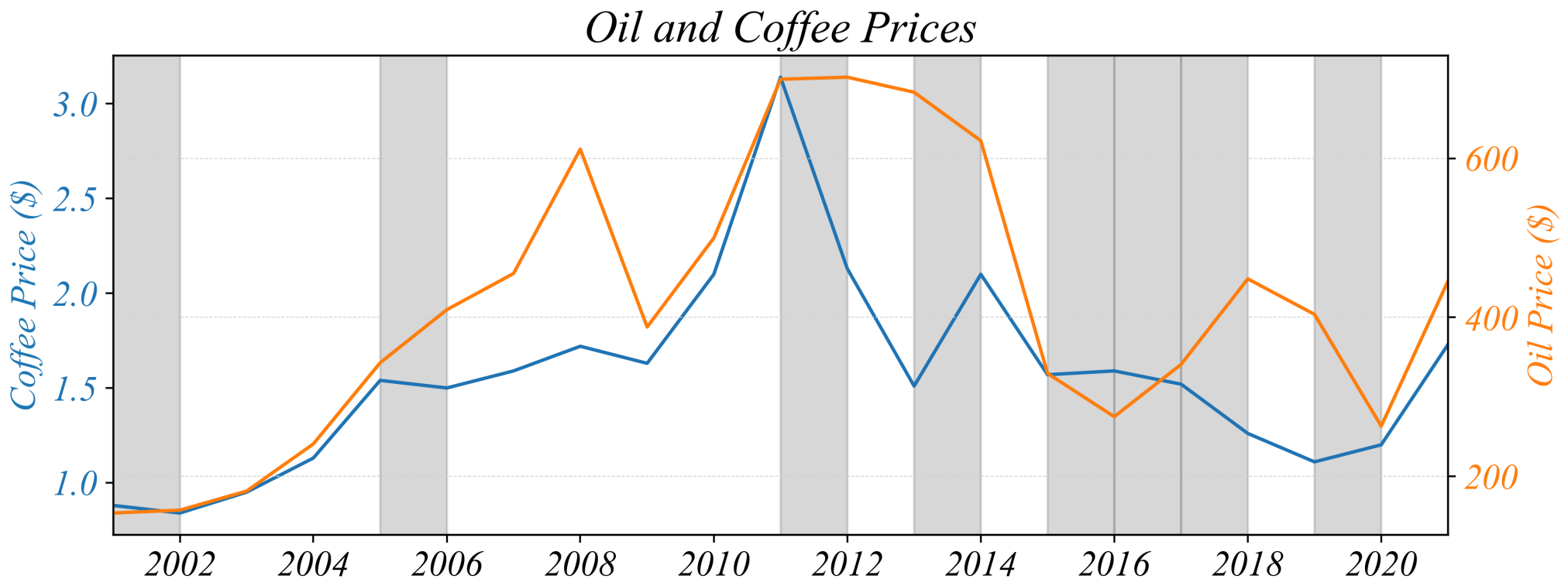


Bivariate Relationships: Timeseries

But are the two prices positively or negatively related to each other?



> *this is difficult to see with just a Multi-Lineplot…*

Bivariate Relationships: Timeseries

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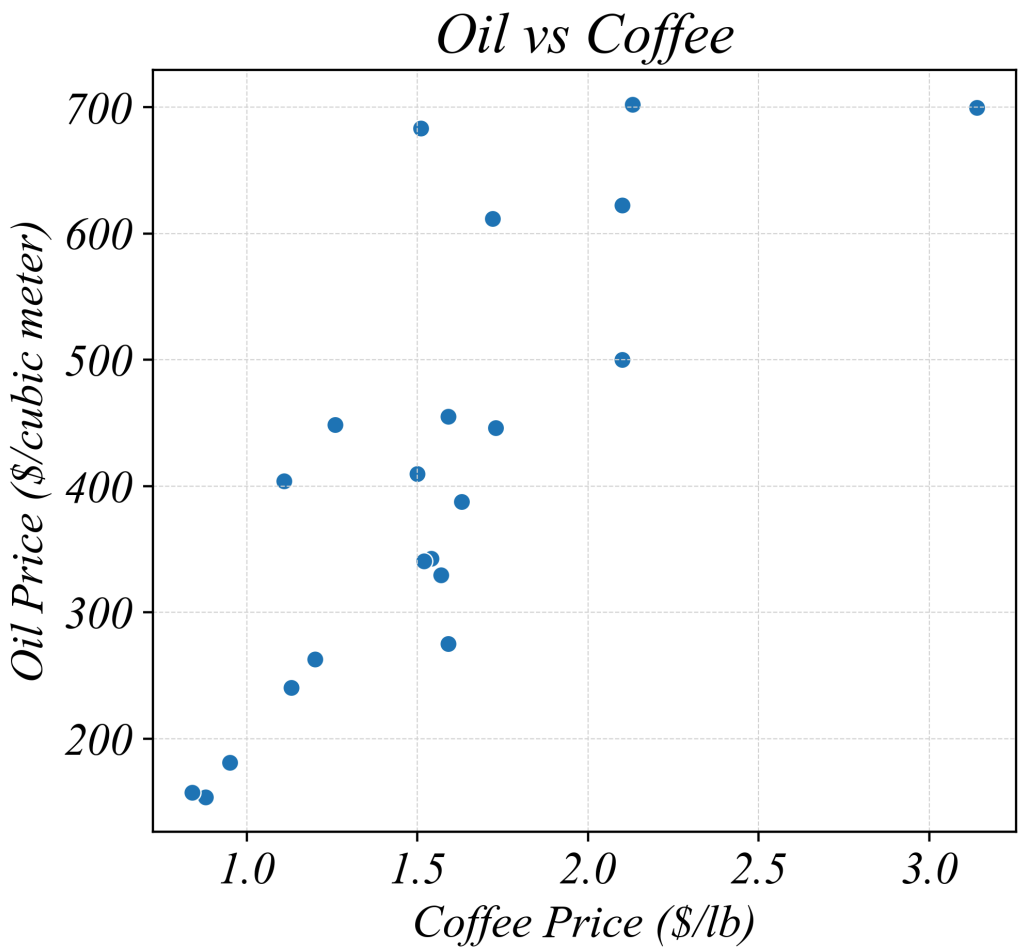
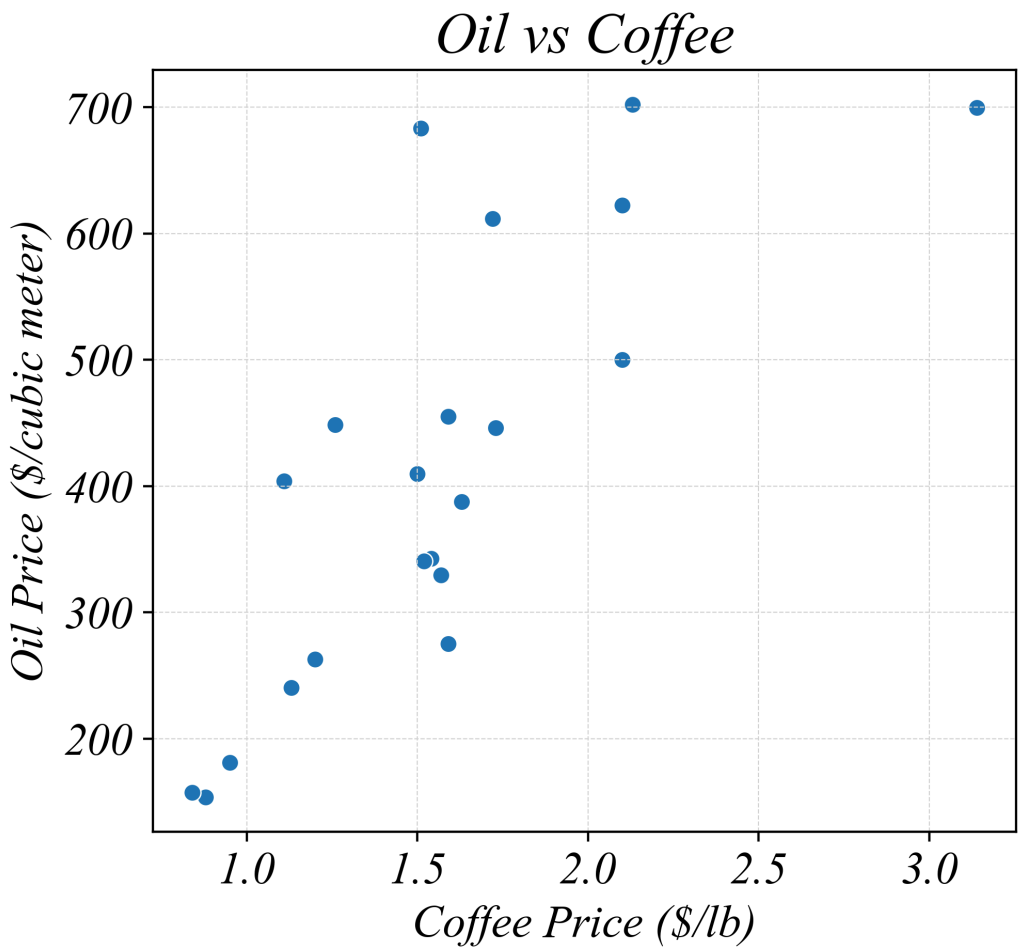


> a Scatterplot can show the relationship between two variables through time

Bivariate Relationships: Timeseries

Does the price of oil determine the price of coffee?



> *a Scatterplot can only show associations not causation* :(

Exercise 2.1 | Timeseries Scatterplots

Visualizing Coffee Prices and Oil Prices

We're going to use a scatterplot to visually examine the relationship between coffee prices and oil prices.

- ***Data:*** `Coffee_Oil.csv`

Exercise 2.1 | Timeseries Scatterplots

Visualizing Coffee Prices and Oil Prices

```
1 # Scatterplot
2 sns.scatterplot(prices, x='Coffee', y='Oil')
```