Phase 2

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Research Question:

How do ESG performance and stock performance correlate across industries? What associations can we find between industry, stock performance, and ESG rating?

Data Collection and Cleaning

In [206…

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
from scipy import stats
from sklearn.linear_model import LinearRegression
esg = pd.read_csv("esg_data.csv")
print(esg.iloc[0:15,:])
```

```
   ticker                              name currency  \
0     dis                 Walt Disney Co      USD
1      gm                General Motors Co      USD
2     gww                  WW Grainger Inc      USD
3     mhk            Mohawk Industries Inc      USD
4     lyv    Live Nation Entertainment Inc      USD
5     lvs              Las Vegas Sands Corp      USD
6     clx                         Clorox Co      USD
7    aacg            ATA Creativity Global      CNY
8     aal      American Airlines Group Inc      USD
9    aame           Atlantic American Corp      USD
10   aaoi      Applied Optoelectronics Inc      USD
```

```
11   aaon                          Aaon Inc      USD
12   aapl                         Apple Inc      USD
13   aatc       Autoscope Technologies Corp      USD
14   aaww  Atlas Air Worldwide Holdings Inc      USD

                        exchange                              industry  \
0   NEW YORK STOCK EXCHANGE, INC.                                Media
1   NEW YORK STOCK EXCHANGE, INC.                            Automobiles
2   NEW YORK STOCK EXCHANGE, INC.  Trading Companies and Distributors
3   NEW YORK STOCK EXCHANGE, INC.                    Consumer products
4   NEW YORK STOCK EXCHANGE, INC.                                Media
5   NEW YORK STOCK EXCHANGE, INC.      Hotels Restaurants and Leisure
6   NEW YORK STOCK EXCHANGE, INC.                    Consumer products
7      NASDAQ NMS - GLOBAL MARKET       Diversified Consumer Services
8      NASDAQ NMS - GLOBAL MARKET                           Airlines
9      NASDAQ NMS - GLOBAL MARKET                          Insurance
10     NASDAQ NMS - GLOBAL MARKET                      Communications
11     NASDAQ NMS - GLOBAL MARKET                            Building
12     NASDAQ NMS - GLOBAL MARKET                          Technology
13     NASDAQ NMS - GLOBAL MARKET                Electrical Equipment
14     NASDAQ NMS - GLOBAL MARKET        Logistics and Transportation

                                                    logo  \
0   https://static.finnhub.io/logo/ef50b4a2b263c84...
1   https://static.finnhub.io/logo/9253db78-80c9-1...
2   https://static.finnhub.io/logo/f153dcda-80eb-1...
3   https://static.finnhub.io/logo/26868a62-80ec-1...
4   https://static.finnhub.io/logo/1cd144d2-80ec-1...
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7   https://static2.finnhub.io/file/publicdatany/f...
8   https://static2.finnhub.io/file/publicdatany/f...
9   https://static.finnhub.io/logo/6b536b3e-826a-1...
10  https://static.finnhub.io/logo/7afdb95a-80ce-1...
11  https://static.finnhub.io/logo/8819421c-80df-1...
12  https://static.finnhub.io/logo/87cb30d8-80df-1...
13                                                NaN
14  https://static.finnhub.io/logo/8b74bf8a-80df-1...

                                     weburl environment_grade  \
```

```
0          https://thewaltdisneycompany.com/                A
1                      https://www.gm.com/                  A
2                 https://www.grainger.com/                 B
3                    https://mohawkind.com/                 A
4   https://www.livenationentertainment.com/               BBB
5                    https://www.sands.com/                 A
6          https://www.thecloroxcompany.com/                A
7                     http://www.ata.net.cn                 B
8      https://americanairlines.gcs-web.com/                 B
9                     http://www.atlam.com/                 B
10                       http://ao-inc.com/                BB
11                    https://www.aaon.com/                 A
12                   https://www.apple.com/                BB
13                                      NaN               BBB
14        https://www.atlasairworldwide.com/                A

   environment_level social_grade  ... governance_grade governance_level  \
0               High           BB  ...               BB           Medium
1               High           BB  ...                B           Medium
2             Medium           BB  ...                B           Medium
3               High            B  ...               BB           Medium
4               High           BB  ...                B           Medium
5               High           BB  ...               BB           Medium
6               High           BB  ...               BB           Medium
7             Medium            B  ...                B           Medium
8             Medium            B  ...                B           Medium
9             Medium            B  ...               BB           Medium
10            Medium            B  ...                B           Medium
11              High           BB  ...                B           Medium
12            Medium            B  ...                B           Medium
13              High            B  ...                B           Medium
14              High            B  ...                B           Medium

   environment_score  social_score  governance_score  total_score  \
0                510           316               321         1147
1                510           303               255         1068
2                255           385               240          880
3                570           298               303         1171
4                492           310               250         1052
5                547           318               313         1178
```

```
6                560           350                345         1255
7                203           200                205          608
8                270           211                265          746
9                220           221                300          741
10               311           256                218          785
11               500           300                223         1023
12               355           281                255          891
13               410           286                240          936
14               520           243                237         1000
```

```
    last_processing_date total_grade total_level      cik
0             19-04-2022         BBB        High  1744489
1             17-04-2022         BBB        High  1467858
2             19-04-2022          BB      Medium   277135
3             18-04-2022         BBB        High   851968
4             18-04-2022         BBB        High  1335258
5             18-04-2022         BBB        High  1300514
6             16-04-2022           A        High    21076
7             01-07-2022           B      Medium  1420529
8             16-04-2022           B      Medium     6201
9             16-04-2022           B      Medium     8177
10            16-04-2022          BB      Medium  1158114
11            16-04-2022         BBB        High   824142
12            16-04-2022          BB      Medium   320193
13            11-06-2022         BBB        High   943034
14            16-04-2022         BBB        High  1135185

[15 rows x 21 columns]
```

In [207…

```python
#cleaning to only have certain companies that represent a variety of industries

companies = ["Walt Disney Co", "American Airlines Group Inc", "Apple Inc", "eBay Inc", "Goldman Sachs Gro
             "Meta Platforms Inc", "Starbucks Corp", "PayPal Holdings Inc", "United Airlines Holdings Inc
             "Bath & Body Works Inc", "Abbvie Inc", "Alexandria Real Estate Equities Inc",
             "Becton Dickinson and Co", "Brown & Brown Inc", "Duke Energy Corp", "T-Mobile US Inc",
             "Marathon Oil Corp", "Chipotle Mexican Grill Inc", "Target Corp",
             "General Motors Co", "Salesforce Inc", "Tesla Inc", "Bank of America Corp"]

relevant_esg = esg[esg["name"].isin(companies)]
print(relevant_esg)
```

	ticker	name	currency	\
0	dis	Walt Disney Co	USD	
1	gm	General Motors Co	USD	
8	aal	American Airlines Group Inc	USD	
12	aapl	Apple Inc	USD	
163	ebay	eBay Inc	USD	
170	meta	Meta Platforms Inc	USD	
196	sbux	Starbucks Corp	USD	
201	pypl	PayPal Holdings Inc	USD	
212	tsla	Tesla Inc	USD	
215	tmus	T-Mobile US Inc	USD	
216	ual	United Airlines Holdings Inc	USD	
231	abbv	Abbvie Inc	USD	
256	are	Alexandria Real Estate Equities Inc	USD	
261	bac	Bank of America Corp	USD	
263	bbwi	Bath & Body Works Inc	USD	
264	bdx	Becton Dickinson and Co	USD	
271	bro	Brown & Brown Inc	USD	
289	cmg	Chipotle Mexican Grill Inc	USD	
295	duk	Duke Energy Corp	USD	
306	gs	Goldman Sachs Group Inc	USD	
333	mro	Marathon Oil Corp	USD	
399	tgt	Target Corp	USD	
445	crm	Salesforce Inc	USD	

	exchange	industry	\
0	NEW YORK STOCK EXCHANGE, INC.	Media	
1	NEW YORK STOCK EXCHANGE, INC.	Automobiles	
8	NASDAQ NMS - GLOBAL MARKET	Airlines	
12	NASDAQ NMS - GLOBAL MARKET	Technology	
163	NASDAQ NMS - GLOBAL MARKET	Retail	
170	NASDAQ NMS - GLOBAL MARKET	Media	
196	NASDAQ NMS - GLOBAL MARKET	Hotels Restaurants and Leisure	
201	NASDAQ NMS - GLOBAL MARKET	Technology	
212	NASDAQ NMS - GLOBAL MARKET	Automobiles	
215	NASDAQ NMS - GLOBAL MARKET	Telecommunication	
216	NASDAQ NMS - GLOBAL MARKET	Airlines	
231	NEW YORK STOCK EXCHANGE, INC.	Biotechnology	
256	NEW YORK STOCK EXCHANGE, INC.	Real Estate	
261	NEW YORK STOCK EXCHANGE, INC.	Banking	

```
263  NEW YORK STOCK EXCHANGE, INC.                         Retail
264  NEW YORK STOCK EXCHANGE, INC.                     Health Care
271  NEW YORK STOCK EXCHANGE, INC.                       Insurance
289  NEW YORK STOCK EXCHANGE, INC.  Hotels Restaurants and Leisure
295  NEW YORK STOCK EXCHANGE, INC.                       Utilities
306  NEW YORK STOCK EXCHANGE, INC.              Financial Services
333  NEW YORK STOCK EXCHANGE, INC.                          Energy
399  NEW YORK STOCK EXCHANGE, INC.                          Retail
445  NEW YORK STOCK EXCHANGE, INC.                      Technology

                                                    logo  \
0    https://static.finnhub.io/logo/ef50b4a2b263c84...
1    https://static.finnhub.io/logo/9253db78-80c9-1...
8    https://static2.finnhub.io/file/publicdatany/f...
12   https://static.finnhub.io/logo/87cb30d8-80df-1...
163  https://static.finnhub.io/logo/919a6270-826a-1...
170  https://static2.finnhub.io/file/publicdatany/f...
196  https://static.finnhub.io/logo/8d4c97ac-80e0-1...
201  https://static.finnhub.io/logo/58e310c0-80d2-1...
212  https://static.finnhub.io/logo/2dd96524-80c9-1...
215  https://static.finnhub.io/logo/4ffaa8b8-80ec-1...
216  https://static.finnhub.io/logo/b3f34b67dcba172...
231  https://static.finnhub.io/logo/8806d72c-80cd-1...
256  https://static.finnhub.io/logo/ffde2ccf9a1b68d...
261  https://static2.finnhub.io/file/publicdatany/f...
263  https://static.finnhub.io/logo/1b846d4a-80ec-1...
264  https://static.finnhub.io/logo/82e1f20c-80eb-1...
271  https://static.finnhub.io/logo/8d4bb0d8-80eb-1...
289  https://static.finnhub.io/logo/a551a6c2-80eb-1...
295  https://static.finnhub.io/logo/c6386312-80eb-1...
306  https://static.finnhub.io/logo/7ba3bd9e8fc91f9...
333  https://static.finnhub.io/logo/2f57969a-80ec-1...
399  https://static.finnhub.io/logo/83bbf858-80ec-1...
445  https://static.finnhub.io/logo/5a800a68f67c85e...

                                  weburl environment_grade  \
0        https://thewaltdisneycompany.com/                A
1                    https://www.gm.com/                  A
8    https://americanairlines.gcs-web.com/                B
12                https://www.apple.com/                 BB
```

163	https://www.ebayinc.com/	A
170	https://www.facebook.com	B
196	https://www.starbucks.com/	BBB
201	https://www.paypal.com/	BB
212	https://www.tesla.com/	A
215	https://www.t-mobile.com/	BB
216	https://ir.united.com/	B
231	https://www.abbvie.com/	A
256	https://www.are.com/	AA
261	https://www.bankofamerica.com	B
263	https://www.bbwinc.com/	A
264	https://www.bd.com/	AA
271	https://www.bbinsurance.com/	BBB
289	https://www.chipotle.com/	B
295	https://www.duke-energy.com/	AA
306	https://www.goldmansachs.com/	A
333	https://www.marathonoil.com/	A
399	https://corporate.target.com/	A
445	https://www.salesforce.com/	B

	environment_level	social_grade	...	governance_grade	governance_level	\
0	High	BB	...	BB	Medium	
1	High	BB	...	B	Medium	
8	Medium	B	...	B	Medium	
12	Medium	B	...	B	Medium	
163	High	BB	...	BB	Medium	
170	Medium	B	...	B	Medium	
196	High	BB	...	B	Medium	
201	Medium	B	...	B	Medium	
212	High	CCC	...	B	Medium	
215	Medium	BB	...	B	Medium	
216	Medium	B	...	B	Medium	
231	High	BB	...	BB	Medium	
256	Excellent	BB	...	BB	Medium	
261	Medium	BB	...	B	Medium	
263	High	BB	...	BB	Medium	
264	Excellent	BB	...	BB	Medium	
271	High	BB	...	BB	Medium	
289	Medium	B	...	B	Medium	
295	Excellent	BB	...	BB	Medium	

```
306              High           BB  ...               BB           Medium
333              High           BB  ...               BB           Medium
399              High           BB  ...               BB           Medium
445            Medium            B  ...                B           Medium

    environment_score  social_score  governance_score  total_score  \
0                 510           316               321         1147
1                 510           303               255         1068
8                 270           211               265          746
12                355           281               255          891
163               500           302               305         1107
170               205           232               215          652
196               475           385               295         1155
201               370           244               285          899
212               555           160               278          993
215               342           331               230          903
216               205           203               221          629
231               505           317               300         1122
256               600           337               345         1282
261               220           394               265          879
263               525           303               300         1128
264               607           384               315         1306
271               405           320               300         1025
289               210           241               213          664
295               604           362               328         1294
306               525           305               305         1135
333               530           313               305         1148
399               550           342               313         1205
445               215           241               200          656

     last_processing_date total_grade total_level      cik
0              19-04-2022         BBB        High  1744489
1              17-04-2022         BBB        High  1467858
8              16-04-2022           B      Medium     6201
12             16-04-2022          BB      Medium   320193
163            17-04-2022         BBB        High  1065088
170            22-04-2022           B      Medium  1326801
196            19-04-2022         BBB        High   829224
201            18-04-2022          BB      Medium  1633917
212            19-04-2022         BBB        High  1318605
```

```
215            19-04-2022         BBB        High  1283699
216            19-04-2022           B      Medium   100517
231            16-04-2022         BBB        High  1551152
256            16-04-2022           A        High  1035443
261            16-04-2022          BB      Medium    70858
263            11-06-2022         BBB        High   701985
264            16-04-2022           A        High    10795
271            16-04-2022         BBB        High    79282
289            16-04-2022           B      Medium  1058090
295            17-04-2022           A        High  1326160
306            17-04-2022         BBB        High   886982
333            21-04-2022         BBB        High   101778
399            19-04-2022           A        High    27419
445            19-04-2022           B      Medium  1108524

[23 rows x 21 columns]
```

In [208…
```python
import yfinance as yf
```

In [209…
```python
#use yfinance to pull stock information of selected stocks.
relevant_esg.loc[:, 'ticker'] = relevant_esg['ticker'].astype(str)
relevant_esg.loc[:, 'name'] = relevant_esg['name'].astype(str)
tickers = relevant_esg['ticker'].tolist()
#Add Start Price, End Price, and Rate of Change (%) of each company to the dataset relevent.esg
relevant_esg.loc[:, 'Start Price'] = None
relevant_esg.loc[:, 'End Price'] = None
relevant_esg.loc[:, 'Rate of Change (%)'] = None

# Loop through each row of the DataFrame to get stock information for each company
for index, row in relevant_esg.iterrows():
    ticker = row['ticker']

    # Download stock data for 2023
    data = yf.download(ticker, start='2021-04-01',end='2022-04-01')

    # Ensure data exists for the given period
    if not data.empty:
        start_price = data['Adj Close'].iloc[0]
        end_price = data['Adj Close'].iloc[-1]
        rate_of_change = ((end_price - start_price) / start_price) * 100
```

```python
        # Add the stock data to the relevant columns in the DataFrame using .loc[]
        relevant_esg.loc[index, 'Start Price'] = start_price
        relevant_esg.loc[index, 'End Price'] = end_price
        relevant_esg.loc[index, 'Rate of Change (%)'] = rate_of_change

print(relevant_esg)
```

```
[*********************100%***********************]  1 of 1 completed
[*********************100%***********************]  1 of 1 completed
[*********************100%***********************]  1 of 1 completed
[*********************100%***********************]  1 of 1 completed
[*********************100%***********************]  1 of 1 completed
[*********************100%***********************]  1 of 1 completed
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[*********************100%***********************]  1 of 1 completed
[*********************100%***********************]  1 of 1 completed
[*********************100%***********************]  1 of 1 completed
    ticker                                 name currency  \
0      dis                       Walt Disney Co      USD
1       gm                    General Motors Co      USD
8      aal          American Airlines Group Inc      USD
12    aapl                            Apple Inc      USD
163   ebay                             eBay Inc      USD
170   meta                  Meta Platforms Inc      USD
196   sbux                       Starbucks Corp      USD
201   pypl                  PayPal Holdings Inc      USD
```

212	tsla	Tesla Inc	USD	
215	tmus	T-Mobile US Inc	USD	
216	ual	United Airlines Holdings Inc	USD	
231	abbv	Abbvie Inc	USD	
256	are	Alexandria Real Estate Equities Inc	USD	
261	bac	Bank of America Corp	USD	
263	bbwi	Bath & Body Works Inc	USD	
264	bdx	Becton Dickinson and Co	USD	
271	bro	Brown & Brown Inc	USD	
289	cmg	Chipotle Mexican Grill Inc	USD	
295	duk	Duke Energy Corp	USD	
306	gs	Goldman Sachs Group Inc	USD	
333	mro	Marathon Oil Corp	USD	
399	tgt	Target Corp	USD	
445	crm	Salesforce Inc	USD	

	exchange	industry	\
0	NEW YORK STOCK EXCHANGE, INC.	Media	
1	NEW YORK STOCK EXCHANGE, INC.	Automobiles	
8	NASDAQ NMS - GLOBAL MARKET	Airlines	
12	NASDAQ NMS - GLOBAL MARKET	Technology	
163	NASDAQ NMS - GLOBAL MARKET	Retail	
170	NASDAQ NMS - GLOBAL MARKET	Media	
196	NASDAQ NMS - GLOBAL MARKET	Hotels Restaurants and Leisure	
201	NASDAQ NMS - GLOBAL MARKET	Technology	
212	NASDAQ NMS - GLOBAL MARKET	Automobiles	
215	NASDAQ NMS - GLOBAL MARKET	Telecommunication	
216	NASDAQ NMS - GLOBAL MARKET	Airlines	
231	NEW YORK STOCK EXCHANGE, INC.	Biotechnology	
256	NEW YORK STOCK EXCHANGE, INC.	Real Estate	
261	NEW YORK STOCK EXCHANGE, INC.	Banking	
263	NEW YORK STOCK EXCHANGE, INC.	Retail	
264	NEW YORK STOCK EXCHANGE, INC.	Health Care	
271	NEW YORK STOCK EXCHANGE, INC.	Insurance	
289	NEW YORK STOCK EXCHANGE, INC.	Hotels Restaurants and Leisure	
295	NEW YORK STOCK EXCHANGE, INC.	Utilities	
306	NEW YORK STOCK EXCHANGE, INC.	Financial Services	
333	NEW YORK STOCK EXCHANGE, INC.	Energy	
399	NEW YORK STOCK EXCHANGE, INC.	Retail	
445	NEW YORK STOCK EXCHANGE, INC.	Technology	

	logo
0	https://static.finnhub.io/logo/ef50b4a2b263c84...
1	https://static.finnhub.io/logo/9253db78-80c9-1...
8	https://static2.finnhub.io/file/publicdatany/f...
12	https://static.finnhub.io/logo/87cb30d8-80df-1...
163	https://static.finnhub.io/logo/919a6270-826a-1...
170	https://static2.finnhub.io/file/publicdatany/f...
196	https://static.finnhub.io/logo/8d4c97ac-80e0-1...
201	https://static.finnhub.io/logo/58e310c0-80d2-1...
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215	https://static.finnhub.io/logo/4ffaa8b8-80ec-1...
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231	https://static.finnhub.io/logo/8806d72c-80cd-1...
256	https://static.finnhub.io/logo/ffde2ccf9a1b68d...
261	https://static2.finnhub.io/file/publicdatany/f...
263	https://static.finnhub.io/logo/1b846d4a-80ec-1...
264	https://static.finnhub.io/logo/82e1f20c-80eb-1...
271	https://static.finnhub.io/logo/8d4bb0d8-80eb-1...
289	https://static.finnhub.io/logo/a551a6c2-80eb-1...
295	https://static.finnhub.io/logo/c6386312-80eb-1...
306	https://static.finnhub.io/logo/7ba3bd9e8fc91f9...
333	https://static.finnhub.io/logo/2f57969a-80ec-1...
399	https://static.finnhub.io/logo/83bbf858-80ec-1...
445	https://static.finnhub.io/logo/5a800a68f67c85e...

	weburl	environment_grade
0	https://thewaltdisneycompany.com/	A
1	https://www.gm.com/	A
8	https://americanairlines.gcs-web.com/	B
12	https://www.apple.com/	BB
163	https://www.ebayinc.com/	A
170	https://www.facebook.com	B
196	https://www.starbucks.com/	BBB
201	https://www.paypal.com/	BB
212	https://www.tesla.com/	A
215	https://www.t-mobile.com/	BB
216	https://ir.united.com/	B
231	https://www.abbvie.com/	A
256	https://www.are.com/	AA

```
261          https://www.bankofamerica.com                B
263               https://www.bbwinc.com/                 A
264                   https://www.bd.com/                AA
271           https://www.bbinsurance.com/               BBB
289              https://www.chipotle.com/                B
295           https://www.duke-energy.com/               AA
306          https://www.goldmansachs.com/                A
333           https://www.marathonoil.com/                A
399          https://corporate.target.com/                A
445            https://www.salesforce.com/                B

    environment_level social_grade  ... social_score governance_score  \
0                High           BB  ...          316              321
1                High           BB  ...          303              255
8              Medium            B  ...          211              265
12             Medium            B  ...          281              255
163              High           BB  ...          302              305
170            Medium            B  ...          232              215
196              High           BB  ...          385              295
201            Medium            B  ...          244              285
212              High          CCC  ...          160              278
215            Medium           BB  ...          331              230
216            Medium            B  ...          203              221
231              High           BB  ...          317              300
256         Excellent           BB  ...          337              345
261            Medium           BB  ...          394              265
263              High           BB  ...          303              300
264         Excellent           BB  ...          384              315
271              High           BB  ...          320              300
289            Medium            B  ...          241              213
295         Excellent           BB  ...          362              328
306              High           BB  ...          305              305
333              High           BB  ...          313              305
399              High           BB  ...          342              313
445            Medium            B  ...          241              200

    total_score  last_processing_date  total_grade  total_level      cik  \
0          1147            19-04-2022          BBB         High  1744489
1          1068            17-04-2022          BBB         High  1467858
8           746            16-04-2022            B       Medium     6201
```

12	891	16-04-2022	BB	Medium	320193
163	1107	17-04-2022	BBB	High	1065088
170	652	22-04-2022	B	Medium	1326801
196	1155	19-04-2022	BBB	High	829224
201	899	18-04-2022	BB	Medium	1633917
212	993	19-04-2022	BBB	High	1318605
215	903	19-04-2022	BBB	High	1283699
216	629	19-04-2022	B	Medium	100517
231	1122	16-04-2022	BBB	High	1551152
256	1282	16-04-2022	A	High	1035443
261	879	16-04-2022	BB	Medium	70858
263	1128	11-06-2022	BBB	High	701985
264	1306	16-04-2022	A	High	10795
271	1025	16-04-2022	BBB	High	79282
289	664	16-04-2022	B	Medium	1058090
295	1294	17-04-2022	A	High	1326160
306	1135	17-04-2022	BBB	High	886982
333	1148	21-04-2022	BBB	High	101778
399	1205	19-04-2022	A	High	27419
445	656	19-04-2022	B	Medium	1108524

	Start Price	End Price	Rate of Change (%)
0	187.491135	136.086594	-27.417052
1	56.471729	42.734833	-24.325263
8	23.860001	18.25	-23.512156
12	120.588425	172.203995	42.803088
163	59.152027	54.319157	-8.170253
170	297.763458	221.692505	-25.547444
196	101.377022	85.777168	-15.387958
201	247.539993	115.650002	-53.280276
212	220.583328	359.200012	62.840961
215	125.69912	126.388428	0.548379
216	57.82	46.360001	-19.82013
231	93.50222	146.184769	56.343634
256	149.982285	181.9478	21.312861
261	36.186047	38.49548	6.382109
263	46.90102	45.340763	-3.326702
264	223.961151	249.956436	11.607051
271	45.428921	71.043533	56.383934
289	28.769199	31.6406	9.980816

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295   83.651123  100.818703          20.522832
306  299.524689   307.67276           2.720334
333    11.18561   24.169741         116.078882
399  184.384384  197.776855           7.263344
445  217.753311  211.381607          -2.926111

[23 rows x 24 columns]
```

In [210…

```python
#Add Start Price, End Price, and Rate of Change (%) of each company to the dataset esg
esg.loc[:, 'ticker'] = esg['ticker'].astype(str)
esg.loc[:, 'name'] = esg['name'].astype(str)
tickers = esg['ticker'].tolist()

# Add columns for Start Price, End Price, and Rate of Change (%)
esg['Start Price'] = None
esg['End Price'] = None
esg['Rate of Change (%)'] = None

# Loop through each row of the DataFrame to get stock information for each company
for index, row in esg.iterrows():
    ticker = row['ticker']

    # Skip rows where the ticker is not valid
    if ticker == 'nan' or ticker.strip() == "":
        continue

    # Download stock data for the given ticker
    data = yf.download(ticker, start='2021-04-01', end='2022-04-01')

    # Ensure data exists for the given period
    if not data.empty:
        start_price = data['Adj Close'].iloc[0]
        end_price = data['Adj Close'].iloc[-1]
        rate_of_change = ((end_price - start_price) / start_price) * 100

        # Add the stock data to the relevant columns in the DataFrame
        esg.loc[index, 'Start Price'] = start_price
        esg.loc[index, 'End Price'] = end_price
        esg.loc[index, 'Rate of Change (%)'] = rate_of_change
```

```python
#Remove companies with missing value on stock information:
esg.dropna(subset=['Start Price', 'End Price', 'Rate of Change (%)'], inplace=True)

#show the first 15 rows of cleaned esg
print(esg.iloc[0:15,:])
```

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	ticker	name	currency	\
0	dis	Walt Disney Co	USD	
1	gm	General Motors Co	USD	
2	gww	WW Grainger Inc	USD	
3	mhk	Mohawk Industries Inc	USD	
4	lyv	Live Nation Entertainment Inc	USD	
5	lvs	Las Vegas Sands Corp	USD	
6	clx	Clorox Co	USD	

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7    aacg          ATA Creativity Global      CNY
8     aal    American Airlines Group Inc      USD
9    aame         Atlantic American Corp      USD
10   aaoi    Applied Optoelectronics Inc      USD
11   aaon                      Aaon Inc      USD
12   aapl                     Apple Inc      USD
13   aatc    Autoscope Technologies Corp      USD
15   aaci      Armada Acquisition Corp I      USD

                        exchange                            industry  \
0   NEW YORK STOCK EXCHANGE, INC.                               Media
1   NEW YORK STOCK EXCHANGE, INC.                           Automobiles
2   NEW YORK STOCK EXCHANGE, INC.  Trading Companies and Distributors
3   NEW YORK STOCK EXCHANGE, INC.                   Consumer products
4   NEW YORK STOCK EXCHANGE, INC.                               Media
5   NEW YORK STOCK EXCHANGE, INC.      Hotels Restaurants and Leisure
6   NEW YORK STOCK EXCHANGE, INC.                   Consumer products
7      NASDAQ NMS - GLOBAL MARKET       Diversified Consumer Services
8      NASDAQ NMS - GLOBAL MARKET                            Airlines
9      NASDAQ NMS - GLOBAL MARKET                           Insurance
10     NASDAQ NMS - GLOBAL MARKET                      Communications
11     NASDAQ NMS - GLOBAL MARKET                            Building
12     NASDAQ NMS - GLOBAL MARKET                          Technology
13     NASDAQ NMS - GLOBAL MARKET               Electrical Equipment
15     NASDAQ NMS - GLOBAL MARKET                                NaN

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0          https://thewaltdisneycompany.com/                 A
1                       https://www.gm.com/                  A
2                  https://www.grainger.com/                 B
3                     https://mohawkind.com/                 A
4   https://www.livenationentertainment.com/                BBB
5                     https://www.sands.com/                 A
6          https://www.thecloroxcompany.com/                 A
7                      http://www.ata.net.cn                 B
8      https://americanairlines.gcs-web.com/                 B
9                      http://www.atlam.com/                 B
10                        http://ao-inc.com/                BB
11                     https://www.aaon.com/                 A
12                    https://www.apple.com/                BB
13                                       NaN                BBB
15                                       NaN                 B

   environment_level social_grade  ... social_score governance_score  \
0               High           BB  ...          316              321
1               High           BB  ...          303              255
2             Medium           BB  ...          385              240
3               High            B  ...          298              303
4               High           BB  ...          310              250
5               High           BB  ...          318              313
6               High           BB  ...          350              345
7             Medium            B  ...          200              205
8             Medium            B  ...          211              265
9             Medium            B  ...          221              300
10            Medium            B  ...          256              218
11              High           BB  ...          300              223
12            Medium            B  ...          281              255
13              High            B  ...          286              240
15            Medium            B  ...          200              200

   total_score  last_processing_date  total_grade  total_level      cik  \
0         1147            19-04-2022          BBB         High  1744489
1         1068            17-04-2022          BBB         High  1467858
```

```
2          880            19-04-2022           BB       Medium   277135
3         1171            18-04-2022          BBB         High   851968
4         1052            18-04-2022          BBB         High  1335258
5         1178            18-04-2022          BBB         High  1300514
6         1255            16-04-2022            A         High    21076
7          608            01-07-2022            B       Medium  1420529
8          746            16-04-2022            B       Medium     6201
9          741            16-04-2022            B       Medium     8177
10         785            16-04-2022           BB       Medium  1158114
11        1023            16-04-2022          BBB         High   824142
12         891            16-04-2022           BB       Medium   320193
13         936            11-06-2022          BBB         High   943034
15         605            20-06-2022            B       Medium  1844817

   Start Price   End Price Rate of Change (%)
0   187.491135  136.086594         -27.417052
1    56.471729   42.734833         -24.325263
2   390.305511  502.428802          28.727058
3   198.279999  124.199997         -37.361308
4        88.07  117.639999          33.575565
5    60.558395   38.058285         -37.154404
6   173.071594  128.059479         -26.007801
7         4.19        1.48         -64.677804
8    23.860001       18.25         -23.512156
9     3.879058    3.051214         -21.341387
10        8.82        3.65         -58.616778
11   46.315861   36.614571         -20.945935
12  120.588425  172.203995          42.803088
13    3.047645    4.370698          43.412329
15        9.75        9.82           0.717946

[15 rows x 24 columns]
```

In [211…

```python
#Extract S&P 500 rate
sp500_data = yf.download('^GSPC', start='2021-04-01',end='2022-04-01')
sp500_df = pd.DataFrame({
    'Date': sp500_data.index,
    'Start Price': sp500_data['Open'],
    'End Price': sp500_data['Close'],
    'Rate of Change (%)': ((sp500_data['Close'] - sp500_data['Open']) / sp500_data['Open']) * 100
```

```
})

sp500_df.set_index('Date', inplace=True)
print(sp500_df)
```

```
[**********************100%**********************]  1 of 1 completed
            Start Price    End Price  Rate of Change (%)
Date
2021-04-01  3992.780029  4019.870117            0.678477
2021-04-05  4034.439941  4077.909912            1.077472
2021-04-06  4075.570068  4073.939941           -0.039998
2021-04-07  4074.290039  4079.949951            0.138918
2021-04-08  4089.949951  4097.169922            0.176530
...                 ...          ...                 ...
2022-03-25  4522.910156  4543.060059            0.445507
2022-03-28  4541.089844  4575.520020            0.758192
2022-03-29  4602.859863  4631.600098            0.624400
2022-03-30  4624.200195  4602.450195           -0.470352
2022-03-31  4599.020020  4530.410156           -1.491837

[253 rows x 3 columns]
```

Data Description

We have two main datasets for our analysis-ready data.

We are using data from a Kaggle csv, and joining this to the yfinance library. First, we downloaded the ESG Kaggle csv, where each row corresponds to a different publicly traded company; this also contains ESG metrics for each company. We have filtered this dataset to only include companies that are traded in USD, and the columns all refer to a specific aspect of the company, such as industry, name, stock close/open/high/low prices, and ESG rating indexes. Then, we join this data to the yfinance library (Yahoo Finance) - from yfinance, we take the stock closing price of the company on 4/1/21 and 4/1/22. We also created a % Change variable, which measures the percentage change in the company stock closing price over the 2 years. All of this information is included in our large dataset - so the columns are company stock ticker, company name, currency, exchange, industry, logo, web url, environment grade, environment level, social grade, governance grade, governance level, environmental score, social score, governance score, total score, last processing date, total grade, total

level, central index key, stock closing price in 4/1/21, stock closing price in 4/1/22, and the percent change between these. Our smaller dataset is meant to be a 'sample' of the original dataset with 722 rows, and involves a few companies that we hand-picked by notability. It contains all of the same columns, but only contains 23 companies.

Our dataframes were created to show different stock prices of various companies over different date ranges, and the original ESG company data was created to compile ESG information for 700 mid / large-cap companies across various industries. Our combined dataframes was made to contrast both stock prices and ESG ratings of companies, and explore any associations. The original ESG company dataset was 'funded' by the efforts of Kaggle user Alistair King, and the yfinance dataset was created by Ran Aroussi as a way around the recent-ish Yahoo Finance API deprecation. For the ESG rating dataset, only mid/large-cap companies are included, so this influences the specific companies that are present in the dataset (the data that was observed and recorded) -- smaller companies will not be 'observed' here.

The preprocessing was described above; we filtered our 722 row dataset for NaNs for our large dataset, and then for our sample dataset, we filtered all 722 companies down to 23 of interest, and joined all data to the yfinance library. Specifically, for each company, we acquired the stock closing price for 4/1/21 and 4/1/24, then created a stock change percentage variable between these two dates.

Individuals are not involved in the data directly, as each observation corresponds to an entire company.

Our raw source data can be found in the yfinance library and https://www.kaggle.com/datasets/alistairking/public-company-esg-ratings-dataset/data, and the specific csv is here: https://github.com/phoebewang28/info-2950-project/blob/main/esg_data.csv.

Data Limitations

1. For our smaller dataset, the current sample of 23 companies was chosen manually by us as we wanted to get a range of industries that are well-known. This is limited to the companies that only use USD, and again, this data only records large/mid-cap companies, so this selection may not be fully representative of all US companies with ESG ratings. Depending on the results of of our analyses, we may consider random sampling or expanding the sample size to improve representativeness of our sample dataset.

2. We are currently comparing the rate of change of the sample stocks to the S&P 500, but other measures of stock

performance might provide more valuable insights. For now, we are focusing on the rate of change between the closing prices of 4/1/21 and 4/1/22.

3. Some stock data from yfinance is missing date information, which causes missing values when extracting prices. One company in our sample had this issue, so we had to exclude it to ensure consistency.

4. Since we are exploring potential connections between ESG ratings and company stock performance, we may need to sample not only by industry but also by ESG rating levels to ensure a more balanced and comprehensive analysis of the different ESG performance tiers (for our sample dataset)

5. ESG is a constent value retrieved from different days for each company in the month of April, 2022, while stock prices for these companies changes over time. We're unable to perform time-series analysis on ESG rating and stock informations due to the fact.

6. ESG is evaluated annually, which might not be accuratly tracking the actual environmental performance of the company. Thus, when considering short-term impact of the company's esg policies, it's likely for that policy change to affect stock but not reflected on company's ESG rating.

Exploratory Data Analysis

part one - exploring different average environmental, social, governance, and total ESG scores by industry

In [212…

```
average_total_score_by_industry = esg.groupby('industry')['total_score'].mean().reset_index()
average_total_score_by_industry.columns = ['Industry', 'Average Total ESG Score']
print(average_total_score_by_industry.head(5))

avg_totals = average_total_score_by_industry.sort_values(by = 'Average Total ESG Score', ascending = Fals
print("best average ESG scores")
print(avg_totals.head(5))

average_total_score_by_industry = average_total_score_by_industry.sort_values(by = 'Average Total ESG Sc
print("worst average ESG scores")
```

```
print(average_total_score_by_industry.head(5))
```

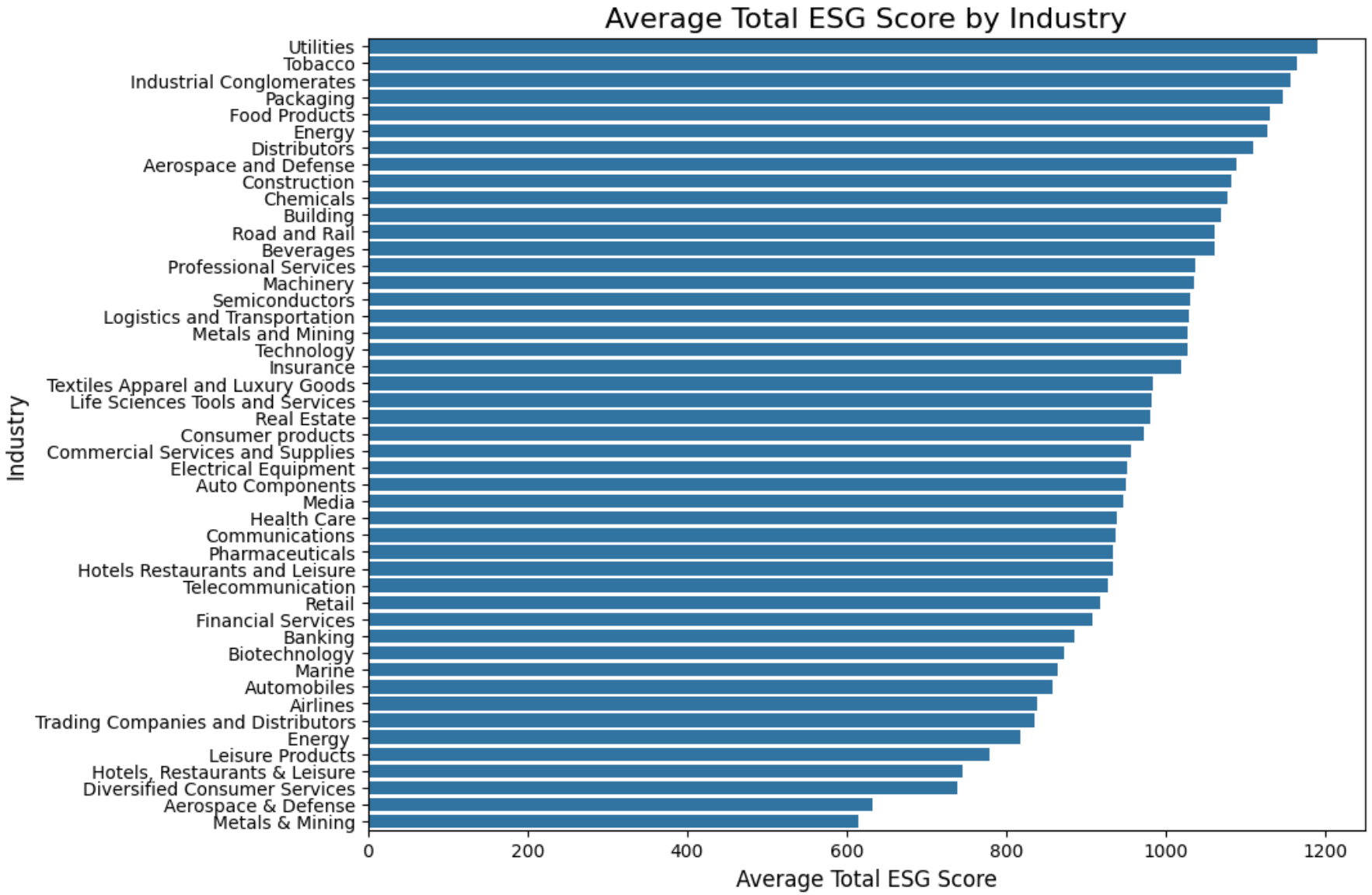
```
                Industry  Average Total ESG Score
0    Aerospace & Defense                633.000000
1  Aerospace and Defense               1089.700000
2               Airlines                838.714286
3        Auto Components                950.000000
4            Automobiles                859.250000
best average ESG scores
                    Industry  Average Total ESG Score
46                 Utilities              1190.633333
44                   Tobacco              1165.000000
24  Industrial Conglomerates              1157.000000
34                 Packaging              1146.666667
20             Food Products              1131.071429
worst average ESG scores
                         Industry  Average Total ESG Score
32                Metals & Mining               615.000000
0              Aerospace & Defense               633.000000
15  Diversified Consumer Services               739.333333
23  Hotels, Restaurants & Leisure               746.000000
26                Leisure Products               780.000000
```

In [213…

```
# Bar chart of Toatl ESG score by Industry
average_total_score_by_industry = average_total_score_by_industry.sort_values('Average Total ESG Score',

# Create the horizontal bar chart
plt.figure(figsize=(10, 8))
sns.barplot(x='Average Total ESG Score', y='Industry', data=average_total_score_by_industry)

# Add labels and title
plt.title('Average Total ESG Score by Industry', fontsize=16)
plt.xlabel('Average Total ESG Score', fontsize=12)
plt.ylabel('Industry', fontsize=12)
```

Out[213…

```
Text(0, 0.5, 'Industry')
```



interestingly (and somewhat predictably) - the industries with the lowest ESG scores are Metals & Mining, Aerospace & Defense, Diversified Consumer Services, Hotels, Restaurants & Leisure, Leisure Products, Auto Components, Airlines, and Automobiles. the industries with the highest ESG scores are Utilities, Tobacco, Industrial Conglomerates, Packaging, and Energy.

future steps: sort different industries by just Environmental score, just Social score, and just Governance score to see if

these differ significantly.

In [214…
```
print(esg.columns)
```

```
Index(['ticker', 'name', 'currency', 'exchange', 'industry', 'logo', 'weburl',
       'environment_grade', 'environment_level', 'social_grade',
       'social_level', 'governance_grade', 'governance_level',
       'environment_score', 'social_score', 'governance_score', 'total_score',
       'last_processing_date', 'total_grade', 'total_level', 'cik',
       'Start Price', 'End Price', 'Rate of Change (%)'],
      dtype='object')
```

In [215…
```
avg_environmental = esg.groupby('industry')['environment_score'].mean().reset_index()
avg_environmental.columns = ['Industry', 'Average Environmental Score']
print(avg_environmental.head(5))

avg_enviro = avg_environmental.sort_values(by = 'Average Environmental Score', ascending = False)
print("best environmental scores")
print(avg_enviro.head(5))

avg_enviro = avg_environmental.sort_values(by = 'Average Environmental Score', ascending = True)
print("worse environmental scores")
print(avg_enviro.head(5))
```

```
                Industry  Average Environmental Score
0    Aerospace & Defense                    225.000000
1  Aerospace and Defense                    485.000000
2               Airlines                    326.714286
3        Auto Components                    407.500000
4            Automobiles                    393.000000
best environmental scores
                    Industry  Average Environmental Score
46                 Utilities                    550.966667
24  Industrial Conglomerates                    534.666667
34                 Packaging                    530.000000
14              Distributors                    525.000000
17                    Energy                    516.611111
worse environmental scores
                         Industry  Average Environmental Score
32                Metals & Mining                    215.000000
0              Aerospace & Defense                    225.000000
26                Leisure Products                    252.333333
23  Hotels, Restaurants & Leisure                    270.000000
15  Diversified Consumer Services                    286.000000
```

In [216…

```python
avg_social = esg.groupby('industry')['social_score'].mean().reset_index()
avg_social.columns = ['Industry', 'Average Social Score']
print(avg_social.head(5))

avg_social = avg_social.sort_values(by = 'Average Social Score', ascending = False)
print("best social scores")
print(avg_social.head(5))

avg_social = avg_social.sort_values(by = 'Average Social Score', ascending = True)
print("worse social scores")
print(avg_social.head(5))
```

```
                Industry  Average Social Score
0    Aerospace & Defense            203.000000
1  Aerospace and Defense            305.700000
2               Airlines            265.714286
3        Auto Components            272.500000
4            Automobiles            229.250000
best social scores
                    Industry  Average Social Score
46                 Utilities            357.400000
39             Road and Rail            329.400000
44                   Tobacco            327.000000
34                 Packaging            322.666667
24  Industrial Conglomerates            318.000000
worse social scores
                         Industry  Average Social Score
32               Metals & Mining            200.000000
0             Aerospace & Defense            203.000000
4                     Automobiles            229.250000
15  Diversified Consumer Services            233.333333
23  Hotels, Restaurants & Leisure            248.500000
```

In [217…

```python
avg_governance = esg.groupby('industry')['governance_score'].mean().reset_index()
avg_governance.columns = ['Industry', 'Average Governance Score']
print(avg_governance.head(5))

avg_governance = avg_governance.sort_values(by = 'Average Governance Score', ascending = False)
print("best governance scores")
print(avg_governance.head(5))

avg_governance = avg_governance.sort_values(by = 'Average Governance Score', ascending = True)
print("worse governance scores")
print(avg_governance.head(5))
```

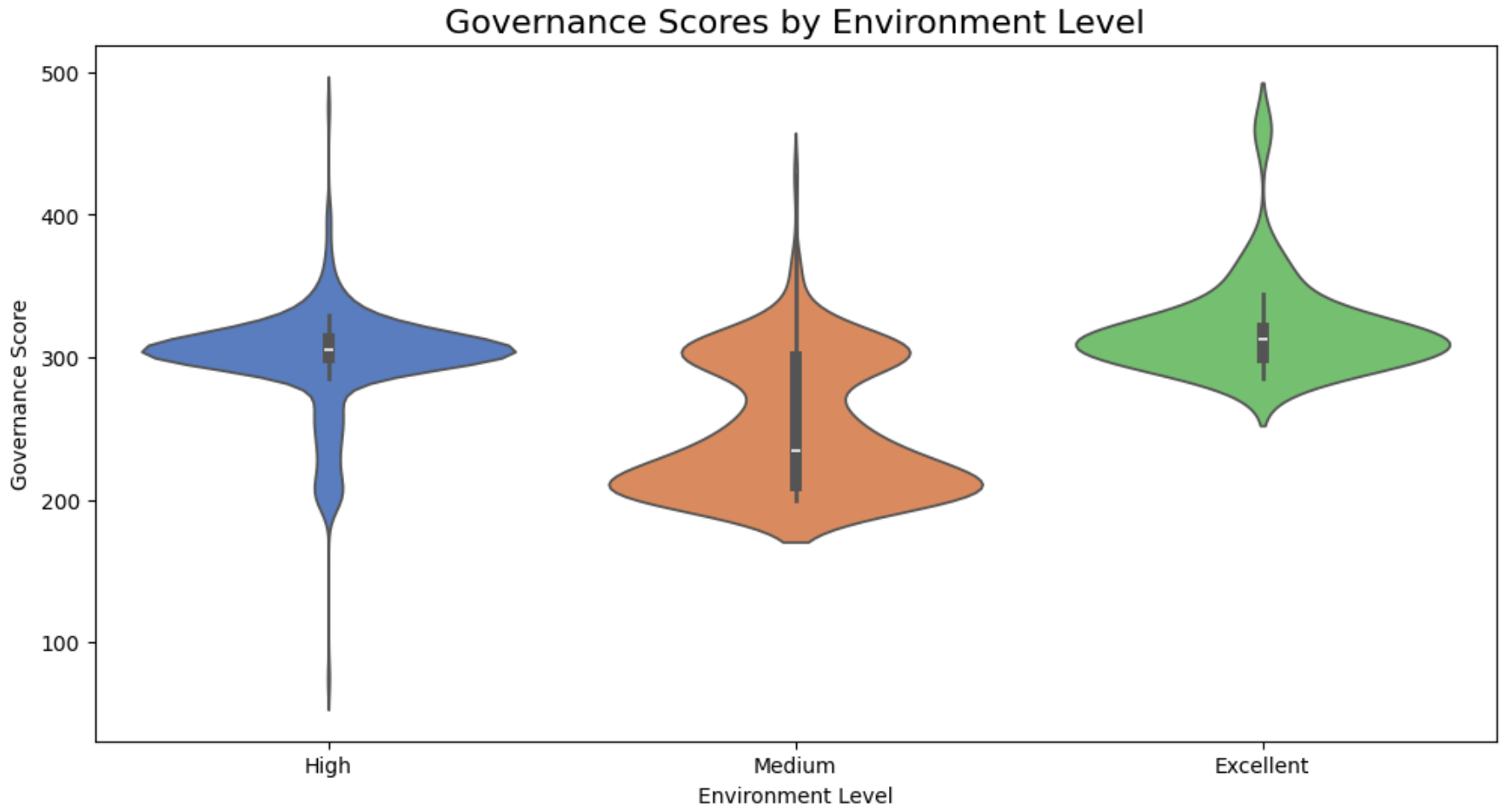
```
                Industry  Average Governance Score
0    Aerospace & Defense                 205.000000
1  Aerospace and Defense                 299.000000
2              Airlines                  246.285714
3        Auto Components                 270.000000
4            Automobiles                 237.000000
best governance scores
                    Industry  Average Governance Score
44                   Tobacco                 328.000000
14              Distributors                 307.666667
24  Industrial Conglomerates                 304.333333
20             Food Products                 303.214286
36     Professional Services                 300.500000
worse governance scores
                         Industry  Average Governance Score
32               Metals & Mining                       200.0
0             Aerospace & Defense                      205.0
15  Diversified Consumer Services                      220.0
23  Hotels, Restaurants & Leisure                      227.5
4                     Automobiles                      237.0
```

part two

In [218…

```
#Violin Plot: Governance Score by Environment Level
plt.figure(figsize=(12, 6))
sns.violinplot(data=esg, x='environment_level', y='governance_score', palette='muted')
plt.title('Governance Scores by Environment Level', fontsize=16)
plt.xlabel('Environment Level')
plt.ylabel('Governance Score')
plt.show()
```

```
/var/folders/j2/kdbytjmd57914f_8rxw949240000gn/T/ipykernel_30230/2624109517.py:3: FutureWarning:

Passing `palette` without assigning `hue` is deprecated and will be removed in v0.14.0. Assign the `x` va
riable to `hue` and set `legend=False` for the same effect.

  sns.violinplot(data=esg, x='environment_level', y='governance_score', palette='muted')
```

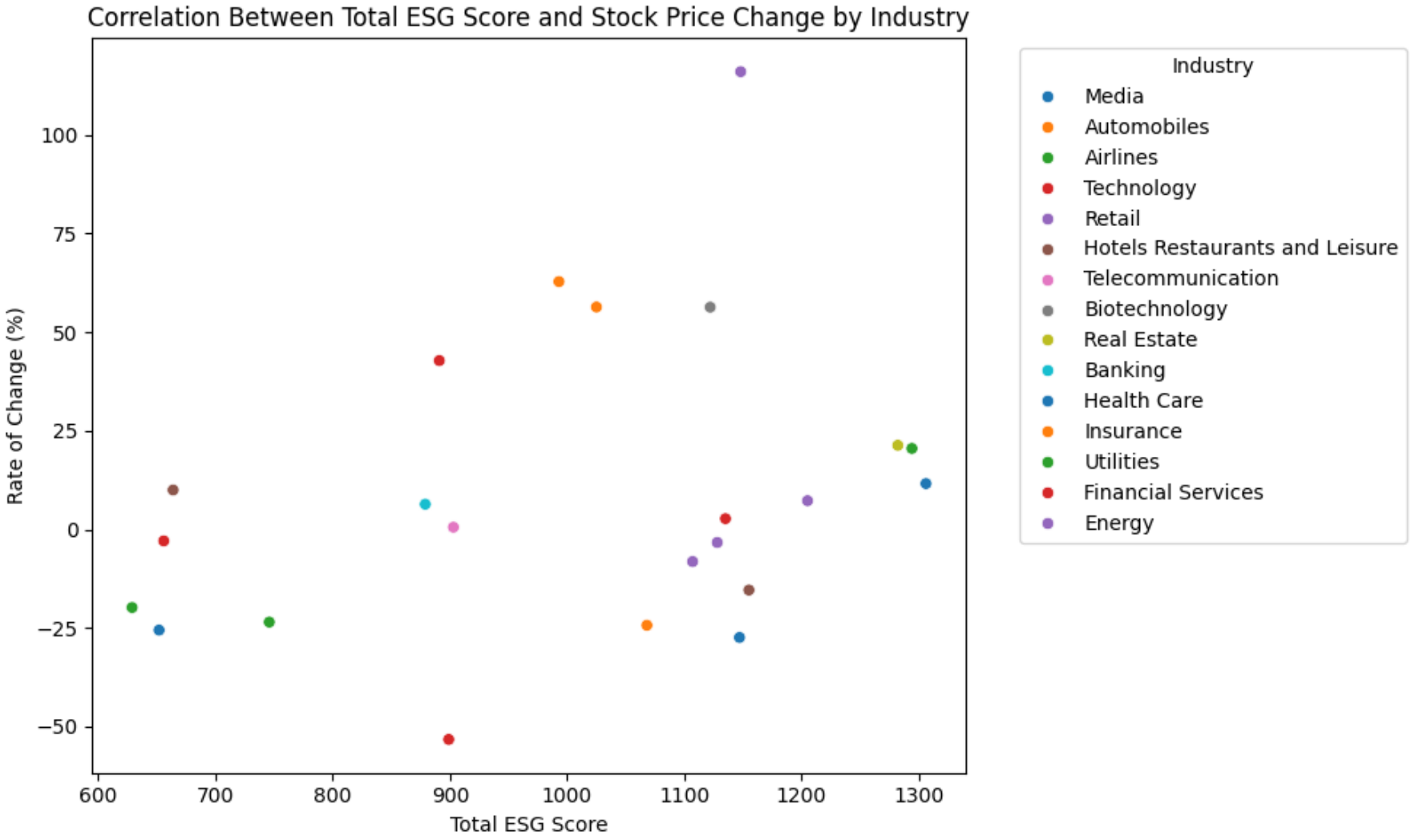


In [219…

```
#violin graph
print(relevant_esg.columns)
correlation = relevant_esg['total_score'].corr(relevant_esg['Rate of Change (%)'])
print(f'Correlation between Total ESG Score and Rate of Change (%): {correlation}')

plt.figure(figsize=(10, 6))
sns.scatterplot(data=relevant_esg, x='total_score', y='Rate of Change (%)', hue='industry', palette='tab1
plt.title('Correlation Between Total ESG Score and Stock Price Change by Industry')
plt.xlabel('Total ESG Score')
plt.ylabel('Rate of Change (%)')
plt.legend(title='Industry', bbox_to_anchor=(1.05, 1), loc='upper left')
plt.tight_layout()
```

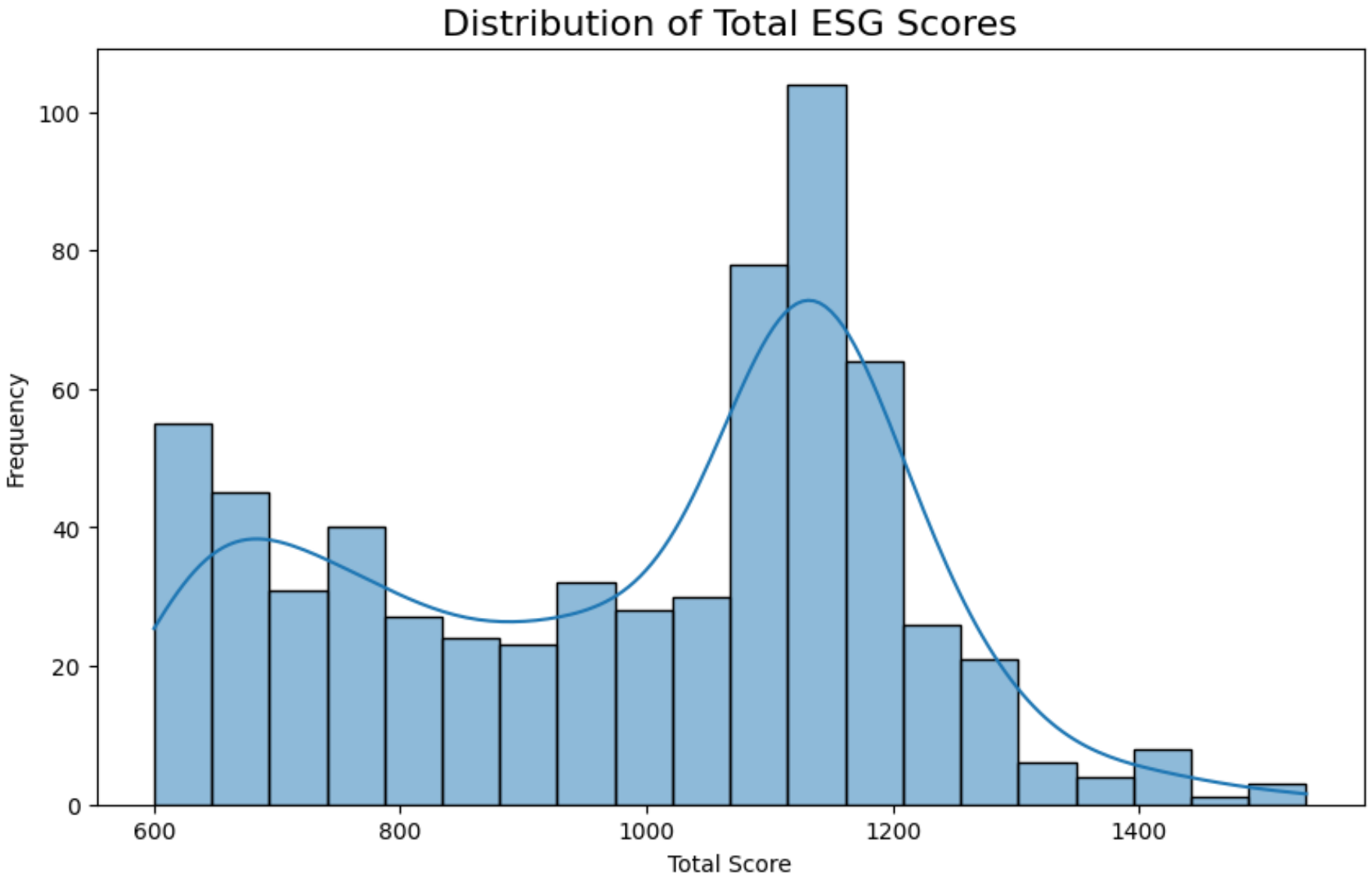
```
plt.show()
```

```
Index(['ticker', 'name', 'currency', 'exchange', 'industry', 'logo', 'weburl',
       'environment_grade', 'environment_level', 'social_grade',
       'social_level', 'governance_grade', 'governance_level',
       'environment_score', 'social_score', 'governance_score', 'total_score',
       'last_processing_date', 'total_grade', 'total_level', 'cik',
       'Start Price', 'End Price', 'Rate of Change (%)'],
      dtype='object')
Correlation between Total ESG Score and Rate of Change (%): 0.2933148427717424
```



In [220…

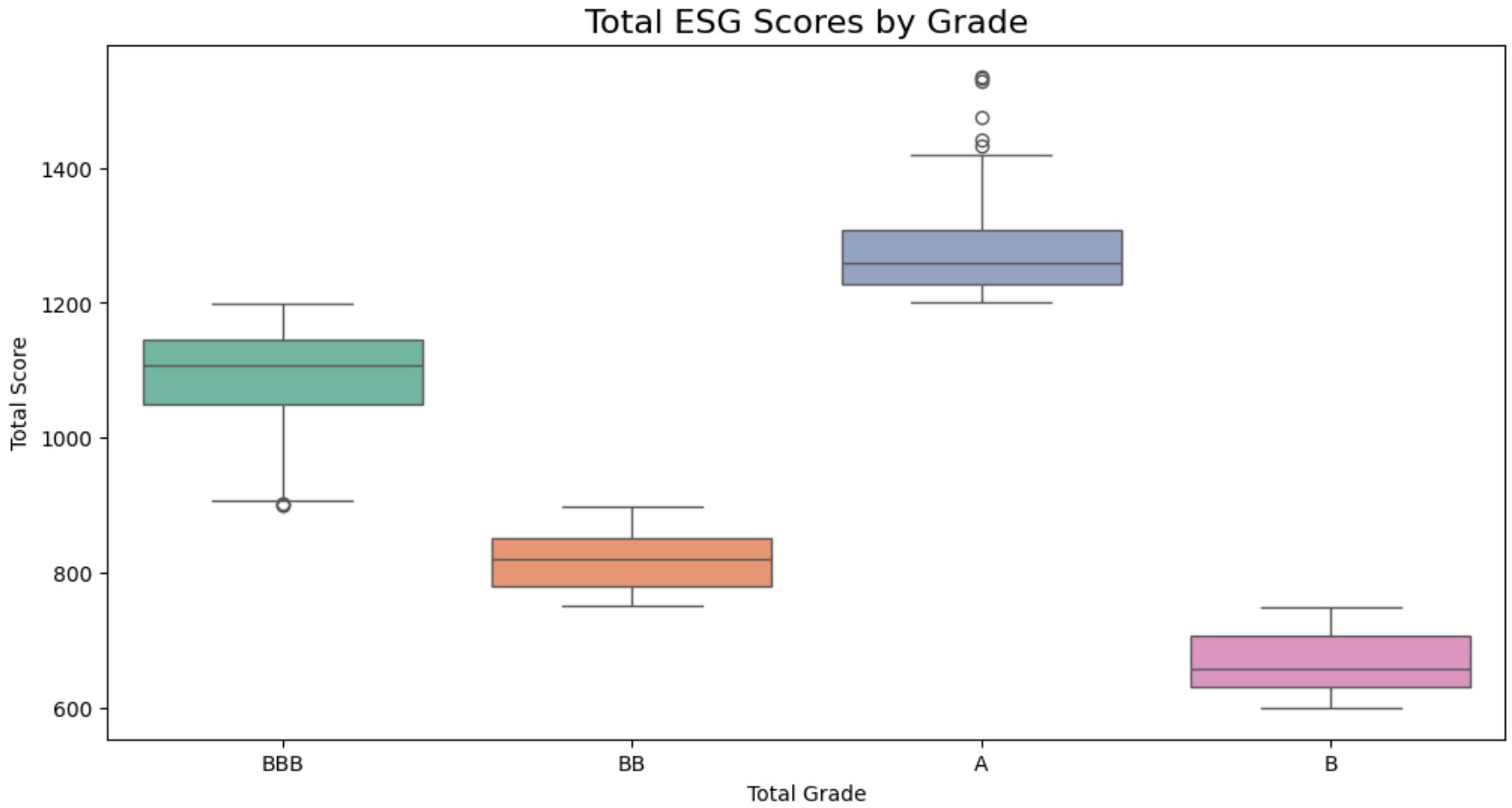
```
# Plot the distribution of total_score
plt.figure(figsize=(10, 6))
sns.histplot(esg['total_score'], kde=True, bins=20)
plt.title('Distribution of Total ESG Scores', fontsize=16)
plt.xlabel('Total Score')
plt.ylabel('Frequency')
plt.show()
```



In [221…

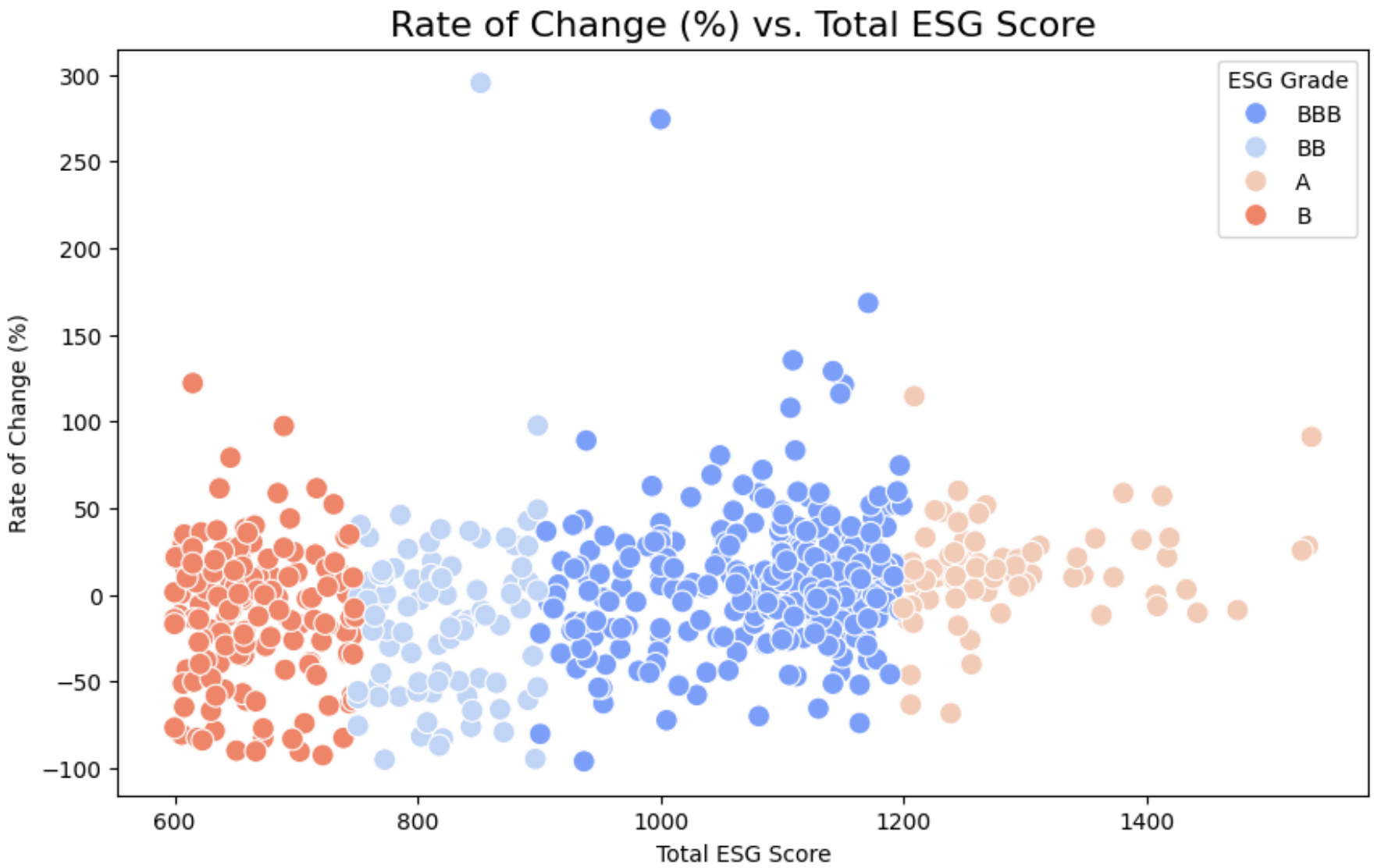
```
#Boxplot of Total Scores by Total Grade
plt.figure(figsize=(12, 6))
sns.boxplot(data=esg, x='total_grade', y='total_score', palette='Set2')
plt.title('Total ESG Scores by Grade', fontsize=16)
plt.xlabel('Total Grade')
plt.ylabel('Total Score')
plt.show()
```

```
/var/folders/j2/kdbytjmd57914f_8rxw949240000gn/T/ipykernel_30230/3588776245.py:3: FutureWarning:

Passing `palette` without assigning `hue` is deprecated and will be removed in v0.14.0. Assign the `x` va
riable to `hue` and set `legend=False` for the same effect.

  sns.boxplot(data=esg, x='total_grade', y='total_score', palette='Set2')
```



In [222…

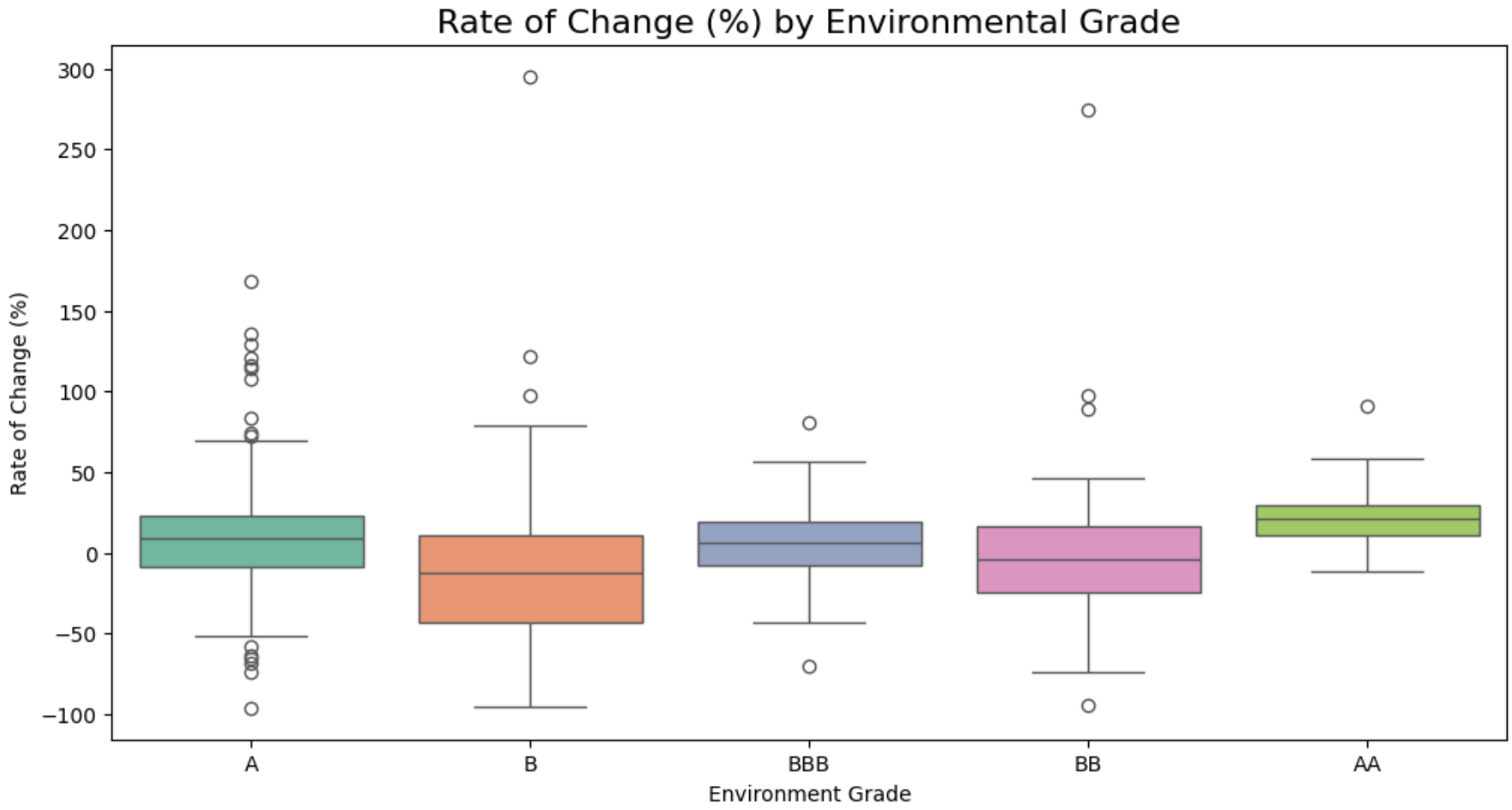
```
#Scatter Plot: Rate of Change vs. Total ESG Score
plt.figure(figsize=(10, 6))
sns.scatterplot(data=esg, x='total_score', y='Rate of Change (%)', hue='total_grade', palette='coolwarm',
plt.title('Rate of Change (%) vs. Total ESG Score', fontsize=16)
plt.xlabel('Total ESG Score')
plt.ylabel('Rate of Change (%)')
plt.legend(title="ESG Grade", loc='upper right')
plt.show()
```



In [223…

```
#Boxplot: Rate of Change by Environment Grade
plt.figure(figsize=(12, 6))
sns.boxplot(data=esg, x='environment_grade', y='Rate of Change (%)', palette='Set2')
plt.title('Rate of Change (%) by Environmental Grade', fontsize=16)
plt.xlabel('Environment Grade')
plt.ylabel('Rate of Change (%)')
plt.show()
```

```
/var/folders/j2/kdbytjmd57914f_8rxw949240000gn/T/ipykernel_30230/3614906153.py:3: FutureWarning:

Passing `palette` without assigning `hue` is deprecated and will be removed in v0.14.0. Assign the `x` va
riable to `hue` and set `legend=False` for the same effect.

  sns.boxplot(data=esg, x='environment_grade', y='Rate of Change (%)', palette='Set2')
```



In [224…

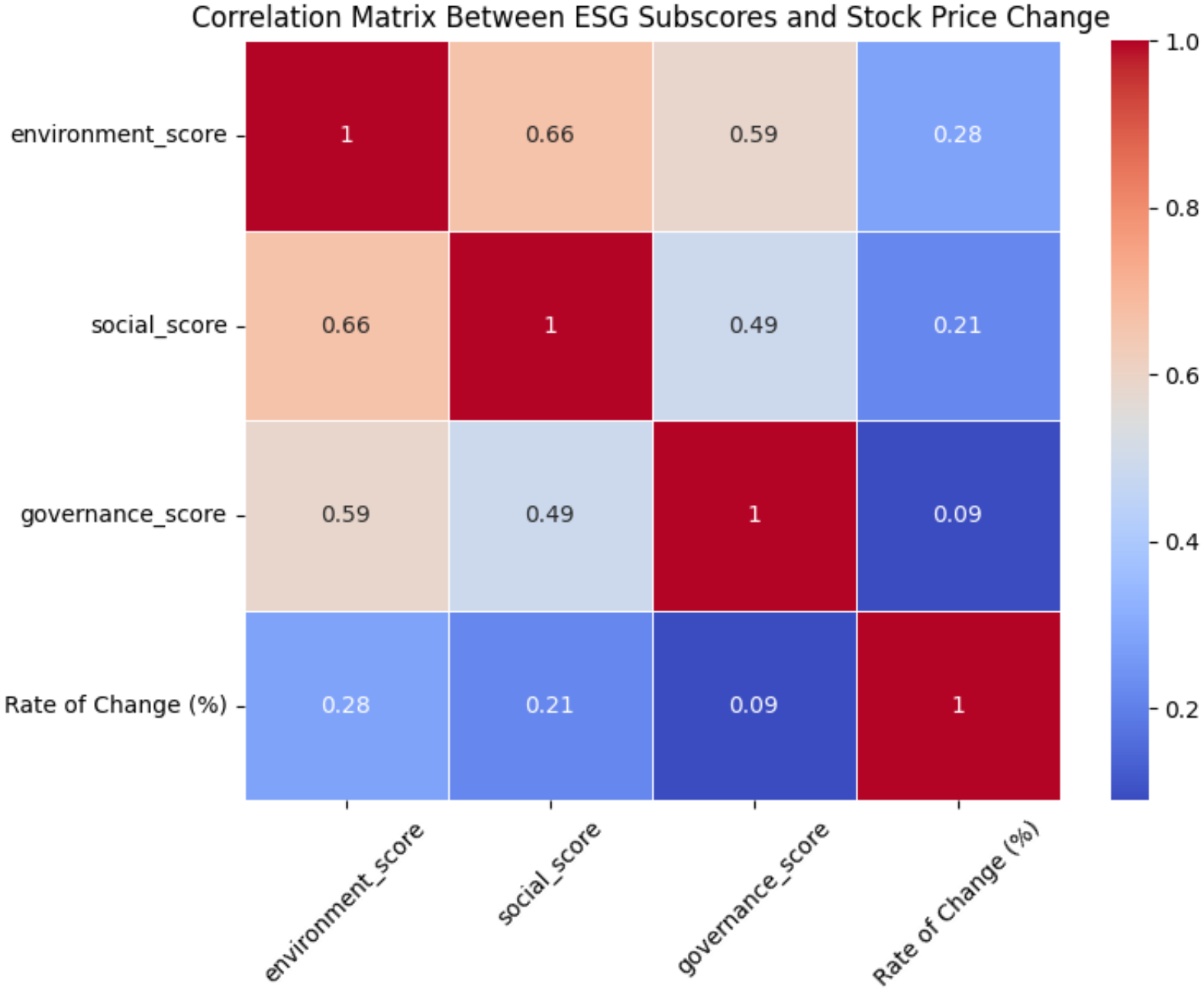
```
#Violin Plot: Rate of Change by Social Grade
plt.figure(figsize=(12, 6))
sns.violinplot(data=esg, x='social_grade', y='Rate of Change (%)', palette='muted')
plt.title('Rate of Change (%) by Social Grade', fontsize=16)
plt.xlabel('Social Grade')
plt.ylabel('Rate of Change (%)')
```

```
plt.show()
```

```
/var/folders/j2/kdbytjmd57914f_8rxw949240000gn/T/ipykernel_30230/4258631131.py:3: FutureWarning:

Passing `palette` without assigning `hue` is deprecated and will be removed in v0.14.0. Assign the `x` va
riable to `hue` and set `legend=False` for the same effect.

  sns.violinplot(data=esg, x='social_grade', y='Rate of Change (%)', palette='muted')
```

In [225…
```
correlation_matrix=esg[['environment_score', 'social_score', 'governance_score', 'Rate of Change (%)']].c
plt.figure(figsize=(8, 6))
sns.heatmap(correlation_matrix, annot=True, cmap='coolwarm', linewidths=0.5)
plt.title('Correlation Matrix Between ESG Subscores and Stock Price Change')
plt.xticks(rotation=45)
```

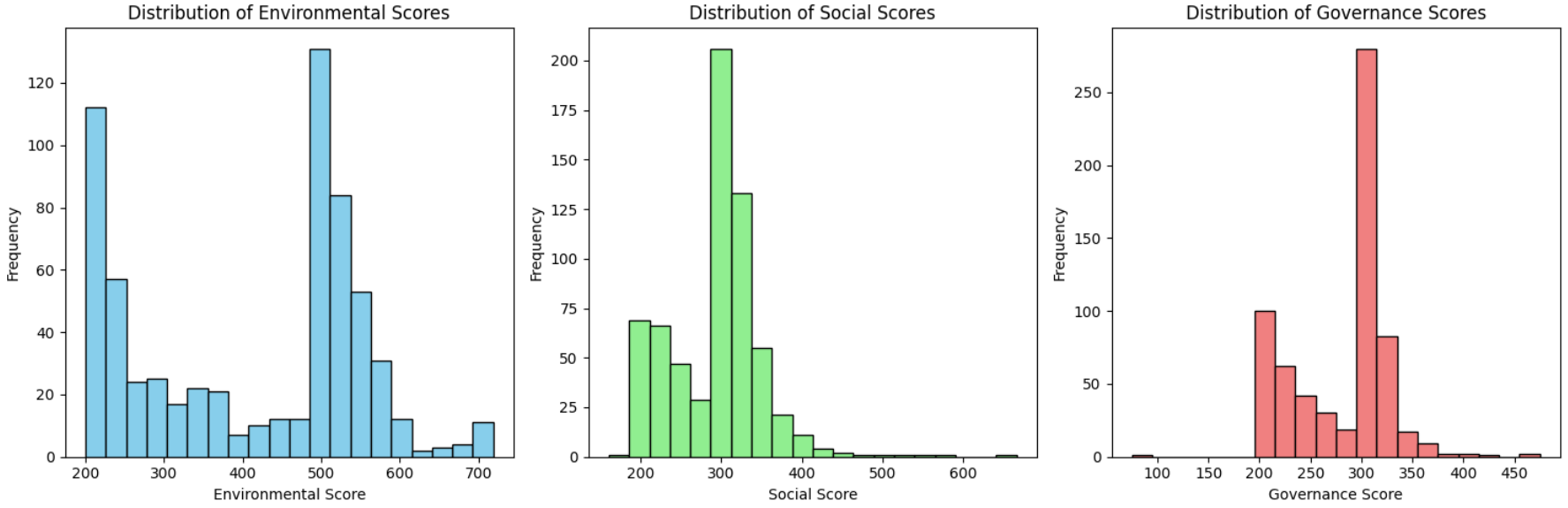
```
plt.show()

correlation_environment = esg['environment_score'].corr(esg['Rate of Change (%)'])
correlation_social = esg['social_score'].corr(esg['Rate of Change (%)'])
correlation_governance = esg['governance_score'].corr(esg['Rate of Change (%)'])

print(f'Correlation between Environmental Score and Rate of Change (%): {correlation_environment:.3f}')
print(f'Correlation between Social Score and Rate of Change (%): {correlation_social:.3f}')
print(f'Correlation between Governance Score and Rate of Change (%): {correlation_governance:.3f}')
```




```
Correlation between Environmental Score and Rate of Change (%): 0.283
Correlation between Social Score and Rate of Change (%): 0.215
Correlation between Governance Score and Rate of Change (%): 0.090
```

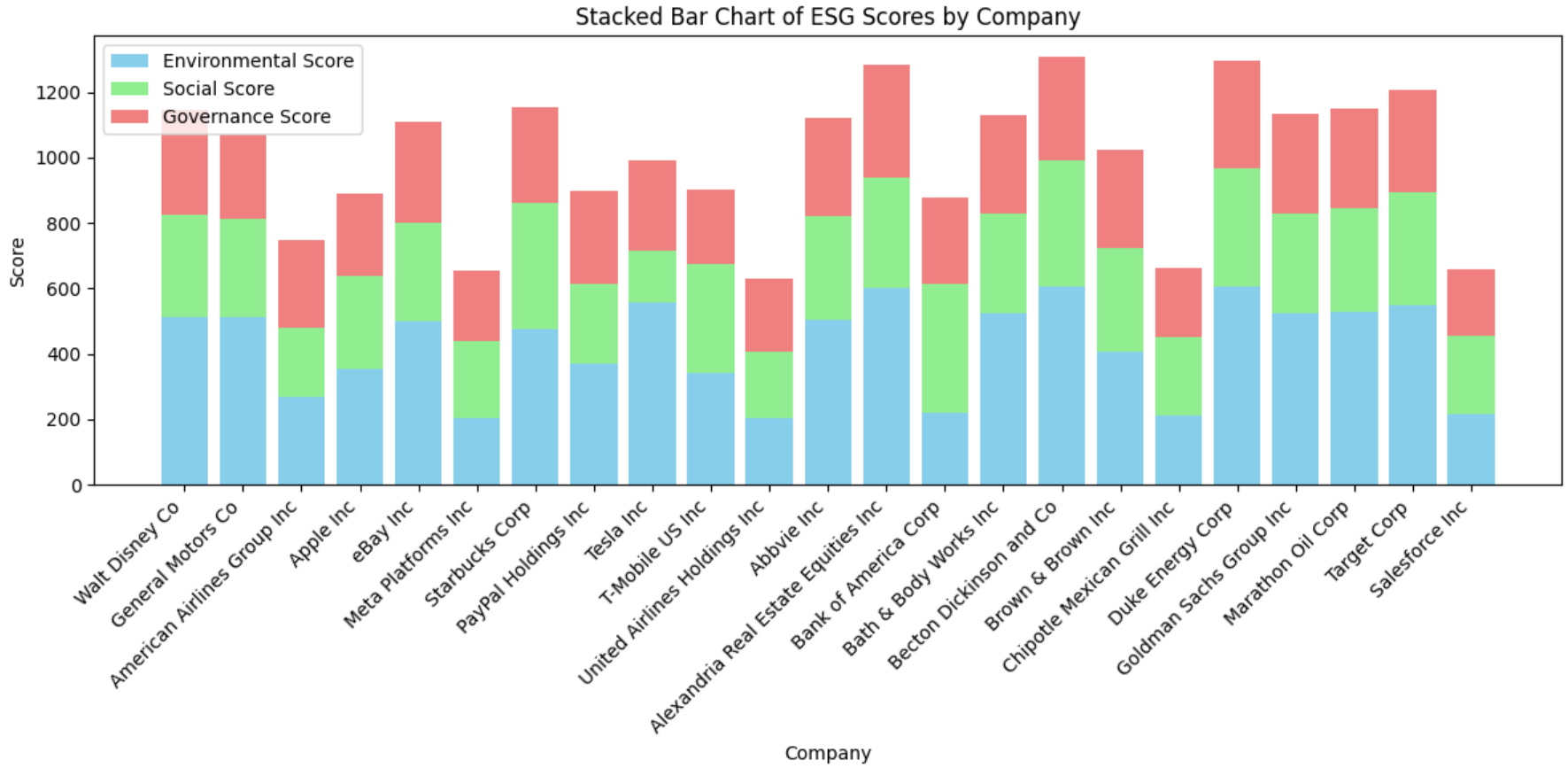
In [226…

```
# Plot histograms for each ESG subscore
plt.figure(figsize=(15, 5))

plt.subplot(1, 3, 1)
plt.hist(esg['environment_score'].dropna(), bins=20, color='skyblue', edgecolor='black')
plt.xlabel('Environmental Score')
plt.ylabel('Frequency')
plt.title('Distribution of Environmental Scores')

plt.subplot(1, 3, 2)
plt.hist(esg['social_score'].dropna(), bins=20, color='lightgreen', edgecolor='black')
plt.xlabel('Social Score')
plt.ylabel('Frequency')
plt.title('Distribution of Social Scores')

plt.subplot(1, 3, 3)
plt.hist(esg['governance_score'].dropna(), bins=20, color='lightcoral', edgecolor='black')
plt.xlabel('Governance Score')
plt.ylabel('Frequency')
plt.title('Distribution of Governance Scores')

plt.tight_layout()
plt.show()
```



In [227…

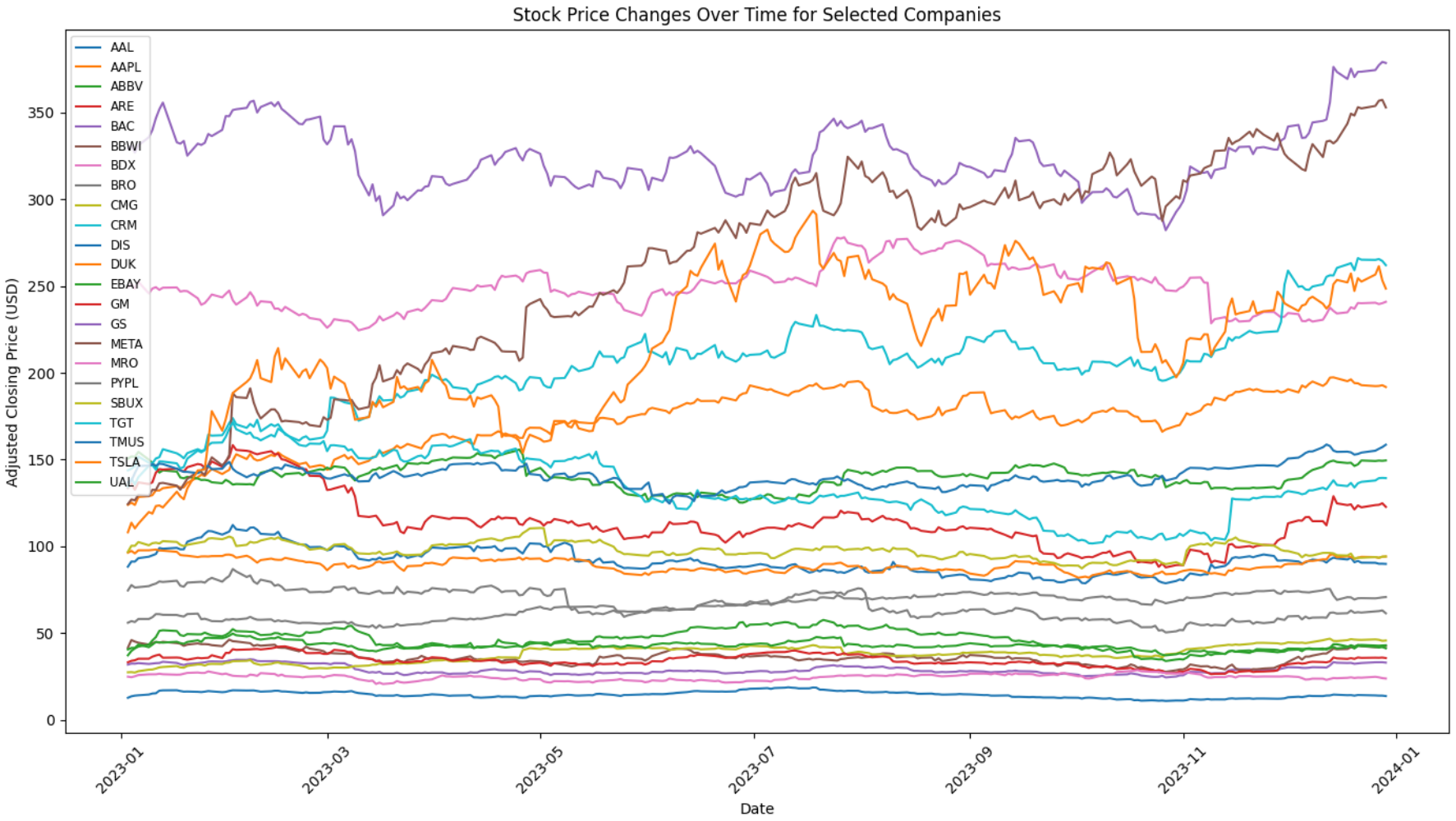
```
env_scores = relevant_esg['environment_score'].values
soc_scores = relevant_esg['social_score'].values
gov_scores = relevant_esg['governance_score'].values
filtered_companies = relevant_esg['name'].values

x = np.arange(len(filtered_companies))

plt.figure(figsize=(12, 6))
plt.bar(x, env_scores, color='skyblue', label='Environmental Score')
plt.bar(x, soc_scores, bottom=env_scores, color='lightgreen', label='Social Score')
plt.bar(x, gov_scores, bottom=env_scores + soc_scores, color='lightcoral', label='Governance Score')

plt.xticks(x, filtered_companies, rotation=45, ha='right')
plt.xlabel('Company')
plt.ylabel('Score')
plt.title('Stacked Bar Chart of ESG Scores by Company')
plt.legend()
plt.tight_layout()
plt.show()
```



In [228…

```
data = yf.download(list(relevant_esg['ticker']), start='2023-01-01', end='2024-01-01')['Adj Close']


plt.figure(figsize=(14, 8))
for ticker in data.columns:
    plt.plot(data.index, data[ticker], label=ticker)

plt.xlabel('Date')
plt.ylabel('Adjusted Closing Price (USD)')
plt.title('Stock Price Changes Over Time for Selected Companies')
plt.legend(loc='upper left', fontsize='small')
plt.xticks(rotation=45)
plt.tight_layout()
plt.show()
```

```
[**********100%**********]  23 of 23 completed
```



In [229…

```python
X = relevant_esg[['environment_score', 'social_score','governance_score']]   # Independent variables
y = relevant_esg['Rate of Change (%)']   # Dependent variable

model = LinearRegression().fit(X, y)
print(f"Environmental Score Coefficient: {model.coef_[0]}")
print(f"Social Score Coefficient: {model.coef_[1]}")
print(f"Governance Score Coefficient: {model.coef_[2]}")
print(f"Intercept: {model.intercept_}")
```

```
Environmental Score Coefficient: 0.1079341804300019
Social Score Coefficient: -0.023698725388349346
Governance Score Coefficient: -0.07501676055180559
Intercept: -8.825036870813836
```

Regression Coefficients Interpretation

For every 1-unit increase in the Environmental score (assuming all other factors remain constant), the stock return is expected to increase by 0.1079 units. The positive coefficient suggests that higher Environmental scores are associated with better stock performance (or higher returns).

For every 1-unit increase in the Social score (with other variables constant), the stock return is expected to decrease by 0.0237 units. The negative coefficient indicates that better Social scores might be associated with lower stock performance, but generally, since the coefficient is so close to 0, Social scores seem to have little impact on stock performance.

For every 1-unit increase in the Governance score (with other variables constant), stock return is expected to decrease by 0.0750 units. This negative coefficient suggests that improvements in governance (e.g., stricter regulation or more ethical practices) are associated with slightly lower stock returns. This could imply that governance improvements come at a financial cost.

In [230…
```
esg_corr = relevant_esg.loc[:, ['environment_score', 'social_score',
                                'governance_score']]
print(esg_corr.corr(numeric_only=True))
```

```
                   environment_score  social_score  governance_score
environment_score           1.000000      0.443407          0.866404
social_score                0.443407      1.000000          0.548976
governance_score            0.866404      0.548976          1.000000
```

In [231…
```
print(esg_corr.cov(numeric_only=True))
```

```
                   environment_score  social_score  governance_score
environment_score       20758.632411   3947.505929       5092.833992
social_score             3947.505929   3818.059289       1383.930830
governance_score         5092.833992   1383.930830       1664.482213
```

Correlation and Covariance

Let's observe the correlation/covariance between the different ESG scores themselves! All the correlations are positive, meaning that there is positive correlation between the scores (when one increases, the other does too). Governance and Environment have a particularly strong correlation, suggesting that companies who invest in environmental factors likely also care about governance (or perhaps some government regulations align with environmental issues). On the other hand, social factors seem to have just a moderately positive relationship with both the other variables.

While the covariance values agree with these claims, it's interesting to note how large the variance is for Environmental Scores (20758.63). This suggests that there is a large spread in environmental performance among the companies we chose, while governance scores are much more consistent.

Questions for Reviewers

1. After combining our yfinance and ESG data, do we have large enough datasets to satisfy the complexity requirement for the research question?
2. Any advice recommanded to follow when we trying to take sample from the population? maybe by industry? how many industry to take sample from? maybe stratify to include all ESG grade? (as a reminder - we have one big dataset with 700+ companies and joined data that we did some EDA with, but we also want to include a smaller sample dataset so we can look at some individual companies as well).
3. How many visualization and statistics are recommanded for the final project? (ballpark range would be helpful) Do the visualizations we currently have seem like they're on the right path for the final phases?
4. Regarding the visualizations and chunks we have made for our EDA so far: should we explore these specific visualizations more in depth? OR should we expand our DA to other variables in the datasets that we maybe haven't used yet?