Introduction

Do higher film budgets lead to more box office revenue? Let's find out if there's a relationship using the movie budgets and financial performance data that I've scraped from the-numbers.com on **May 1st, 2018**.

Movie Budget and Financial Performance Records

Import Statements

```
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.linear_model import LinearRegression
```

Notebook Presentation

```
pd.options.display.float_format = '{:,.2f}'.format

from pandas.plotting import register_matplotlib_converters
register_matplotlib_converters()
```

Read the Data

```
data = pd.read_csv('data/cost_revenue_dirty.csv')
```

Explore and Clean the Data

1. How many rows and columns does the dataset contain?
2. Are there any NaN values present?
3. Are there any duplicate rows?
4. What are the data types of the columns?

```
data.shape
```

```
(5391, 6)
```

```
print(f'Any NaN values among the data: {data.isna().values.any()}')
```

```
Any NaN values among the data: False
```

```
print(f'Any duplicates: {data.duplicated().values.any()}')
duplicates_rows = data[data.duplicated()]
print(f'Number of duplicates: {len(duplicates_rows)}')
```

```
Any duplicates: False
Number of duplicates: 0
```

```
# data.Rank.describe()
data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 5391 entries, 0 to 5390
Data columns (total 6 columns):
 #   Column                 Non-Null Count  Dtype
---  ------                 --------------  -----
 0   Rank                   5391 non-null   int64
 1   Release_Date           5391 non-null   object
 2   Movie_Title            5391 non-null   object
 3   USD_Production_Budget  5391 non-null   object
 4   USD_Worldwide_Gross    5391 non-null   object
 5   USD_Domestic_Gross     5391 non-null   object
dtypes: int64(1), object(5)
memory usage: 252.8+ KB
```

```
data.head()
```

	Rank	Release_Date	Movie_Title	USD_Production_Budget	USD_Worldwide_Gross	USD_Domestic_Gross
0	5293	8/2/1915	The Birth of a Nation	$110,000	$11,000,000	$10,000,000
1	5140	5/9/1916	Intolerance	$385,907	$0	$0
2	5230	12/24/1916	20,000 Leagues Under the Sea	$200,000	$8,000,000	$8,000,000
3	5299	9/17/1920	Over the Hill to the Poorhouse	$100,000	$3,000,000	$3,000,000
4	5222	1/1/1925	The Big Parade	$245,000	$22,000,000	$11,000,000

```
data.sample(5)
```

	Rank	Release_Date	Movie_Title	USD_Production_Budget	USD_Worldwide_Gross	USD_Domestic_Gross
1345	1575	12/2/1999	Blast from the Past	$35,000,000	$26,613,620	$26,613,620
640	491	6/18/1992	Batman Returns	$80,000,000	$266,824,291	$162,833,635
1910	4194	11/10/2002	The Rules of Attraction	$4,000,000	$11,799,060	$6,525,762
4212	5184	8/17/2012	Compliance	$270,000	$830,700	$319,285
606	2219	8/23/1991	Harley Davidson and the Marlboro Man	$23,000,000	$7,018,525	$7,018,525

Data Type Conversions

Converting the `USD_Production_Budget`, `USD_Worldwide_Gross`, and `USD_Domestic_Gross` columns to a numeric format by removing `$` signs and `,`.

```
chars_to_remove = [',', '$']
columns_to_clean = ["USD_Production_Budget", "USD_Worldwide_Gross", "USD_Domestic_Gross"]

for col in columns_to_clean:
    for element in chars_to_remove:
        data[col] = data[col].astype(str).str.replace(element,"")

    data[col] = pd.to_numeric(data[col])
```

```
C:\Users\AS-Computer\AppData\Local\Temp\ipykernel_16400\2320085852.py:6: FutureWarning: The default value of regex will change from True to False in a future version. In addition, single character regular expressions will *not* be treated as literal strings when regex=True
  data[col] = data[col].astype(str).str.replace(element,"")
```

Converting the `Release_Date` column to a Pandas Datetime type.

```
print(type(data.Release_Date[0]))
```

```
<class 'str'>
```

```
data.Release_Date = pd.to_datetime(data.Release_Date)
```

```
print(type(data.Release_Date[0]))
```

```
<class 'pandas._libs.tslibs.timestamps.Timestamp'>
```

```
data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 5391 entries, 0 to 5390
Data columns (total 6 columns):
 #   Column                 Non-Null Count  Dtype
---  ------                 --------------  -----
 0   Rank                   5391 non-null   int64
 1   Release_Date           5391 non-null   datetime64[ns]
 2   Movie_Title            5391 non-null   object
 3   USD_Production_Budget  5391 non-null   int64
 4   USD_Worldwide_Gross    5391 non-null   int64
 5   USD_Domestic_Gross     5391 non-null   int64
dtypes: datetime64[ns](1), int64(4), object(1)
memory usage: 252.8+ KB
```

Descriptive Statistics

1. What is the average production budget of the films in the data set?
2. What is the average worldwide gross revenue of films?
3. What were the minimums for worldwide and domestic revenue?
4. Are the bottom 25% of films actually profitable or do they lose money?
5. What are the highest production budget and highest worldwide gross revenue of any film?
6. How much revenue did the lowest and highest budget films make?

```
data.describe()
```

	Rank	USD_Production_Budget	USD_Worldwide_Gross	USD_Domestic_Gross
count	5,391.00	5,391.00	5,391.00	5,391.00
mean	2,696.00	31,113,737.58	88,855,421.96	41,235,519.44
std	1,556.39	40,523,796.88	168,457,757.00	66,029,346.27
min	1.00	1,100.00	0.00	0.00
25%	1,348.50	5,000,000.00	3,865,206.00	1,330,901.50
50%	2,696.00	17,000,000.00	27,450,453.00	17,192,205.00
75%	4,043.50	40,000,000.00	96,454,455.00	52,343,687.00
max	5,391.00	425,000,000.00	2,783,918,982.00	936,662,225.00

```
# lowest budget film
data[data.USD_Production_Budget == 1100.00]
```

	Rank	Release_Date	Movie_Title	USD_Production_Budget	USD_Worldwide_Gross	USD_Domestic_Gross
2427	5391	2005-05-08	My Date With Drew	1100	181041	181041

```
# highest budget film
data[data.USD_Production_Budget == 425000000.00]
```

	Rank	Release_Date	Movie_Title	USD_Production_Budget	USD_Worldwide_Gross	USD_Domestic_Gross
3529	1	2009-12-18	Avatar	425000000	2783918982	760507625

Investigating the Zero Revenue Films

How many films grossed $0 domestically (i.e., in the United States)? What were the highest budget films that grossed nothing?

```
zero_domestic = data[data.USD_Domestic_Gross == 0]
print(f"Numbwer of films that grossed $0 domestically {len(zero_domestic)}")

# data was scrapped on the May 1st of 2018 so all films with released date after
# dont have any data for making any money on them
zero_domestic.sort_values("USD_Production_Budget", ascending=False)[:6]
```

```
Numbwer of films that grossed $0 domestically 512
```

	Rank	Release_Date	Movie_Title	USD_Production_Budget	USD_Worldwide_Gross	USD_Domestic_Gross
5388	96	2020-12-31	Singularity	175000000	0	0
5387	126	2018-12-18	Aquaman	160000000	0	0
5384	321	2018-09-03	A Wrinkle in Time	103000000	0	0
5385	366	2018-10-08	Amusement Park	100000000	0	0
5090	556	2015-12-31	Don Gato, el inicio de la pandilla	80000000	4547660	0
4294	566	2012-12-31	Astérix et Obélix: Au service de Sa Majesté	77600000	60680125	0

How many films grossed $0 worldwide? What are the highest budget films that had no revenue internationally?

```
zero_worldwide = data[data.USD_Worldwide_Gross == 0]
print(f"Numbwer of films that grossed $0 worldwide {len(zero_worldwide)}")

# data was scrapped on the May 1st of 2018 so all films with released date after
# dont have any data for making any money on them
zero_domestic.sort_values("USD_Production_Budget", ascending=False)[:6]
```

```
Numbwer of films that grossed $0 worldwide 357
```

	Rank	Release_Date	Movie_Title	USD_Production_Budget	USD_Worldwide_Gross	USD_Domestic_Gross
5388	96	2020-12-31	Singularity	175000000	0	0
5387	126	2018-12-18	Aquaman	160000000	0	0
5384	321	2018-09-03	A Wrinkle in Time	103000000	0	0
5385	366	2018-10-08	Amusement Park	100000000	0	0
5090	556	2015-12-31	Don Gato, el inicio de la pandilla	80000000	4547660	0
4294	566	2012-12-31	Astérix et Obélix: Au service de Sa Majesté	77600000	60680125	0

Filtering on Multiple Conditions

```
international_releases = data.loc[(data.USD_Domestic_Gross == 0) &
                                  (data.USD_Worldwide_Gross != 0)]
print(f"Number of international releases: {(len(international_releases))}")
international_releases.head()
```

```
Number of international releases: 155
```

	Rank	Release_Date	Movie_Title	USD_Production_Budget	USD_Worldwide_Gross	USD_Domestic_Gross
71	4310	1956-02-16	Carousel	3380000	3220	0
1579	5087	2001-02-11	Everything Put Together	500000	7890	0
1744	3695	2001-12-31	The Hole	7500000	10834406	0
2155	4236	2003-12-31	Nothing	4000000	63180	0
2203	2513	2004-03-31	The Touch	20000000	5918742	0

Using the `.query()` function to accomplish the same thing. Create a subset for international releases that had some worldwide gross revenue, but made zero revenue in the United States.

```
international_releases = data.query("USD_Domestic_Gross == 0 and USD_Worldwide_Gross != 0")
print(f"Number of international releases: {(len(international_releases))}")
international_releases.head()
```

```
Number of international releases: 155
```

	Rank	Release_Date	Movie_Title	USD_Production_Budget	USD_Worldwide_Gross	USD_Domestic_Gross
71	4310	1956-02-16	Carousel	3380000	3220	0
1579	5087	2001-02-11	Everything Put Together	500000	7890	0
1744	3695	2001-12-31	The Hole	7500000	10834406	0
2155	4236	2003-12-31	Nothing	4000000	63180	0
2203	2513	2004-03-31	The Touch	20000000	5918742	0

Unreleased Films

- Identifing which films were not released yet as of the time of data collection (May 1st, 2018).
- How many films are included in the dataset that have not yet had a chance to be screened in the box office?

- Creating another DataFrame called data_clean that does not include these films.

```
# Date of Data Collection
scrape_date = pd.Timestamp('2018-5-1')
```

```
future_released = data[data.Release_Date > scrape_date]
print(f"Number of unreleased movies: {len(future_released)}")
data_clean = data.drop(future_released.index)
data_clean.shape
```

```
Number of unreleased movies: 7
(5384, 6)
```

```
# or same as above
data_clean = data.query("Release_Date <= @scrape_date")
data_clean.shape
```

```
(5384, 6)
```

Films that Lost Money

Calculating the percentage of films where the production costs exceeded the worldwide gross revenue?

```
money_losing = data_clean.loc[data_clean.USD_Production_Budget > data_clean.USD_Worldwide_Gross]
len(money_losing)/len(data_clean)*100
money_losing.shape[0]/data_clean.shape[0]*100
```

```
37.27711738484398
```

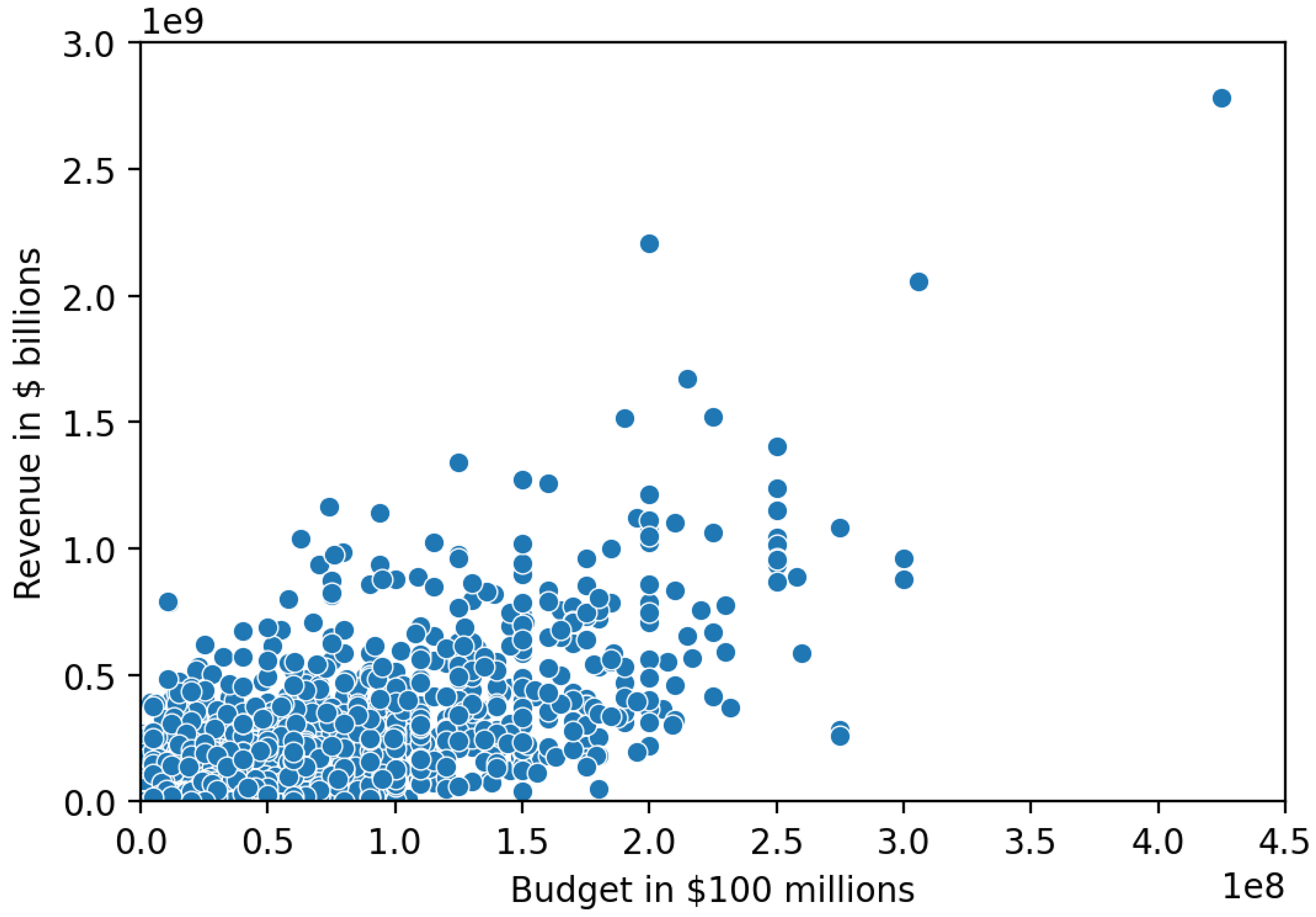
Seaborn for Data Viz: Bubble Charts

```
plt.figure(figsize=(6,4), dpi=200)

# creating a scatterplot
ax = sns.scatterplot(
    data = data_clean,
    x='USD_Production_Budget',
    y='USD_Worldwide_Gross',
)

ax.set(
    ylim=(0,3000000000),
    xlim=(0,450000000),
    ylabel='Revenue in $ billions',
    xlabel='Budget in $100 millions',
)

plt.show()
```



Plotting Movie Releases over Time

Creating a Bubble Chart:

```
plt.figure(figsize=(6,4), dpi=200)

# bubble chart - some bubbles are bigger and darker (with more revenue)
ax = sns.scatterplot(
    data = data_clean,
    x='USD_Production_Budget',
    y='USD_Worldwide_Gross',
    hue='USD_Worldwide_Gross', # colour
    size='USD_Worldwide_Gross', # dot size
)

ax.set(
    ylim=(0,3000000000),
    xlim=(0,450000000),
    ylabel='Revenue in $ billions',
    xlabel='Budget in $100 millions',
)

plt.show()
```

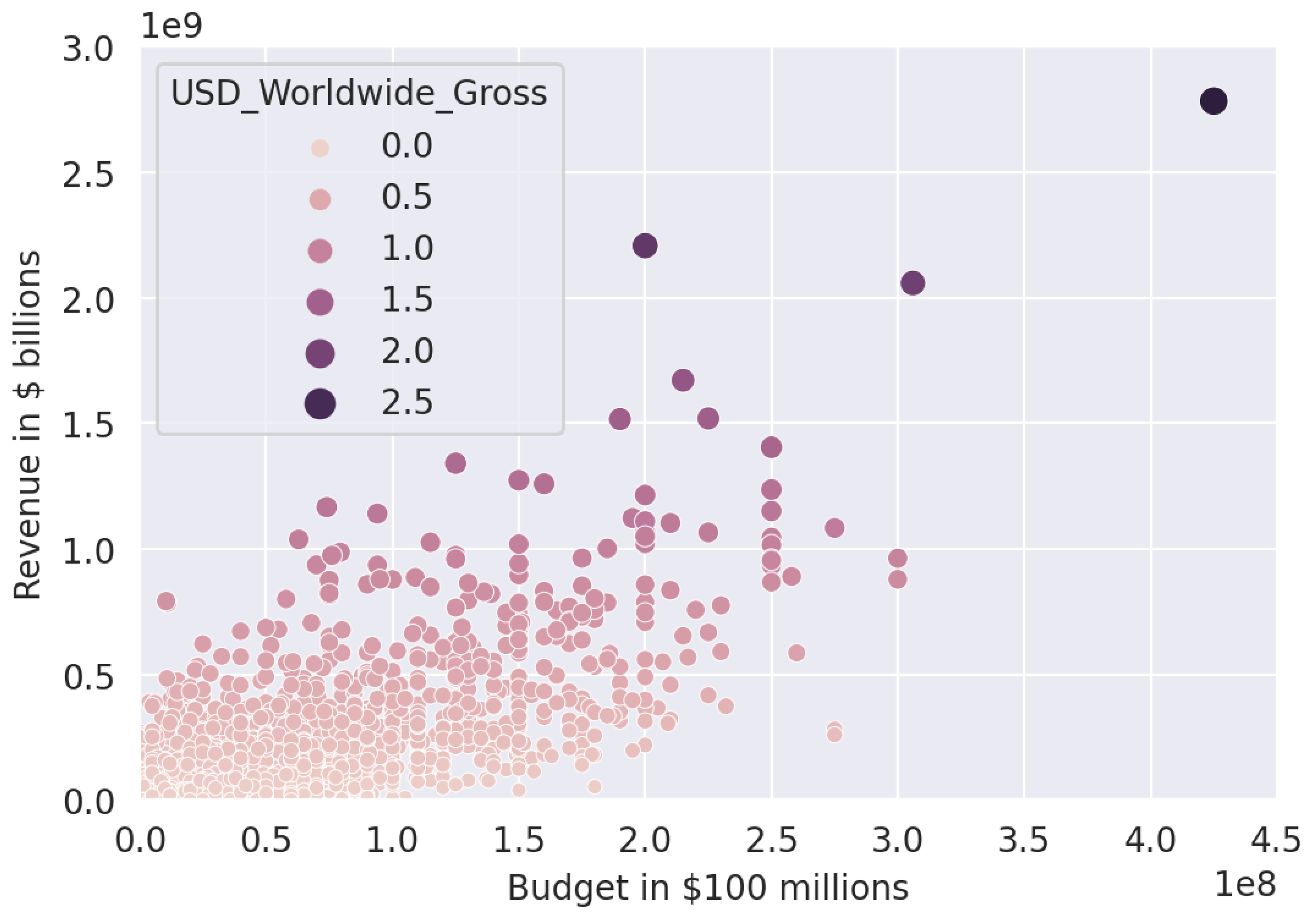
Styling the chart

```
plt.figure(figsize=(6,4), dpi=200)

# set styling on a single chart
# 'whitegrid', 'dark', 'ticks', 'darkgrid'
with sns.axes_style('darkgrid'):
    ax = sns.scatterplot(
        data = data_clean,
        x='USD_Production_Budget',
        y='USD_Worldwide_Gross',
        hue='USD_Worldwide_Gross', # colour
        size='USD_Worldwide_Gross', # dot size
    )

    ax.set(
        ylim=(0,3000000000),
        xlim=(0,450000000),
        ylabel='Revenue in $ billions',
        xlabel='Budget in $100 millions',
    )

plt.show()
```



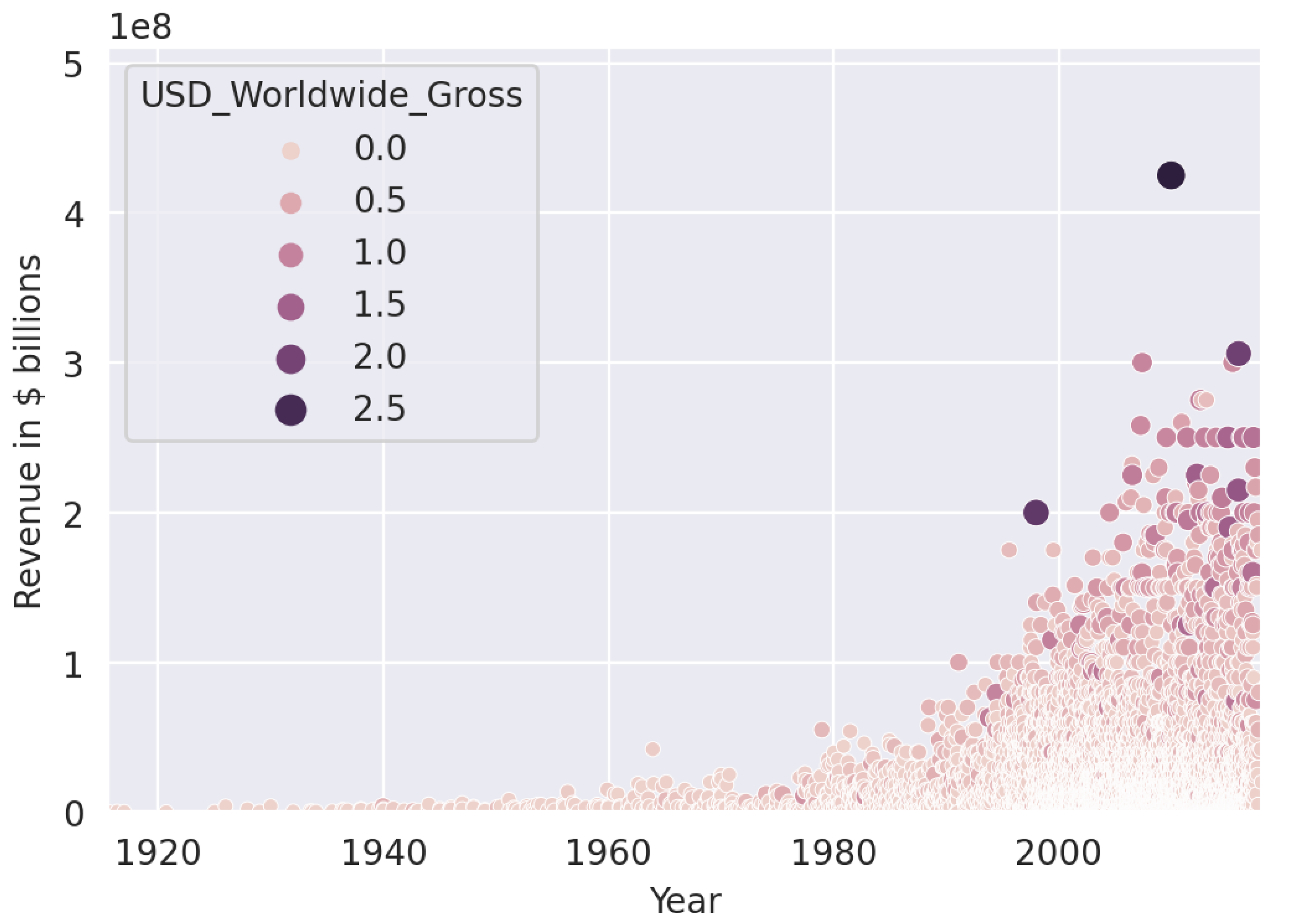
Movie Budgets over Time

```
plt.figure(figsize=(6,4), dpi=200)

# set styling on a single chart
# 'whitegrid', 'dark', 'ticks', 'darkgrid'
with sns.axes_style('darkgrid'):
    ax = sns.scatterplot(
        data = data_clean,
        x='Release_Date',
        y='USD_Production_Budget',
        hue='USD_Worldwide_Gross', # colour
        size='USD_Worldwide_Gross', # dot size
    )

    ax.set(
        ylim=(0,data_clean.USD_Production_Budget.max()*1.2),
        xlim=(data_clean.Release_Date.min(),data_clean.Release_Date.max()),
        ylabel='Revenue in $ billions',
        xlabel='Year',
    )

plt.show()
```



Converting Years to Decades

Creating a column in `data_clean` that has the decade of the release.

1. Creating a [`DatetimeIndex` object](#) from the Release_Date column.
2. Grabing all the years from the `DatetimeIndex` object using the `.year` property.
3. Using the floor division `//` to convert the year data to the decades of the films.
4. Adding the decades as a `Decade` column to the `data_clean` DataFrame.

```
dt_index = pd.DatetimeIndex(data_clean.Release_Date)
years = dt_index.year
decades = (years // 10) *10
data_clean["Decade"] = decades
```

Separating the "old" (before 1969) and "New" (1970s onwards) Films

Creating two new DataFrames: `old_films` and `new_films`

- `old_films` includes all the films before 1969 (up to and including 1969)
- `new_films` includes all the films from 1970 onwards
- How many films were released prior to 1970?

- What was the most expensive film made prior to 1970?

```
old_films = data_clean[data_clean.Decade <= 1960]
new_films = data_clean[data_clean.Decade > 1960]
```

```
old_films.describe()
```

	Rank	USD_Production_Budget	USD_Worldwide_Gross	USD_Domestic_Gross	Decade
count	153.00	153.00	153.00	153.00	153.00
mean	4,274.77	4,611,297.65	30,419,634.38	22,389,473.87	1,949.15
std	742.14	5,713,648.85	54,931,828.93	32,641,752.41	12.72
min	1,253.00	100,000.00	0.00	0.00	1,910.00
25%	3,973.00	1,250,000.00	5,273,000.00	5,000,000.00	1,940.00
50%	4,434.00	2,900,000.00	10,000,000.00	10,000,000.00	1,950.00
75%	4,785.00	5,000,000.00	33,208,099.00	28,350,000.00	1,960.00
max	5,299.00	42,000,000.00	390,525,192.00	198,680,470.00	1,960.00

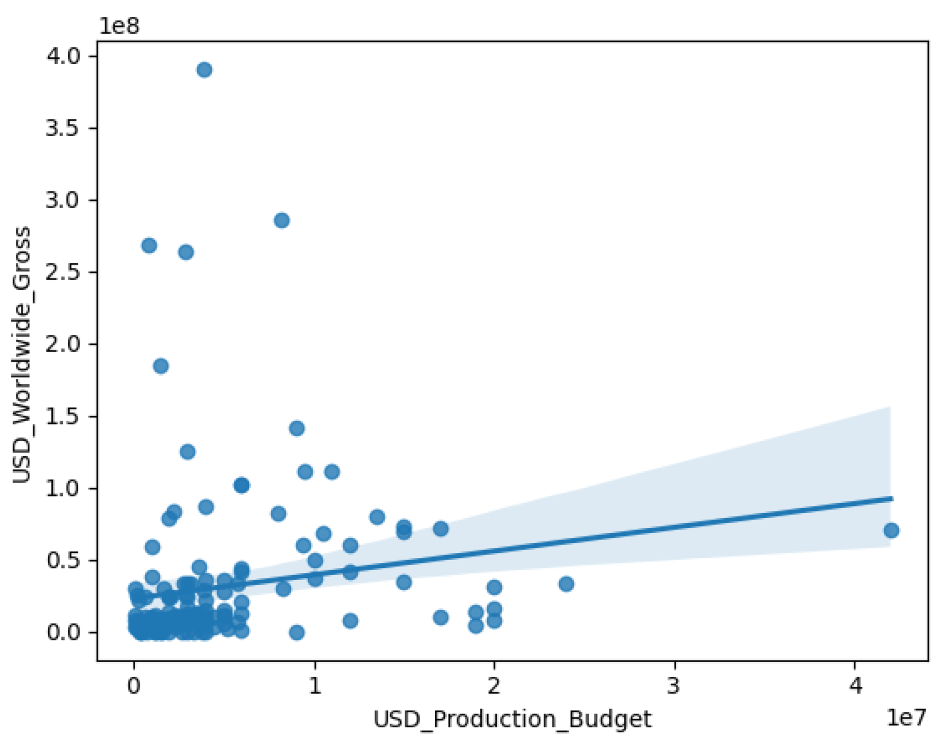
```
old_films.sort_values("USD_Production_Budget", ascending=False).head()
```

	Rank	Release_Date	Movie_Title	USD_Production_Budget	USD_Worldwide_Gross	USD_Domestic_Gross	Decade
109	1253	1963-12-06	Cleopatra	42000000	71000000	57000000	1960
150	2175	1969-12-16	Hello, Dolly	24000000	33208099	33208099	1960
143	2465	1969-01-01	Sweet Charity	20000000	8000000	8000000	1960
118	2425	1965-02-15	The Greatest Story Ever Told	20000000	15473333	15473333	1960
148	2375	1969-10-15	Paint Your Wagon	20000000	31678778	31678778	1960

Seaborn Regression Plots

```
sns.regplot(
    data=old_films,
    x='USD_Production_Budget',
    y='USD_Worldwide_Gross',
)
```

<AxesSubplot: xlabel='USD_Production_Budget', ylabel='USD_Worldwide_Gross'>



Using Seaborn's `.regplot()` we can show the scatter plot and linear regression line against the `new_films`.

with the given styling :

- Putting the chart on a `'darkgrid'`.
- Setting limits on the axes so that they don't show negative values.
- Labeling the axes on the plot "Revenue in $ billions" and "Budget in $ millions".
- Providing HEX colour codes for the plot and the regression line. Making the dots dark blue (#2f4b7c) and the line orange (#ff7c43).

With this chart we will be able to answer following questions.

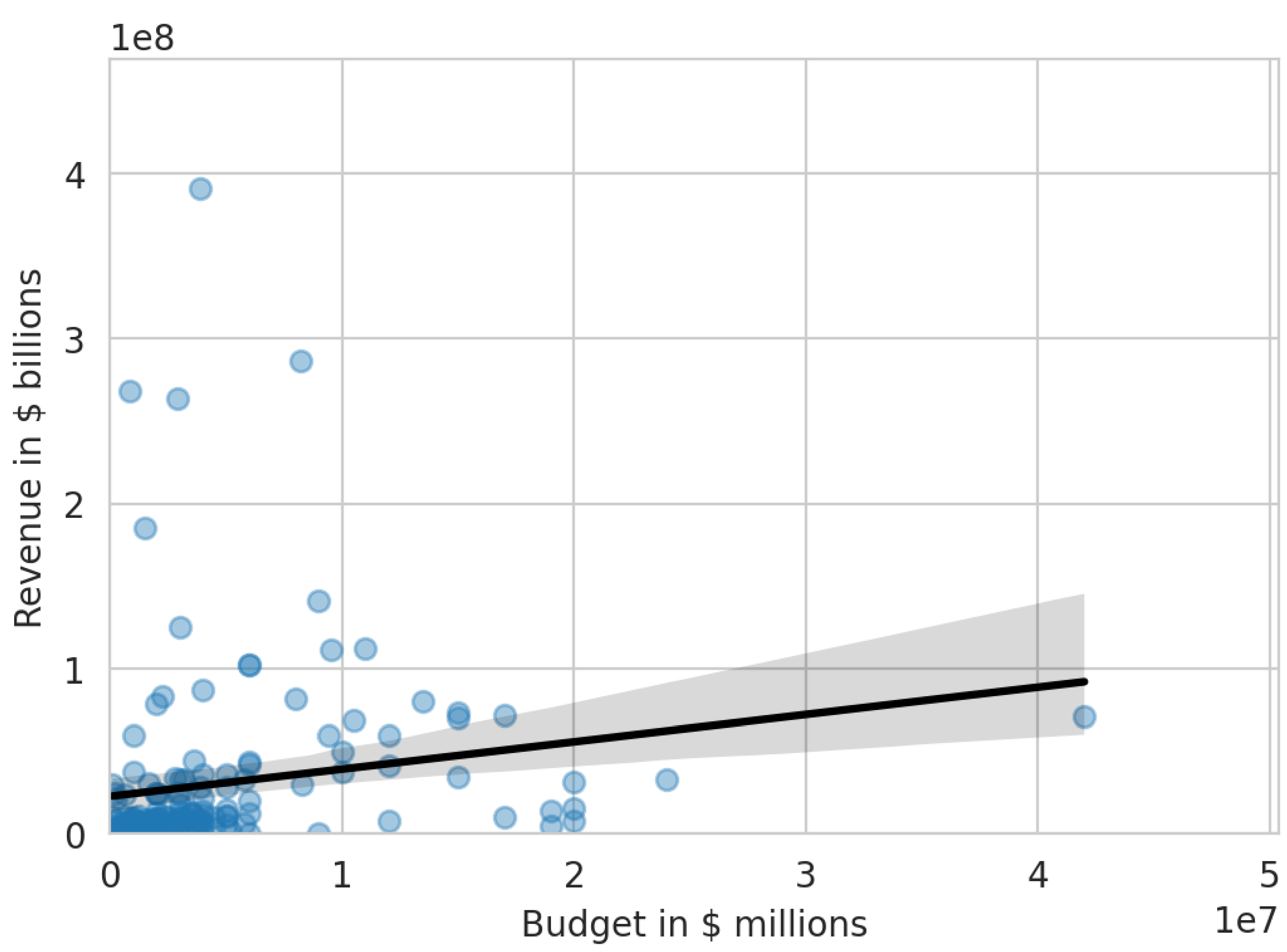
- Do our data points for the new films align better or worse with the linear regression than for our older films?
- Roughly how much would a film with a budget of $150 million make according to the regression line?

```
plt.figure(figsize=(6,4), dpi=200)

with sns.axes_style('whitegrid'):
    ax = sns.regplot(
        data = old_films,
        x='USD_Production_Budget',
        y='USD_Worldwide_Gross',
        scatter_kws = {'alpha': 0.4},
        line_kws = {'color': 'black'},
    )

    ax.set(
        ylim=(0,old_films.USD_Worldwide_Gross.max()*1.2),
        xlim=(0,old_films.USD_Production_Budget.max()*1.2),
        ylabel='Revenue in $ billions',
        xlabel='Budget in $ millions',
    )

plt.show()
```



and for the new movies

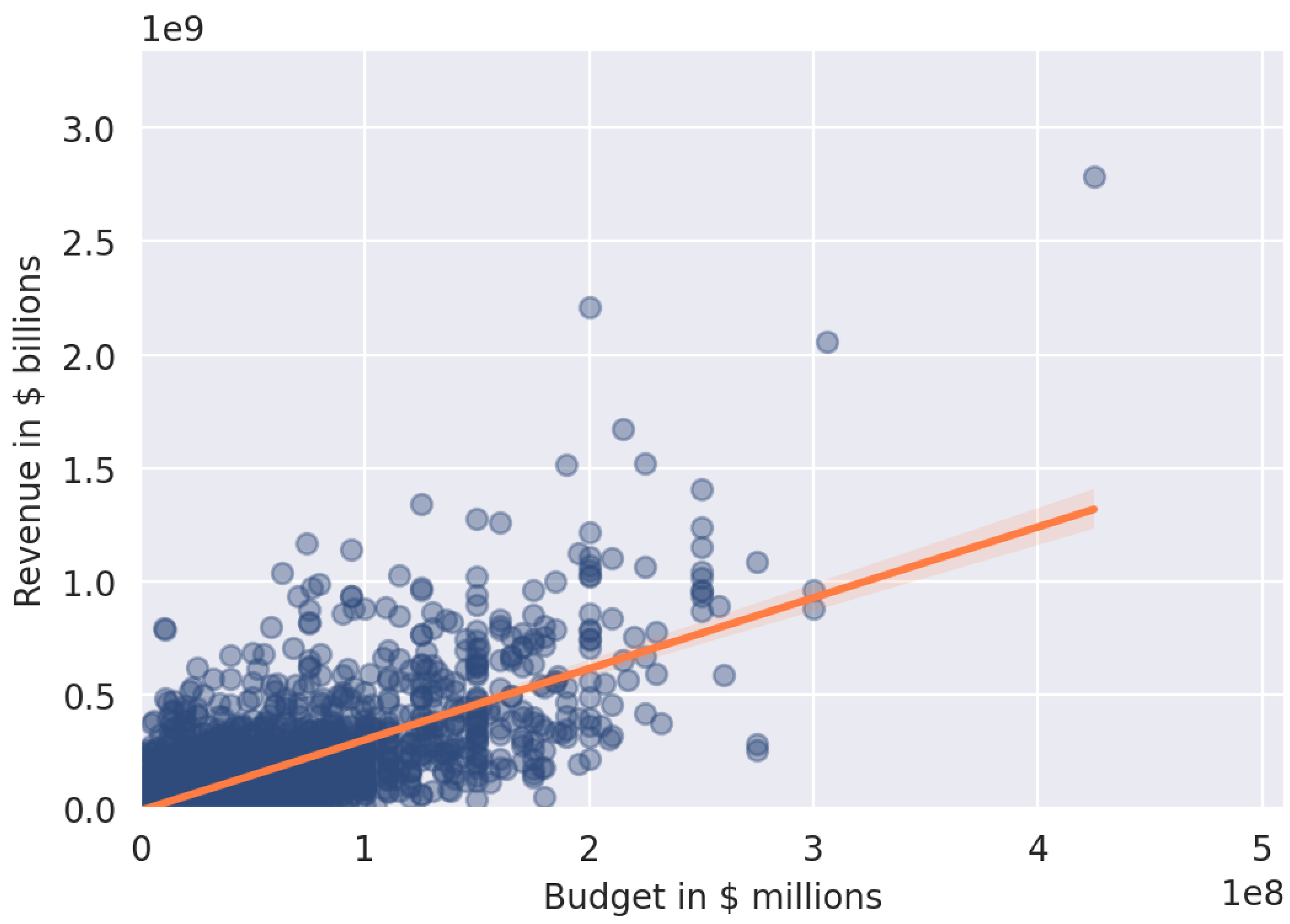
```
plt.figure(figsize=(6,4), dpi=200)

with sns.axes_style('darkgrid'):
    ax = sns.regplot(
        data = new_films,
        x='USD_Production_Budget',
```

```
        y='USD_Worldwide_Gross',
        color='#2f4b7c',
        scatter_kws = {'alpha': 0.4},
        line_kws = {'color': '#ff7c43'},
    )

    ax.set(
        ylim=(0,new_films.USD_Worldwide_Gross.max()*1.2),
        xlim=(0,new_films.USD_Production_Budget.max()*1.2),
        ylabel='Revenue in $ billions',
        xlabel='Budget in $ millions',
    )

plt.show()
```



Run Your Own Regression with scikit-learn

$$REV\hat{E}NUE = \theta_0 + \theta_1 BUDGET$$

```
regression = LinearRegression()
```

```
# Explanatory Variable(s) or Feature(s)
X = pd.DataFrame(new_films, columns=['USD_Production_Budget'])
```

```
# Response Variable or Target
y = pd.DataFrame(new_films, columns=['USD_Worldwide_Gross'])
```

```
regression.fit(X,y)
```

```
▸ LinearRegression
LinearRegression()
```

```
# Theta zero
regression.intercept_
```

```
array([-8650768.00661042])
```

```
# Theta one
regression.coef_
```

```
array([[3.12259592]])
```

Interpretation

if a movie budget is $0, the estimated movie revenue is -$8.65. The slope tells us that for every extra $1 in the budget, movie revenue increases by $3.1

One measure of figuring out how well our model fits our data is by looking at a metric called r-squared.

```
# R-squared
regression.score(X, y)
# This means that our model explains about 56% of
# the variance in movie revenue.
```

```
0.5577032617720403
```

Running a linear regression for the `old_films`. Calculating the intercept, slope and r-squared. How much of the variance in movie revenue does the linear model explain in this case?

```
# Explanatory Variable(s) or Feature(s)
X = pd.DataFrame(old_films, columns=['USD_Production_Budget'])
# Response Variable or Target
y = pd.DataFrame(old_films, columns=['USD_Worldwide_Gross'])
regression.fit(X,y)
# Theta zero
print(f"The intercept is: {regression.intercept_[0]}")
# Theta one
print(f"The slope coefficient is: {regression.coef_[0][0]}")
# R-squared
# This means that our model explains about 3% of
# the variance in movie revenue.
print(f"The r-square is: {regression.score(X, y)}")
```

```
The intercept is: 22821538.635080386
The slope coefficient is: 1.6477131440107315
The r-square is: 0.02937258620576877
```

Using our Model to Make a Prediction

We just estimated the slope and intercept! our Linear Model has the following form:

$$REV\hat{E}NUE = \theta_0 + \theta_1 BUDGET$$

Based on that we can callculate how much global revenue does our model estimate for a film with a budget of $350 million?

```
revenue = regression.intercept_[0] + regression.coef_[0,0] * 350000000
```

```
print(f"Estimated Revenue: ${revenue:.10}")
```

```
Estimated Revenue: $599521139.0
```