How ESG impact on financial performance? Optimizing ESG efforts and what to focus on

Lorenzo Ausiello, Fabrizio Dimino, Samuele Mugnai, Bo Sun

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Abstract This report presents an in-depth analysis of the S&P 500 companies, scrutinizing their Environmental, Social, and Governance (ESG) scores alongside financial performance and market trends spanning two decades (2002-2022). The study is anchored in exploring the complex interplay between corporate sustainability initiatives, their financial outcomes, and the broader market movements. This exploration is pivotal in elucidating how ESG practices are intertwined with economic returns and market behaviors, offering valuable insights for shaping future investment strategies and reinforcing corporate sustainability frameworks. The culmination of this research promises to be a critical resource for investors and corporations alike, guiding them towards more informed decisions that align with both financial goals and sustainability commitments.

Introduction

This report offers an analysis of companies listed in the S&P500 index, focusing on their ESG scores, financial performance, and market data collected from 2002 to 2022. The insights gleaned from this analysis could significantly enhance our understanding of the intricate relationship between sustainability, financial returns, and market behavior. This, in turn, can greatly influence future investment decisions and corporate sustainability strategies.

Analysis Objective

The primary goal here is to uncover correlations or connections between ESG scores, financial/economic performances, and market data, particularly stock prices. This investigation aims to discern meaningful associations between corporate sustainability practices, financial performance, and the behavior of the stock market.

Data Source and Reference Period

ESG (Environmental, Social, Governance) scores utilized in this study were sourced from the Refinitiv V2 Score database released in May 2023. This database provides quarterly updated annual scores spanning from 2002 to 2022.

Historical stock prices of selected companies were acquired using the quantmod library. Subsequently, logarithmic returns were computed from this data to assess the percentage changes in stock prices over time. This step significantly contributes to comprehending the dynamics of companies' financial returns during the considered period.

Additional pertinent financial data, including Return on Equity (ROE) and Return on Assets (ROA), were retrieved from the Bloomberg terminal. These financial metrics offer crucial insights into companies' profitability and asset utilization efficiency during the analyzed period.

All collected data was meticulously organized and integrated to construct a cohesive dataset. This unified dataset comprises information on ESG scores, corresponding logarithmic returns, and financial indicators like ROE and ROA. This integration allows for a holistic and in-depth analysis of companies' performances within the spheres of sustainability and financial resilience.

Dataset

The dataframe containing the data used for the entire project consists of a total of 21 columns and 1448 rows. Each of the data points has been meticulously selected and downloaded from various data warehouses, including "Wharton Research Data Services," "Bloomberg Terminal," and "Yahoo Finance."To provide an optimal analysis regarding the meaning of each data type, it is necessary to develop an accurate description of each column in the dataframe:

• Year: We have selected the data from 2002 to 2022. This specific selection has allowed us to obtain a robust and meaningful dataset for the following analysis.

• Primary.Ticker: This column identifies the ticker of each of the companies selected for the study. Specifically, this nickname represents the acronym by which the company is displayed within the used terminal. Totally, we have picked 67 firms.

• Community.Score: A score indicating the company's performance in community-related aspects. Higher scores generally imply better performance in community-related initiatives.

• CSR.Strategy.Score: This score evaluates the company's commitment to Corporate Social Responsibility (CSR) strategies. It measures how actively the company engages in socially responsible practices. A higher score indicates a more robust CSR strategy, showcasing a strong commitment to social responsibility.

• Emissions.Score: This score assesses the effectiveness of the company's efforts in reducing emissions. It reflects the company's commitment to environmental sustainability. Higher scores indicate that the company has implemented more effective measures to reduce its carbon footprint.

• Environment.Pillar.Score: The "Environment" pillar score, integral to the Environmental, Social, and Governance (ESG) framework, gauges a company's commitment to sustainable and ethical practices. It assesses how effectively a company addresses environmental concerns through various components.

• Environment. Innovation.Score: The Environmental Innovation Score assesses a company's level of innovation in implementing environmentally friendly practices and processes. he score aims to measure how well a company incorporates innovative and eco-friendly technologies, business processes, and approaches to minimize its ecological footprint.

• ESG.Combined.Score: The ESG Combined Score is an aggregated or composite score that represents a company's overall performance across Environmental, Social, and Governance (ESG) factors. ESG factors are used to evaluate a company's sustainability, ethical practices, and its impact on the broader world.

• ESG.Controversies.Score: The ESG Controversies Score is a metric that assesses the level of controversy associated with a company regarding its Environmental, Social, and Governance (ESG) practices. This score is an indicator of the degree to which a company is involved in or associated with controversial events or issues that may have negative social or environmental implications.

• Governance.Score: The Governance Score is a metric that assesses a company's governance practices within the context of Environmental, Social, and Governance (ESG) criteria. Governance refers to the systems and processes by which companies are directed, controlled, and held accountable to their stakeholders.

• Human.Rights.Score: The Human Rights Score is a metric that assesses a company's commitment to and performance in protecting and promoting human rights within the framework of Environmental, Social, and Governance (ESG) criteria. Human rights encompass a broad range of fundamental rights and freedoms inherent to all individuals, regardless of nationality, ethnicity, gender, religion, or other characteristics.

• Management.Score: The Management Score is a metric used in Environmental, Social, and Governance (ESG) assessments to evaluate the quality of a company's management practices. It provides insights into how well a company is governed and managed, which can be indicative of its long-term sustainability and overall performance.

• Product.Responsability.Score: The Product Responsibility Score is a metric within Environmental, Social, and Governance (ESG) assessments that evaluates a company's responsibility in the production of goods. This score reflects how well a company manages and addresses the potential social and environmental impacts associated with its products throughout their lifecycle.

• Resource.Use.Score: The Resource Use Score is a metric within Environmental, Social, and Governance (ESG) assessments that evaluates a company's efficiency in utilizing and managing natural resources. This score provides insights into how well a company optimizes and handles resources such as water, energy, and raw materials.

• Shareholders.Score: The ShareholdersScore is a metric within Environmental, Social, and Governance (ESG) assessments that evaluates a company's performance in shareholder-related aspects. It provides insights into how well a company manages relationships with its shareholders and addresses their interests.

• Social.Score: The "SocialScore" is a metric within Environmental, Social, and Governance (ESG) assessments, providing an overall evaluation of a company's performance in various social responsibility aspects. This score is crucial for investors and stakeholders interested in understanding how a company manages its social impact and interacts with the broader community.

• Workforce.Score: The term "Workforce.Score" is not a standard or widely recognized metric in the context of Environmental, Social, and Governance (ESG) assessments. However, it implies an evaluation of a company's performance related to its workforce, considering various factors that contribute to a positive and sustainable work environment.

• Returns: Historical stock prices of selected companies were acquired using the quantmod library. Subsequently, logarithmic returns were computed from this data to assess the percentage changes in stock prices over time. This step significantly contributes to comprehending the dynamics of companies' financial returns during the considered period.

• ROA (Return on Assets): ROA" stands for Return on Assets, and it is a financial metric that measures a company's efficiency in using its assets to generate profit. Its components are represented by Net Income and Average Total Assets.

• ROE (Return on Equity): ROE" stands for Return on Equity, and it is a financial metric that measures the profitability of a company in relation to its shareholders' equity. Its components are represented by Net Income and Average Shareholders' Equity. Initially, we focused on core variables such as ESG score, ESG combined score, ESG controversies score, environmental pillar score, governance score, and social score for analysis, later integrating other variables into regression models.

Methods

EDA, Multiple linear regression, Random forest

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## No id variables; using all as measure variables
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HOW RETURNS VARY FOR DIFFERENT RATINGS?

Table 1: Returns statistics by different ESG SCORE

ESG.SCORE.Value	Mean	Min	25%Quantile	Median	75%Quantile	Max
A+	0.0938386	-0.5483165	-0.0510736	0.0608085	0.2989319	0.4546240
A	0.0924282	-0.7752931	-0.0396715	0.1237321	0.2506607	0.6315794
A-	0.0744036	-1.4248376	-0.0494970	0.1042516	0.2284874	0.8910273
B+	0.1077941	-0.9967680	-0.0130564	0.1218258	0.2457228	1.1846686
B	0.1011046	-1.1659485	-0.0347578	0.1374641	0.2656923	0.8160374
B-	0.0413160	-1.0143768	-0.0929023	0.0777283	0.1919219	0.7783296
C+	0.0402539	-3.5945149	-0.0390874	0.1137133	0.2385426	0.8393004
C	0.0835780	-0.7227595	-0.0435604	0.1540559	0.2323303	0.4744026
C-	0.0986344	-0.7821015	-0.0299156	0.0805006	0.2553537	1.0244636
D+	0.1221329	-0.5914202	0.0032960	0.1444646	0.2285182	0.7053805
D	-0.0103183	-1.7599824	-0.1197165	0.0691401	0.2894065	0.4904811
D-	0.0867209	-0.0371877	-0.0101789	0.0529898	0.0978323	0.3301490

Table 2: Returns statistics by different ESG COMBINED SCORE

ESG.COMBINED.SCORE.Value	Mean	Min	25%Quantile	Median	75%Quantile	Max
A+	-0.0872525	-0.5483165	-0.0929499	-0.0559393	0.0205993	0.2403442
A	0.1202281	-0.3169663	-0.0548180	0.1417679	0.3027188	0.4906858
A-	0.1073772	-0.7498905	-0.0286097	0.1281894	0.2452768	0.6315794
B+	0.1420264	-0.6197031	0.0193034	0.1417863	0.2671230	1.1846686
B	0.0856966	-0.7424263	-0.0799560	0.1190223	0.2306125	0.8910273
B-	0.0487045	-1.0143768	-0.0490856	0.0636307	0.1908982	0.8160374
C+	0.0839358	-1.4248376	-0.0376152	0.1295924	0.2443053	0.7988382
C	0.0739508	-1.1659485	-0.0580866	0.1113736	0.2472617	0.7783296
C-	0.0624732	-3.5945149	-0.0191045	0.0922377	0.2462412	1.0244636
D+	0.0905744	-1.4387954	-0.0121645	0.1434416	0.2724597	0.7053805
D	0.0391592	-1.7599824	-0.1197165	0.0860014	0.3284560	0.9644121
D-	0.0867209	-0.0371877	-0.0101789	0.0529898	0.0978323	0.3301490

Table 3: Returns statistics by different ESG CONTROVERSIES SCORE

ESG.CONTROVERSIES.SCORE.Value	Mean	Min	25%Quantile	Median	75%Quantile	Max
A+	0.1014545	-1.7599824	-0.0311094	0.1368993	0.2479881	1.1846686
A	0.0625448	-1.0143768	-0.0393778	0.1103935	0.2010474	0.5319131
A-	0.0338117	-0.6966637	-0.1208939	0.0438539	0.1924337	0.6281237
B+	0.1030048	-0.6994822	0.0148737	0.1194569	0.2560438	0.8130704
B	0.0709182	-0.3135719	-0.0297185	0.0965096	0.1882806	0.3630793

ESG.CONTROVERSIES.SCORE.Value	Mean	Min	25%Quantile	Median	75%Quantile	Max
B-	0.0787197	-0.5932230	-0.1005417	0.1036674	0.2466588	0.8160374
C+	0.0822810	-0.7470582	-0.0354871	0.0796488	0.1962917	1.0244636
C	0.1319709	-0.7821015	0.0495581	0.1516256	0.3019086	0.8910273
C-	0.0908204	-0.6087629	-0.0424691	0.0703335	0.2106553	0.8534335
D+	0.0715462	-0.9268170	-0.0486312	0.0900870	0.2272052	0.7988382
D	0.0401511	-3.5945149	-0.1012107	0.1353905	0.2642658	0.6136867
D-	0.0791662	-1.4387954	-0.0482713	0.0953931	0.2596191	0.9644121

Table 4: Returns statistics by different ENVIRONMENTAL PILLAR SCORE

ENVIRONMENT.PILLAR.SCORE.Value	Mean	Min	25%Quantile	Median	75%Quantile	Max
A+	0.0866928	-0.7042726	-0.0527538	0.1076645	0.2687331	0.6940108
A	0.0677867	-1.4248376	-0.0438559	0.0906338	0.2237663	0.8910273
A-	0.0951888	-1.1659485	-0.0215177	0.1331469	0.2519892	0.6663670
B+	0.1077582	-0.9967680	-0.0154158	0.1085226	0.2494441	1.1846686
B	0.0859696	-1.0143768	-0.0503512	0.1128507	0.2327470	0.6471151
B-	0.0700260	-1.4387954	-0.0660143	0.0924806	0.2167629	0.8393004
C+	0.0383659	-3.5945149	-0.0462771	0.1482060	0.2197821	0.6759742
C	0.0902434	-0.6966637	-0.0114844	0.1513081	0.2739486	0.3892802
C-	0.0998764	-0.5091858	-0.0049850	0.1049141	0.2223437	0.6533389
D+	0.0621428	-0.7470582	-0.0390874	0.1066584	0.2336922	0.4735932
D	0.0419772	-0.5264935	-0.1635427	0.0747680	0.1665171	0.7783296
D-	0.0742276	-1.7599824	-0.1048646	0.0825531	0.2383789	1.0244636

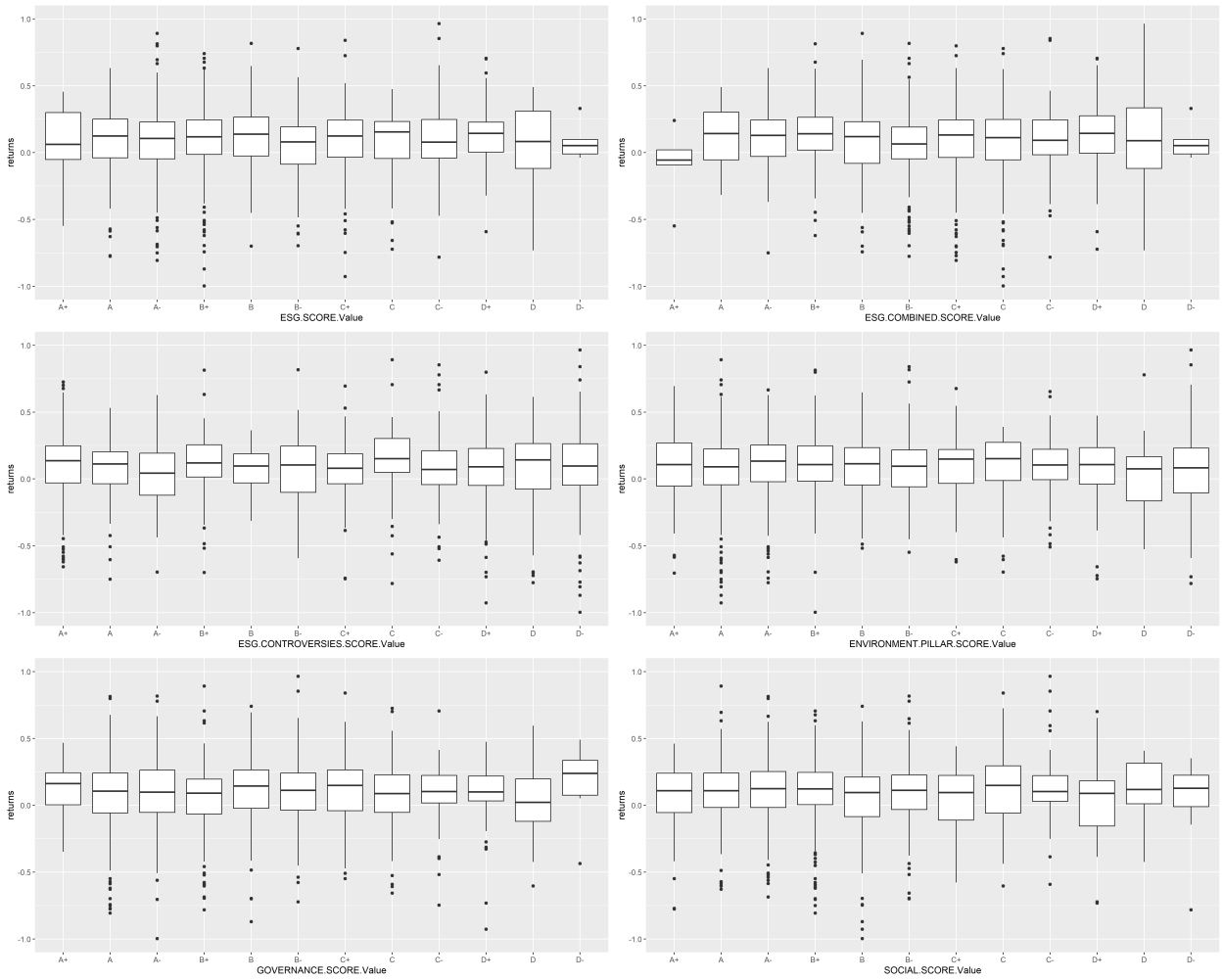
Table 5: Returns statistics by different GOVERNANCE SCORE

GOVERNANCE.SCORE.Value	Mean	Min	25%Quantile	Median	75%Quantile	Max
A+	0.1313202	-0.3477648	0.0035242	0.1624230	0.2437285	0.4677379
A	0.0759699	-0.8072075	-0.0564388	0.1067808	0.2418563	1.1846686

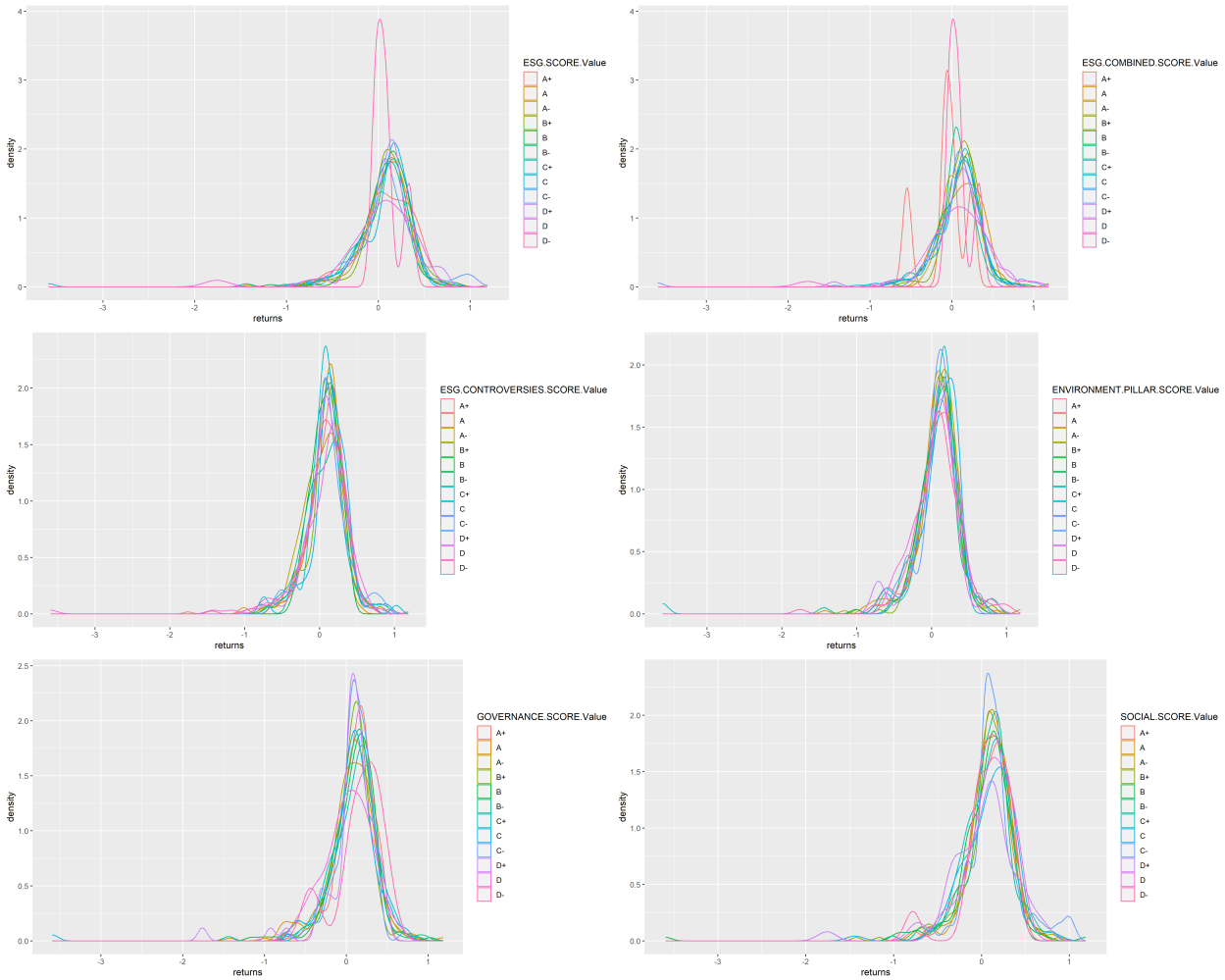
GOVERNANCE.SCORE.ValueMean	Min	25%Quantile	Median	75%Quantile	Max
A- 0.0843579	-1.4248376	-0.0540375	0.0965096	0.2629882	0.8160374
B+ 0.0558942	-0.7821015	-0.0654782	0.0908655	0.1959759	0.8910273
B 0.0999865	-1.1659485	-0.0295663	0.1427810	0.2648914	1.0244636
B- 0.0893436	-1.4387954	-0.0368105	0.1092019	0.2395396	0.9644121
C+ 0.1170248	-0.5487298	-0.0406474	0.1487205	0.2640622	0.8393004
C 0.0390276	-3.5945149	-0.0552089	0.0850233	0.2211977	0.7256723
C- 0.0951078	-0.7470582	0.0180057	0.1031795	0.2225869	0.7053805
D+ 0.0527872	-1.7599824	0.0263407	0.0959605	0.2157264	0.4744026
D 0.0259365	-0.6039003	-0.1197165	0.0223399	0.1975531	0.5960779
D- 0.1595435	-0.4353182	0.0754111	0.2380134	0.3364029	0.4904811

Table 6: Returns statistics by different SOCIAL SCORE

SOCIAL.SCORE.Value	Mean	Min	25%Quantile	Median	75%Quantile	Max
A+	0.0738812	-0.7752931	-0.0551206	0.1090494	0.2398998	0.4614801
A	0.1008707	-0.6281593	-0.0169064	0.1084733	0.2417507	0.8910273
A-	0.1062351	-0.6854809	-0.0159518	0.1237518	0.2519658	0.8130704
B+	0.0840990	-1.4248376	0.0042778	0.1128507	0.2465507	0.7058076
B	0.0429758	-3.5945149	-0.0853680	0.0948390	0.2127529	1.1846686
B-	0.0827702	-1.0143768	-0.0349144	0.1110610	0.2261073	0.8160374
C+	0.0570657	-0.5781874	-0.1105160	0.0948748	0.2233704	0.4420184
C	0.0863837	-1.4387954	-0.0803762	0.1409137	0.2927496	0.8393004
C-	0.1500456	-0.5914202	0.0314332	0.1046001	0.2224334	1.0244636
D+	-0.0026912	-1.7599824	-0.1621911	0.0760263	0.1795973	0.7009352
D	0.1090019	-0.4235434	0.0115218	0.1182477	0.3152652	0.4075648
D-	0.0728018	-0.7821015	-0.0101789	0.1276536	0.2251294	0.3519868



The displayed box plots provide a visualization of financial returns distribution across various ESG score categories: overall ESG, controversies, combined, environmental, governance, and social scores. Each plot categorizes companies based on their ESG rating, ranging from 'A+' to 'D-', and showcases the median, quartiles, and potential outliers in returns. Notably, the plots reveal that companies with both very high and very low ESG scores tend to have a wider dispersion of returns, hinting at a complex, non-linear relationship between ESG performance and financial returns. This analysis serves as a foundational step in understanding how ESG factors may correlate with financial outcomes in the context of S&P 500 companies.



This collection of density plots illustrates the distribution of financial returns for S&P 500 companies, segmented by their respective ratings in various ESG categories: overall score, controversies, combined, environmental, governance, and social. Each color-coded line represents a different ESG rating, from 'A+' to 'D-'. The plots highlight the probability density of returns within each ESG category, offering insights into the frequency and variability of returns associated with each ESG grade. These density distributions are critical for understanding the prevalence and likelihood of financial returns at different levels of ESG performance, showcasing subtle differences in the financial implications of each ESG aspect.

HOW ROE VARY FOR DIFFERENT RATINGS?

Table 7: ROE statistics by different ESG SCORE

ESG.SCORE.Value	Mean	Min	25%Quantile	Median	75%Quantile	Max
A+	93.11402	10.8154	22.73260	27.50680	47.11500	626.7442
A	46.58440	-13.6000	13.13215	25.59700	36.24495	1048.6216
A-	44.44819	-52.4184	9.89055	19.56070	31.26935	1048.6216
B+	35.38496	-31.3443	10.56420	18.64180	32.77290	701.2152
B	24.99280	-20.4741	11.69580	18.40290	26.15960	150.2827
B-	27.19038	-17.8170	11.77290	16.91245	24.20038	527.8846
C+	19.59482	-134.2694	11.19390	17.40420	24.45920	166.2238
C	23.29701	-9.3266	12.60515	18.19215	22.25000	475.7325
C-	19.17079	-1.3453	14.20350	18.05960	23.64670	58.4767
D+	18.90592	-21.4405	11.00070	17.51835	21.55418	85.1383
D	17.24304	-1.0378	12.13045	17.58020	22.34177	40.4472
D-	14.46734	8.1009	14.22240	14.95070	16.08270	18.9800

Table 8: ROE statistics by different ESG COMBINED SCORE

ESG.COMBINED.SCORE.Value	Mean	Min	25%Quantile	Median	75%Quantile	Max
A+	266.88380	13.2146	20.58070	320.41420	353.46530	626.7442
A	53.79062	9.7646	25.32450	33.04305	50.50952	340.9211
A-	52.68145	-4.0181	12.08067	22.09635	44.31932	1048.6216
B+	31.40768	-23.5841	11.13750	20.61940	32.02635	151.9943
B	29.24837	-20.4741	12.37797	20.48320	28.70205	340.9211
B-	33.99552	-17.8170	11.66495	19.19685	29.03357	701.2152
C+	37.90561	-52.4184	10.86870	18.71090	28.26630	1048.6216
C	28.26038	-31.3443	10.74625	16.34090	24.12930	1048.6216
C-	17.63296	-134.2694	9.74970	16.20810	22.31630	150.2827
D+	16.88998	-32.4067	10.37360	16.44350	19.91580	85.1383
D	17.04939	-1.0378	12.13045	17.75210	22.34177	40.4472
D-	14.46734	8.1009	14.22240	14.95070	16.08270	18.9800

Table 9: ROE statistics by different ESG CONTROVERSIES SCORE

ESG.CONTROVERSIES.SCORE.Value	Mean	Min	25%Quantile	Median	75%Quantile	Max
A+	31.39915	-21.4405	11.675700	19.14730	26.86052	626.7442
A	23.46509	-23.5841	12.715100	19.63720	29.07220	136.5128
A-	56.72891	-6.6156	16.203400	28.32800	41.45490	1048.6216
B+	28.10368	-9.6604	11.009400	17.69395	22.79348	275.6027
B	25.63090	-20.1633	10.316150	17.79050	25.33770	133.7837
B-	29.45769	3.0840	11.602900	18.18955	30.97675	149.4413
C+	29.15090	-10.8244	12.445800	18.73510	28.37010	298.2547
C	57.44405	-13.5309	16.043900	24.88460	38.26960	701.2152
C-	35.70260	3.6462	10.909150	17.96230	27.99010	684.0275
D+	31.05088	-9.1165	11.437350	17.66460	29.87635	298.2547
D	40.98855	-134.2694	9.761075	16.78650	32.26132	1048.6216

ESG.CONTROVERSIES.SCORE.Value	Mean	Min	25%Quantile	Median	75%Quantile	Max
D-	28.58629	-52.4184	9.706975	14.66790	23.73082	1048.6216

Table 10: ROE statistics by different ENVIRONMENT PILLAR SCORE

ENVIRONMENT.PILLAR.SCORE.Value	Mean	Min	25%Quantile	Median	75%Quantile	Max
A+	39.97777	-8.2792	7.022775	16.39540	28.80773	626.7442
A	45.20235	-52.4184	9.852800	18.52440	38.81350	1048.6216
A-	43.51692	-20.1633	11.437350	19.50345	32.14608	1048.6216
B+	36.00314	-3.1044	12.814350	19.83405	31.16315	701.2152
B	23.40931	-31.3443	12.155100	17.82090	25.96550	150.2827
B-	27.33993	-9.1165	10.295975	19.38945	26.12210	527.8846
C+	20.40158	-134.2694	12.709100	20.58290	27.52520	118.0525
C	19.44040	-17.8170	14.697400	19.29210	25.59600	35.1321
C-	17.25760	-6.1771	12.564000	16.29930	21.27005	45.4416
D+	21.23183	-9.3266	11.068600	17.11930	23.34980	127.9814
D	39.19766	-2.3527	12.665925	18.16090	30.51450	449.1070
D-	22.90060	-21.4405	12.233650	17.90250	25.13837	475.7325

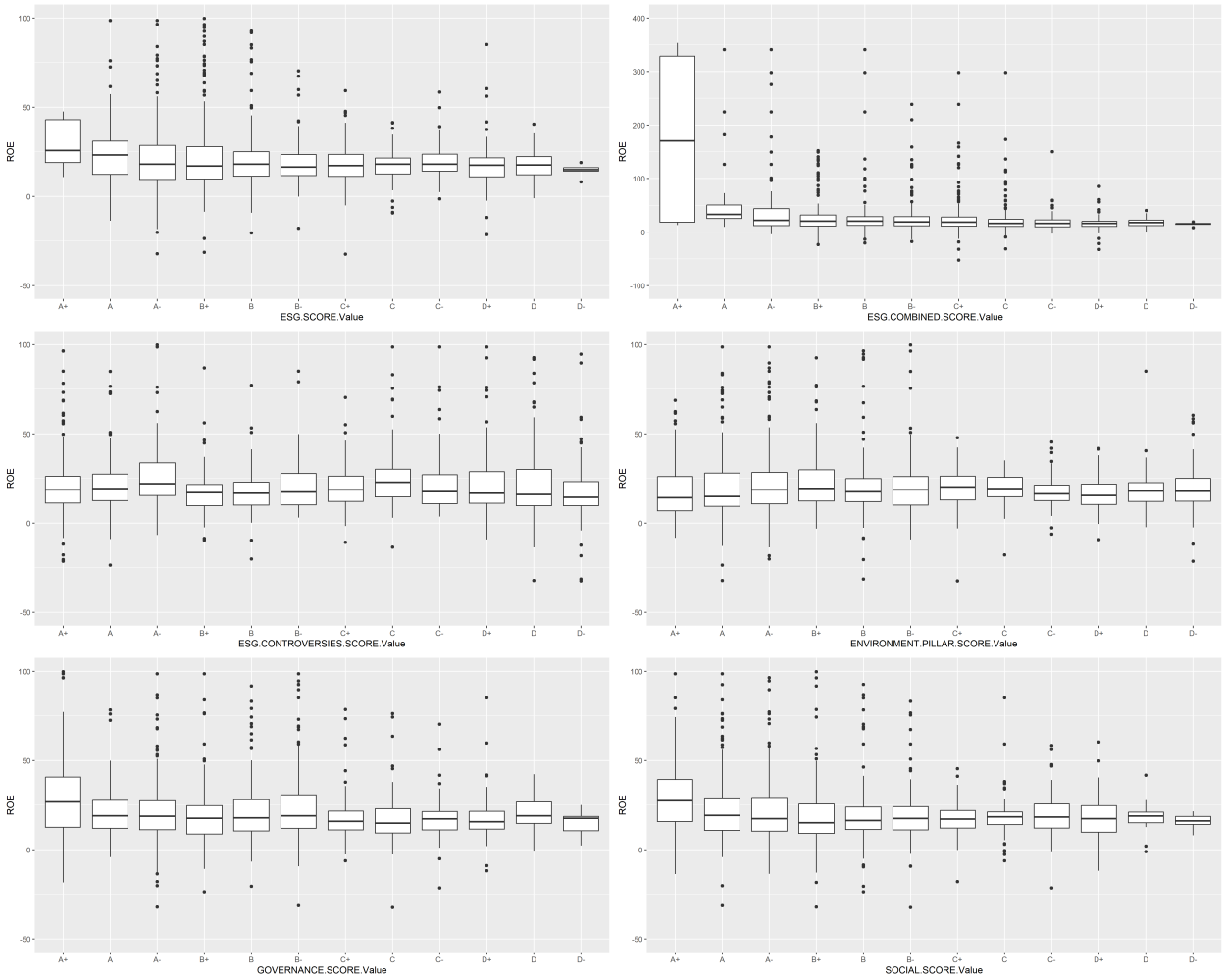
Table 11: ROE statistics by different GOVERNANCE SCORE

GOVERNANCE.SCORE.Value	Mean	Min	25%Quantile	Median	75%Quantile	Max
A+	34.12326	-18.3483	12.865025	27.20870	42.36940	126.3768
A	33.04085	-52.4184	12.188450	19.52590	29.14975	626.7442
A-	47.99443	-32.1420	12.040000	20.19230	31.49270	1048.6216
B+	32.39669	-23.5841	9.285625	18.67585	28.17790	1048.6216
B	40.69144	-20.4741	11.024825	19.13715	32.07795	1048.6216
B-	28.83993	-31.3443	12.528925	19.49365	32.88547	298.2547
C+	25.01068	-6.1771	11.178775	16.32360	21.85480	527.8846
C	22.79572	-134.2694	9.472850	15.31310	25.72895	150.2827
C-	23.85108	-21.4405	11.570475	17.55415	23.40830	158.8031
D+	17.88163	-11.8443	11.594525	15.64820	21.50500	85.1383
D	20.31286	-1.0378	14.765200	18.96875	26.80688	42.2727
D-	14.77743	2.3350	10.610850	17.58270	18.65340	24.9958

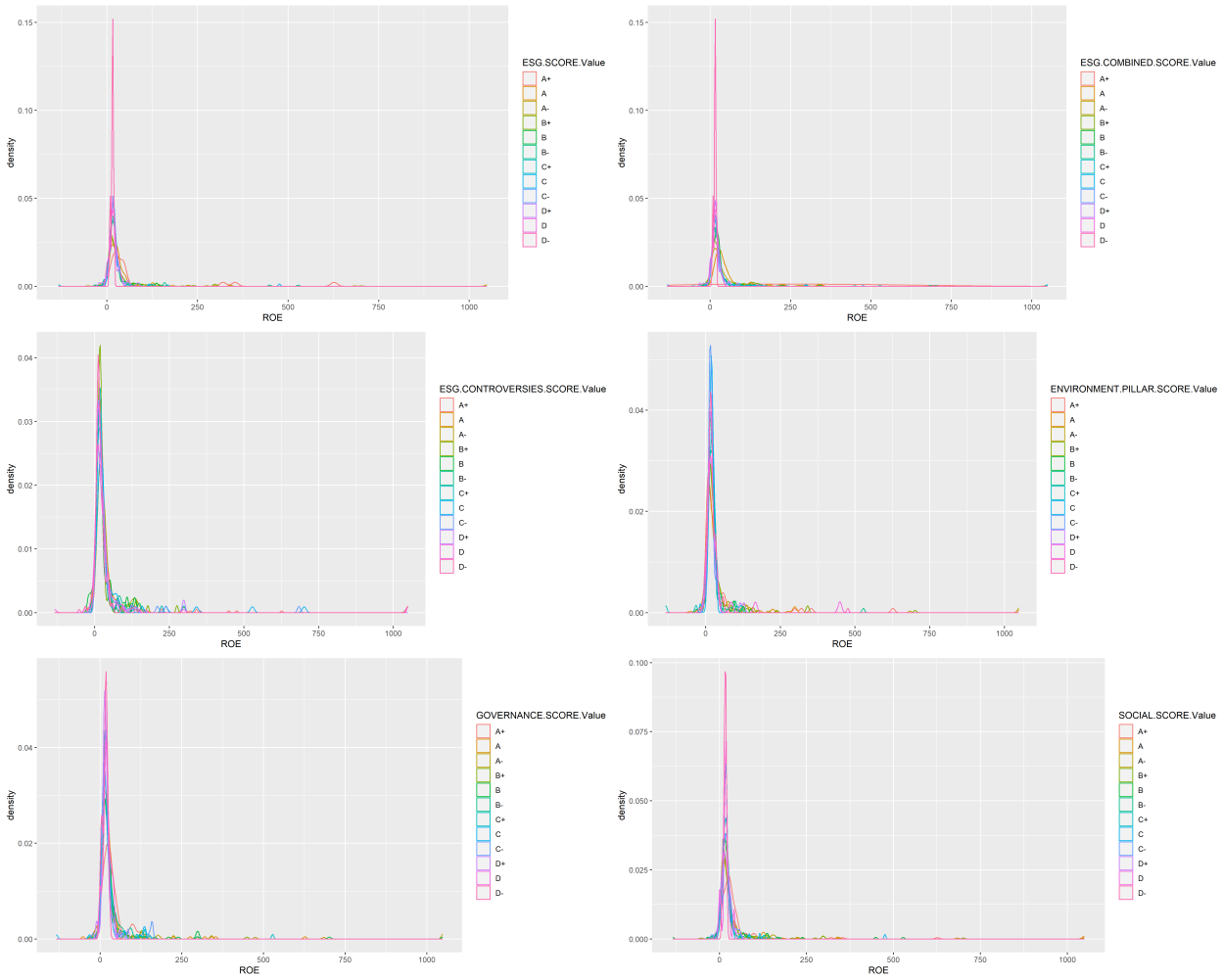
Table 12: ROE statistics by different SOCIAL SCORE

SOCIAL.SCORE.Value	Mean	Min	25%Quantile	Median	75%Quantile	Max
A+	48.94498	-13.6000	17.158825	27.55170	42.16508	1048.6216
A	47.80419	-31.3443	11.378475	20.29245	34.83030	1048.6216
A-	40.98674	-13.5309	10.826050	18.74690	32.12825	1048.6216
B+	31.27980	-52.4184	9.332100	15.58230	28.06925	701.2152
B	29.71793	-134.2694	11.633525	17.68630	25.33213	527.8846
B-	21.94700	-32.4067	11.265500	17.82090	24.45450	166.2238
C+	18.50017	-17.8170	12.163200	17.14100	22.01685	127.9814
C	24.62981	-6.1771	14.119250	18.44920	21.32913	475.7325
C-	20.22668	-21.4405	12.087100	18.32680	25.62630	58.4767

SOCIAL.SCORE.Value	Mean	Min	25%Quantile	Median	75%Quantile	Max
D+	18.01367	-11.8443	9.859475	17.36250	24.69882	60.4513
D	18.15286	-1.0378	15.050150	18.85425	21.02675	41.7482
D-	15.42925	8.1009	14.222400	16.08270	18.58420	21.5353



The provided box plots graphically summarize the distribution of Return on Equity (ROE) for S&P 500 companies classified by their ESG score ratings, which span from 'A+' to 'D-'. These visual representations allow for the comparison of median values, the spread, and the range (including potential outliers) of ROE within each ESG category. It's observable that while some categories, like the ESG Combined Score, show extreme values, others maintain a tighter interquartile range, indicating less variability in ROE performance. This analysis assists in discerning the potential influence of ESG ratings on the financial efficiency of companies as measured by their equity returns.



The set of density plots illustrates the distribution of Return on Equity (ROE) among S&P 500 companies, categorized by their respective ESG scores from 'A+' to 'D-'. Each plot corresponds to a different aspect of ESG — overall score, controversies, combined score, environmental, governance, and social. The density curves represent the probability of ROE values within each ESG rating class, showcasing the concentration and spread of equity returns. Notably, the plots reveal a sharp peak close to zero, indicating a high frequency of companies with low ROE across all ESG ratings. The long tails suggest that while high ROE values are less common, they occur across the spectrum of ESG ratings, indicating that exceptional financial performance is not confined to any single ESG category. These plots offer a nuanced view of the relationship between ESG performance and financial efficiency, as expressed through equity returns.

HOW ROA VARY FOR DIFFERENT RATINGS?

Table 13: ROA statistics by different ESG SCORE

ESG.SCORE.Value	Mean	Min	25%Quantile	Median	75%Quantile	Max
A+	13.603447	3.0179	11.243600	13.99220	16.238950	23.7659
A	9.972348	-3.5806	5.134050	9.13670	14.280550	36.7976
A-	7.880550	-8.3097	3.011200	7.75400	11.297200	35.2920
B+	7.503014	-10.6031	2.500000	6.69290	11.220950	35.0845
B	6.663754	-7.3881	1.737100	6.48700	9.562200	29.9452
B-	6.798323	-2.8654	1.888600	6.06415	10.504625	22.4219
C+	6.729798	-10.4034	2.423300	5.81170	9.581100	27.4083
C	6.268771	-2.3323	1.765750	4.75610	9.176475	24.8374
C-	7.086355	-0.5265	2.541800	7.98955	10.293875	21.1972
D+	7.444240	-15.1353	4.924475	7.79250	9.307525	33.7142
D	7.850640	-0.3620	5.682650	7.45990	10.574600	19.6006
D-	4.382700	1.6548	2.915200	5.59520	5.867900	5.8804

Table 14: ROA statistics by different ESG COMBINED SCORE

ESG.COMBINED.SCORE.Value	Mean	Min	25%Quantile	Median	75%Quantile	Max
A+	12.385440	5.7278	11.601800	13.19250	13.99220	17.4129
A	14.836282	3.1684	9.021450	13.76240	18.21250	36.7976
A-	10.024606	-3.5806	4.469800	9.02405	13.99132	35.2920
B+	8.073502	-10.6031	3.410300	7.64230	11.52160	35.0845
B	8.008474	-7.3881	3.894625	7.54810	11.25587	29.9452
B-	7.310856	-3.2985	2.683150	6.84375	10.33465	26.0084
C+	7.261699	-8.3097	2.303150	6.46050	10.96930	28.6658
C	6.570040	-10.1129	1.237300	5.53590	10.66805	25.1231
C-	5.977685	-10.4034	1.667000	5.94510	9.72820	21.1972
D+	6.507591	-15.1353	3.143600	6.65510	8.92520	33.7142
D	7.767812	-0.3620	5.682650	7.67220	10.57460	19.6006
D-	4.382700	1.6548	2.915200	5.59520	5.86790	5.8804

Table 15: ROA statistics by different ESG CONTROVERSIES SCORE

ESG.CONTROVERSIES.SCORE.Value	Mean	Min	25%Quantile	Median	75%Quantile	Max
A+	8.390135	-15.1353	3.394400	7.76590	11.62005	36.7976
A	7.113828	-10.6031	3.981300	7.00440	9.72250	25.2978
A-	10.977194	-3.5806	7.361600	10.34780	15.11560	33.7586
B+	6.679871	-4.1379	2.401925	6.04155	10.53150	26.7259
B	6.854203	-7.2577	1.753600	6.10170	10.52255	19.9975
B-	7.737850	0.1777	2.296550	7.38935	12.85470	19.4814
C+	7.582456	-3.8169	3.604700	7.06530	10.91870	23.0708
C	7.991523	-2.3104	4.516500	7.67985	10.18988	26.0084
C-	7.456605	0.4632	3.195150	7.05680	11.03935	23.8023
D+	7.956550	-1.0695	2.192825	7.01455	11.63180	28.6658
D	6.646591	-10.4034	0.969650	5.34435	11.13440	25.1231

ESG.CONTROVERSIES.SCORE.Value	Mean	Min	25%Quantile	Median	75%Quantile	Max
D-	6.190284	-10.1129	1.032950	5.48055	10.02755	23.7659

Table 16: ROA statistics by different ENVIRONMENT PILLAR SCORE

ENVIRONMENT.PILLAR.SCORE.Value	Mean	Min	25%Quantile	Median	75%Quantile	Max
A+	8.844726	-0.3741	0.813700	7.96105	12.254650	35.2920
A	7.409905	-10.6031	1.180200	6.28600	12.542400	36.7976
A-	7.182646	-7.2577	3.006950	6.71370	9.818475	35.0845
B+	9.130832	-0.9608	4.144800	8.29475	13.443175	33.7586
B	7.461570	-10.1129	3.455100	7.35510	11.134000	21.7023
B-	7.201474	-1.9602	2.939050	7.36330	10.820950	21.3451
C+	7.682351	-10.4034	3.426700	7.39160	10.697700	29.9452
C	6.552239	-2.8654	3.493700	6.42530	8.537300	16.7699
C-	4.835572	-2.3323	1.277550	2.39735	8.089300	24.8374
D+	7.163343	-2.2549	2.637300	6.69500	11.138900	17.9458
D	9.336607	-0.5265	3.862075	8.32410	12.080300	33.7142
D-	8.103862	-15.1353	5.616825	7.90155	10.376600	25.6368

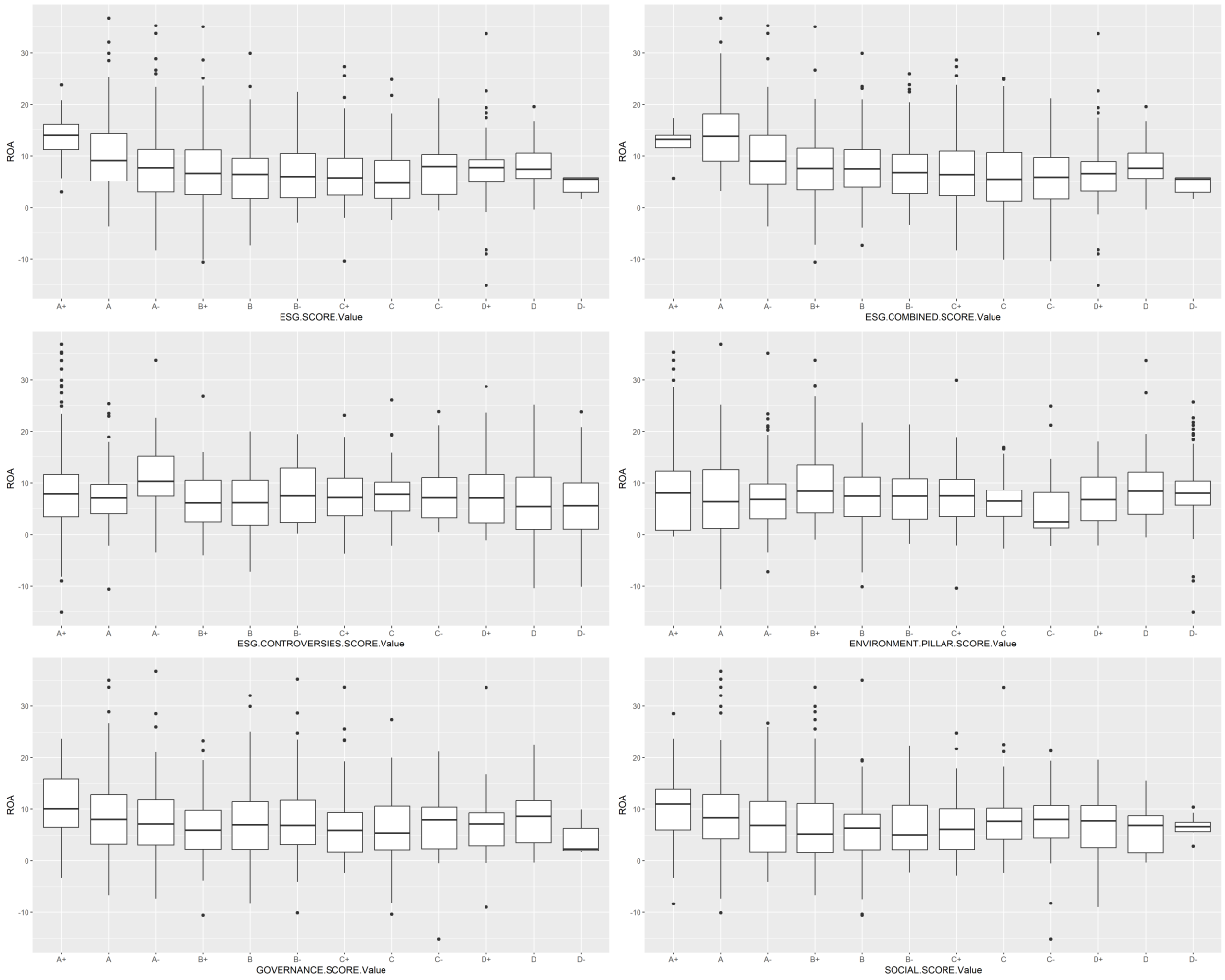
Table 17: ROA statistics by different GOVERNANCE SCORE

GOVERNANCE.SCORE.Value	Mean	Min	25%Quantile	Median	75%Quantile	Max
A+	10.739803	-3.2985	6.511800	10.04470	15.91130	23.7659
A	8.778239	-6.5719	3.330400	8.03500	12.94820	35.0845
A-	7.622524	-7.2577	3.158000	7.15850	11.78725	36.7976
B+	6.651228	-10.6031	2.316500	5.95550	9.76200	23.3539
B	7.736606	-8.3097	2.271150	7.01950	11.42980	32.0883
B-	7.963857	-10.1129	3.245850	6.89560	11.69810	35.2920
C+	6.520024	-2.3323	1.600500	5.94865	9.35730	33.7259
C	6.555992	-10.4034	2.217175	5.42080	10.55387	27.4083
C-	6.963718	-15.1353	2.418125	7.95355	10.38620	21.1972
D+	6.877825	-9.0092	2.986825	7.17020	9.28525	33.7142
D	8.516735	-0.3620	3.581375	8.61685	11.64283	22.5959
D-	4.388357	1.6548	2.065950	2.36940	6.32255	9.9173

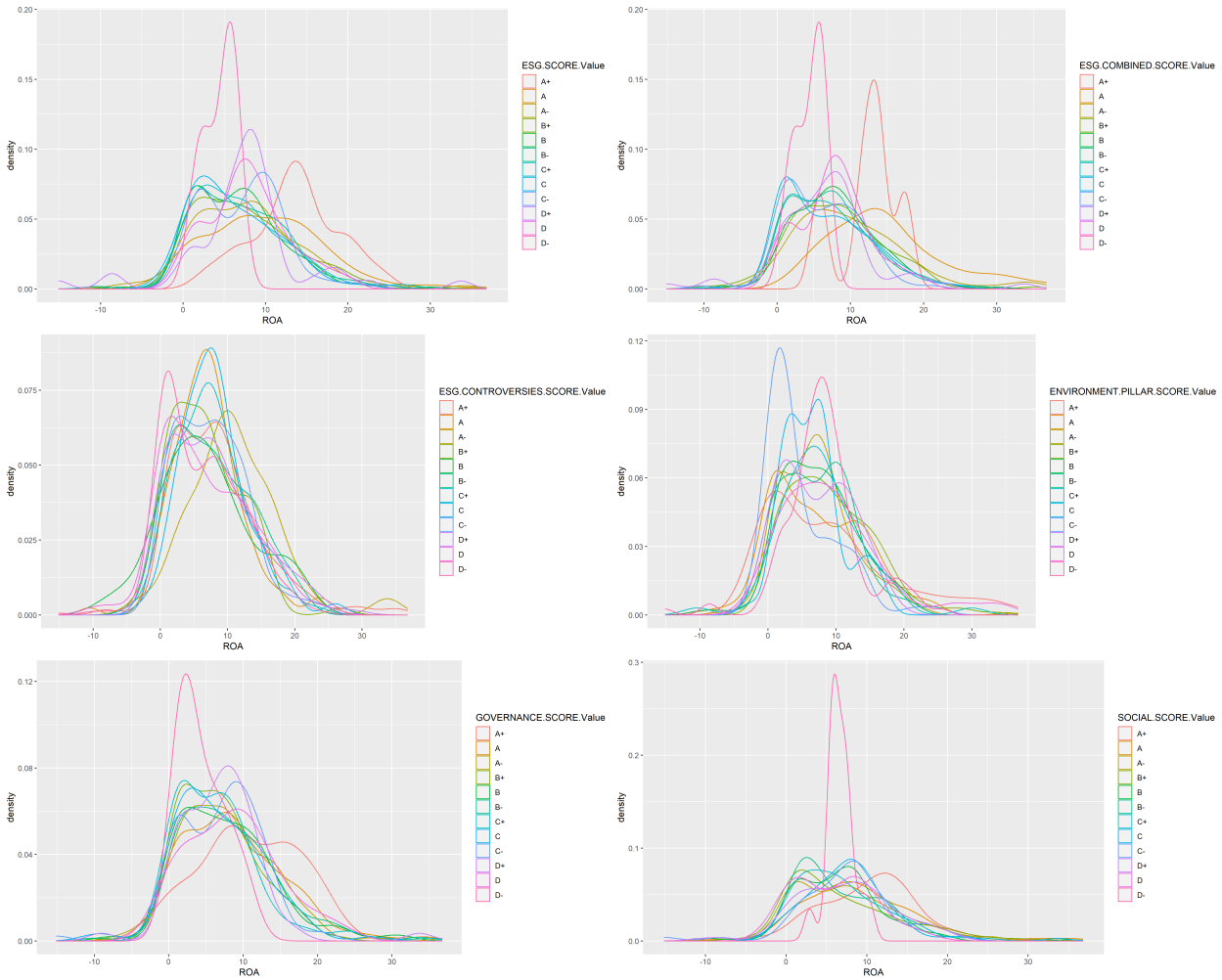
Table 18: ROA statistics by different SOCIAL SCORE

SOCIAL.SCORE.Value	Mean	Min	25%Quantile	Median	75%Quantile	Max
A+	10.222306	-8.3097	6.007050	10.95075	13.959450	28.5422
A	9.099915	-10.1129	4.361050	8.36015	12.994900	36.7976
A-	7.536311	-4.0576	1.614250	6.90225	11.495600	26.7259
B+	7.066315	-6.5719	1.530000	5.22640	11.084750	33.7586
B	6.393075	-10.6031	2.217375	6.38330	9.007750	35.0845
B-	6.543946	-2.2549	2.234450	5.06970	10.724900	22.4219
C+	6.801182	-2.8654	2.288250	6.14060	10.062550	24.8374
C	7.719442	-2.3323	4.262125	7.69160	10.161825	33.7142
C-	7.504684	-15.1353	4.514400	8.04390	10.701000	21.3451

SOCIAL.SCORE.Value	Mean	Min	25%Quantile	Median	75%Quantile	Max
D+	7.276159	-9.0092	2.634175	7.74620	10.680050	19.6006
D	5.898229	-0.3620	1.495275	6.89535	8.757375	15.6157
D-	6.670747	2.9152	5.702900	6.65510	7.491100	10.3891

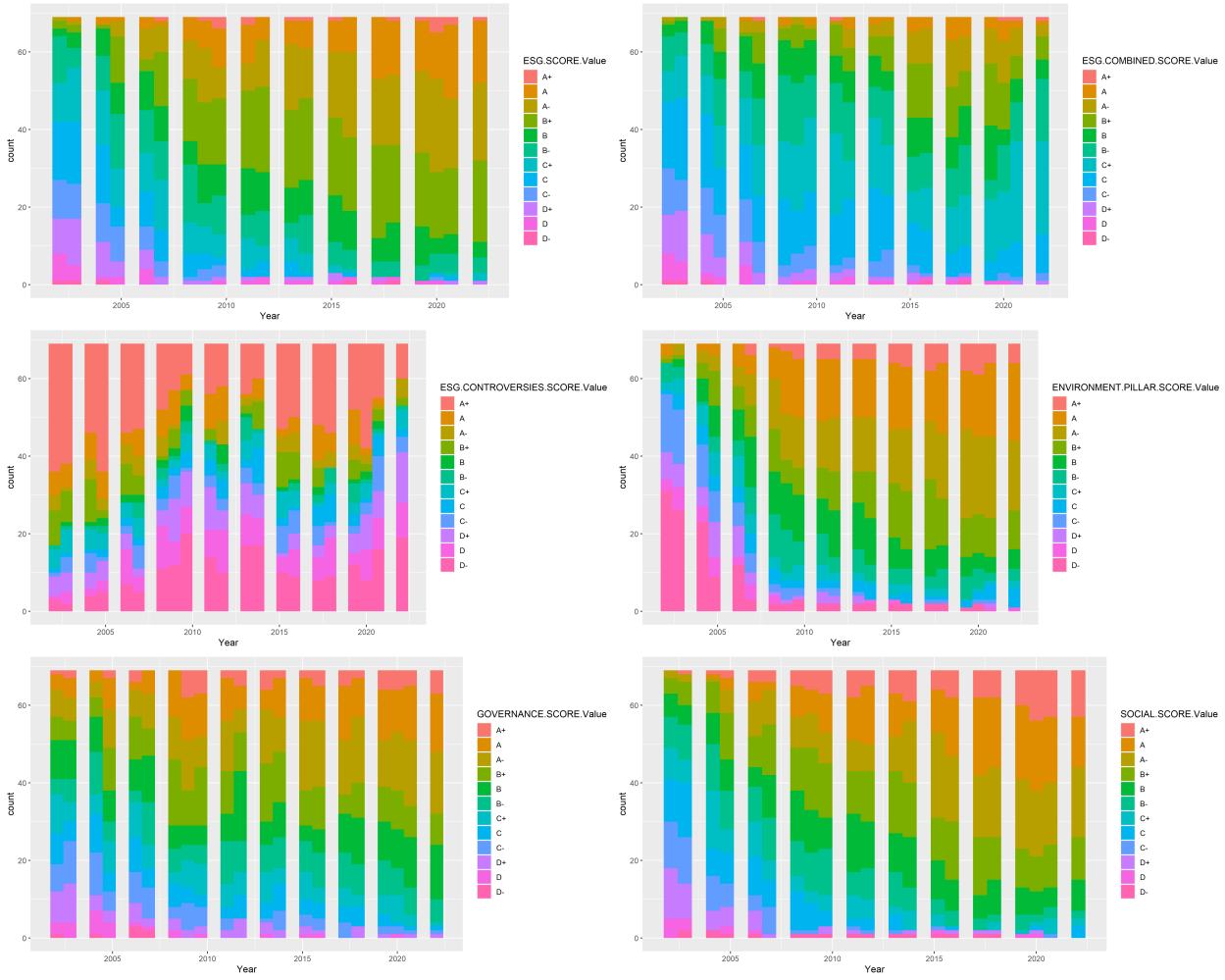


These box plots compare the Return on Assets (ROA) against different categories of ESG scores, ranging from 'A+' to 'D-', for companies in the S&P 500 index. The plots illustrate the central tendency and dispersion of ROA for each ESG category, revealing any potential outliers in the data. It is evident that the median ROA does not vary significantly across ESG scores, suggesting a more subtle or possibly indirect influence of ESG performance on asset returns. Additionally, the relatively consistent spread across categories implies that the ESG rating, while important, is just one of many factors that could influence the ROA.

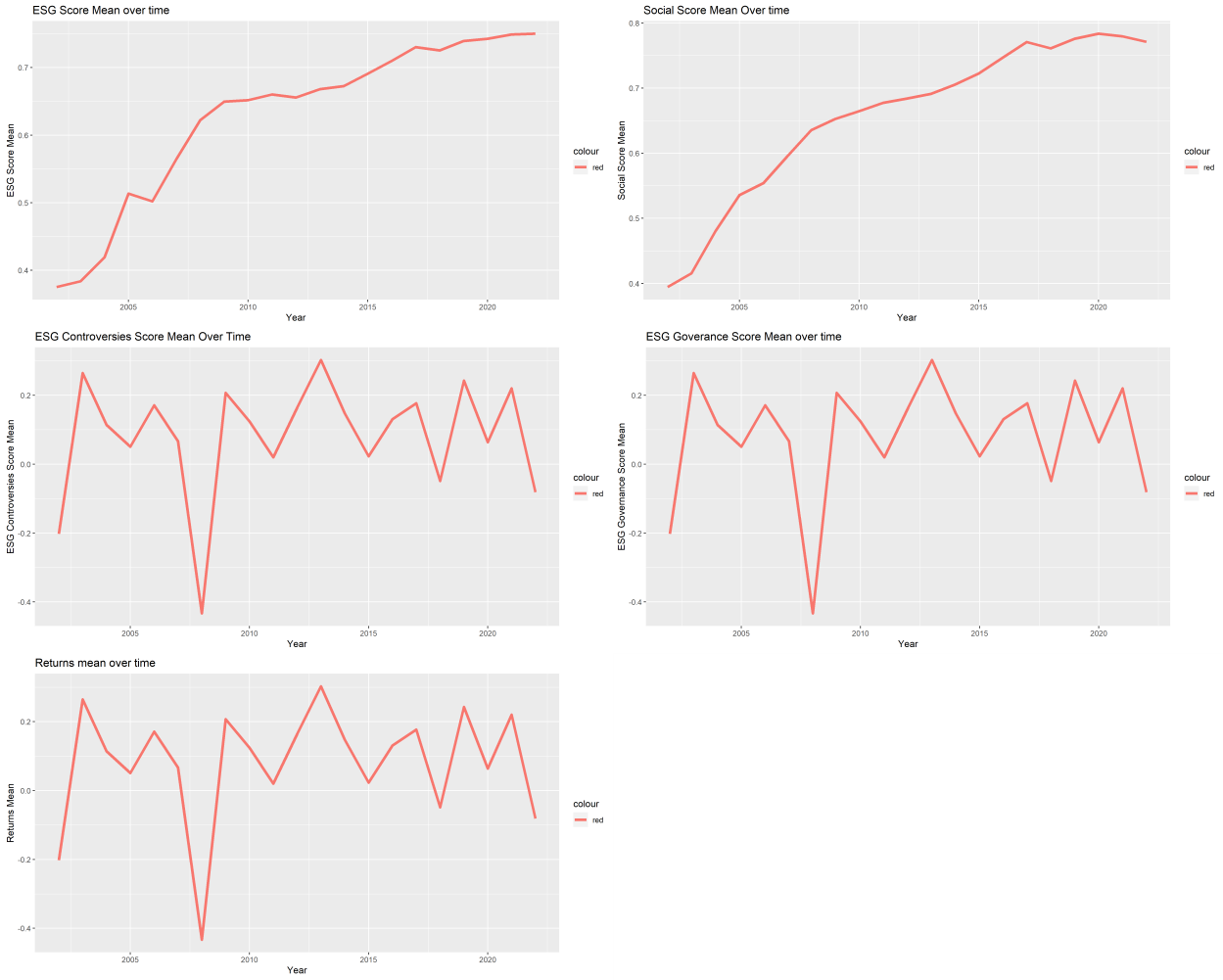


This set of density plots portrays the distribution of Return on Assets (ROA) for S&P 500 firms according to different ESG score categories: overall, controversies, combined, environmental, governance, and social scores. Each curve within the plots represents a different ESG rating, color-coded from 'A+' to 'D-'. The plots elucidate the distribution density and variability of ROA values associated with each ESG rating, offering a probabilistic view of asset return performance. A notable feature is the peak concentration around lower ROA values across all categories, suggesting a common central tendency. However, variations in the tail lengths and heights across different ratings indicate varying levels of ROA extremes and distribution shapes, reflecting the diverse impact of each ESG factor on asset profitability.

HOW DIFFERENT ESG SCORES CHANGED OVER TIME?



The stacked bar charts illustrate the distribution of ESG score categories over time, from 2002 to 2022, for companies within the S&P 500 index. Each colored segment of the bars corresponds to a specific ESG score, from 'A+' to 'D-', depicting the count of companies within each rating per year. These charts offer a visual timeline of the ESG score evolution, reflecting shifts in corporate sustainability and governance practices. The consistent layering across years suggests a stable distribution of ESG scores, while any changes in the thickness of the layers indicate shifts in the prevalence of certain ESG ratings over time. This visualization aids in understanding the dynamic landscape of corporate ESG performance in relation to evolving global sustainability trends.



The line graphs display the progression of mean ESG scores and financial returns for S&P 500 companies over two decades, from 2002 to 2022. The first graph shows a general upward trend in overall ESG scores, reflecting an increased commitment to sustainability. The second and fourth graphs depict fluctuations in ESG controversies and returns, indicating variability in corporate behavior and market reactions over time. The third graph's steady incline in social scores suggests a growing focus on social responsibility. Lastly, the governance scores exhibit stability with slight fluctuations, underscoring a consistent approach to corporate governance. These trends provide a longitudinal view of how ESG considerations and financial performance metrics evolve concurrently within the corporate landscape.

DO ESG SCORES EXPLAIN ROA, ROE OR RETURNS? (linear regression, stepwise selection)

for each regression we show results as follows:

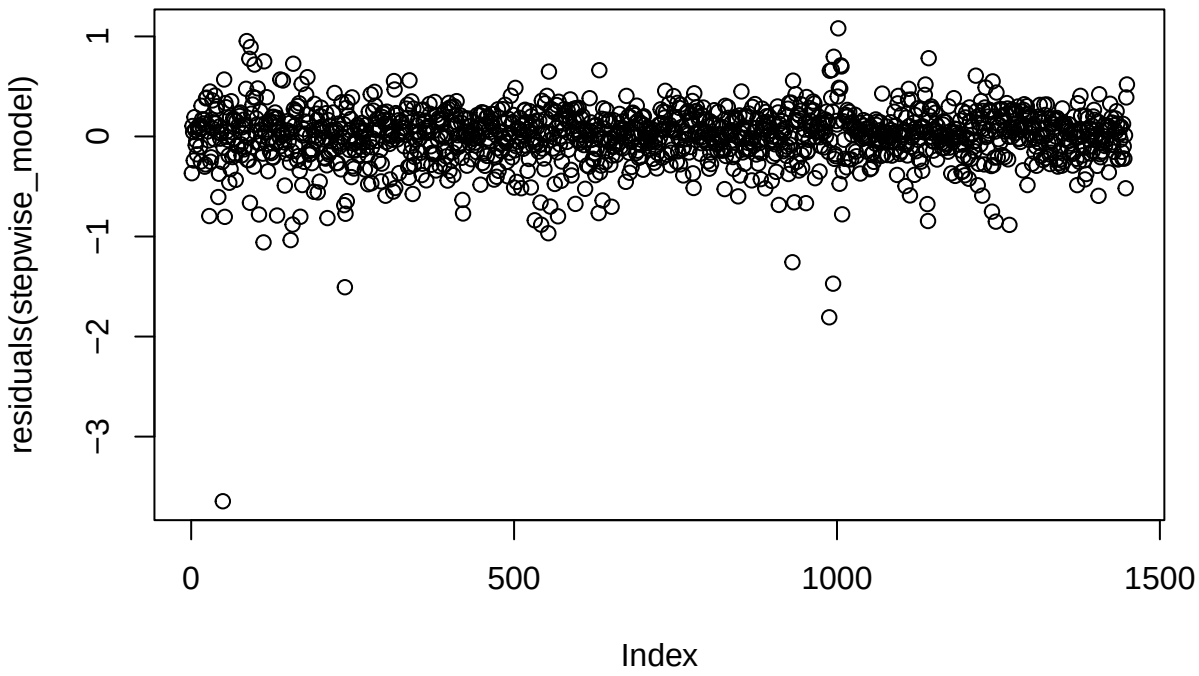
1. summary
2. VIF (multicollinearity issues)
3. mean of abs value of residuals
4. plot of residuals

For ROA regression we updated the regression 2 times in order to remove non significant variables and variables with the highest VIF

```
##
## Call:
## lm(formula = returns ~ EMISSIONS.SCORE_y + ENVIRONMENT.PILLAR.SCORE.Score +
##     ESG.COMBINED.SCORE.Score + HUMAN.RIGHTS.SCORE_y + WORKFORCE.SCORE_y,
##     data = Dataset)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -3.6461 -0.1304  0.0308  0.1592  1.0806
##
## Coefficients:
##                                Estimate Std. Error t value Pr(>|t|)
## (Intercept)                     0.07788    0.02940   2.649  0.00817 **
## EMISSIONS.SCORE_y               0.08000    0.04676   1.711  0.08729 .
## ENVIRONMENT.PILLAR.SCORE.Score -0.10196    0.05637  -1.809  0.07069 .
## ESG.COMBINED.SCORE.Score        0.11753    0.05508   2.134  0.03303 *
## HUMAN.RIGHTS.SCORE_y            0.04766    0.02670   1.785  0.07450 .
## WORKFORCE.SCORE_y              -0.08933    0.04643  -1.924  0.05457 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.2818 on 1443 degrees of freedom
## Multiple R-squared:  0.008526,   Adjusted R-squared:  0.00509
## F-statistic: 2.482 on 5 and 1443 DF,  p-value: 0.03007
```

```
##              EMISSIONS.SCORE_y ENVIRONMENT.PILLAR.SCORE.Score
##                       4.016959                       4.434409
##       ESG.COMBINED.SCORE.Score           HUMAN.RIGHTS.SCORE_y
##                       1.671072                       1.741152
##              WORKFORCE.SCORE_y
##                       1.818799
```

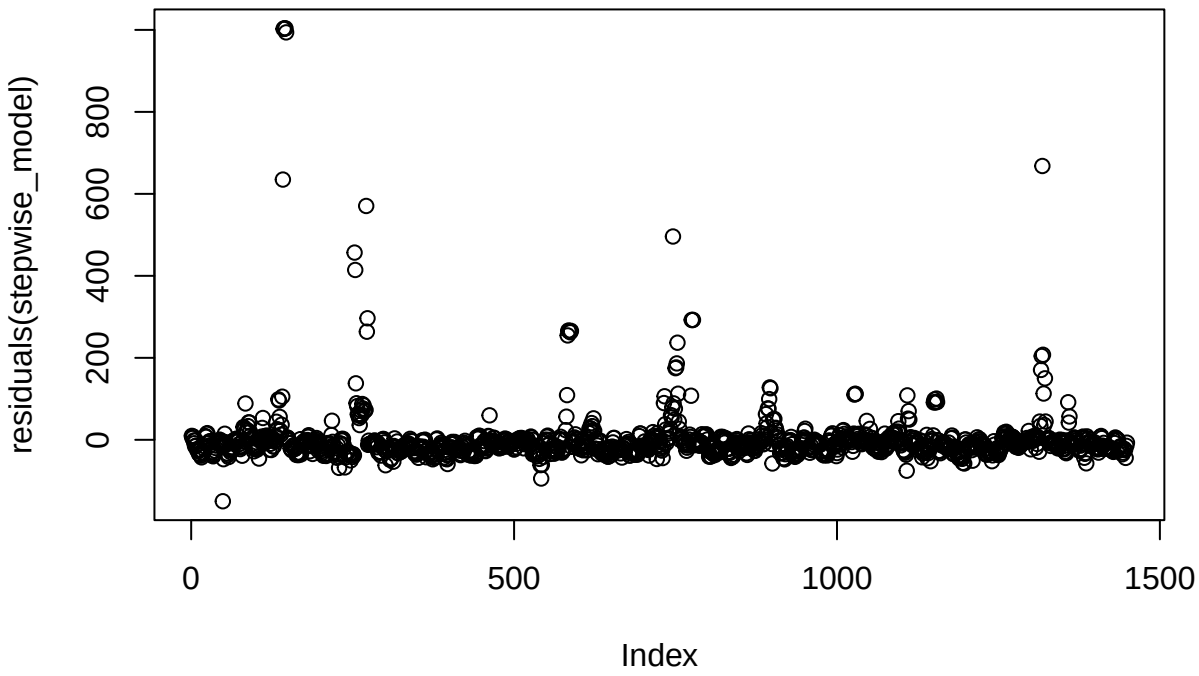
```
## [1] 0.1928763
```




```
##
## Call:
## lm(formula = ROE ~ ESG.COMBINED.SCORE.Score + HUMAN.RIGHTS.SCORE_y,
##     data = Dataset)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -149.85  -24.13  -11.05    0.69 1003.77
##
## Coefficients:
##                           Estimate Std. Error t value Pr(>|t|)
## (Intercept)                  8.602      6.379   1.349   0.1777
## ESG.COMBINED.SCORE.Score    25.479     13.486   1.889   0.0591 .
## HUMAN.RIGHTS.SCORE_y        26.772      6.405   4.180 3.09e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 79.07 on 1446 degrees of freedom
## Multiple R-squared:  0.02433,    Adjusted R-squared:  0.02298
## F-statistic: 18.03 on 2 and 1446 DF,  p-value: 1.84e-08

## ESG.COMBINED.SCORE.Score     HUMAN.RIGHTS.SCORE_y
##                 1.272275                 1.272275

## [1] 28.6824
```

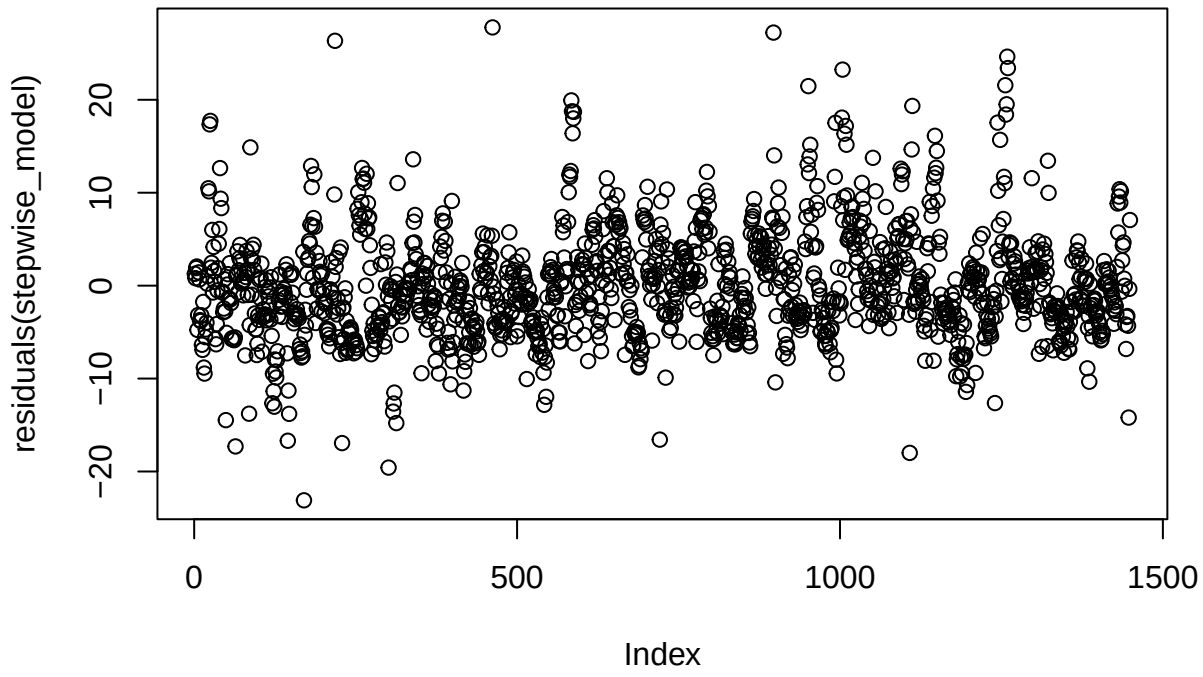



```
##
## Call:
## lm(formula = ROA ~ COMMUNITY.SCORE_y + ENVIRONMENT.PILLAR.SCORE.Score +
##     ESG.CONTROVERSIES.SCORE.Score + ESG.SCORE.Score + GOVERNANCE.SCORE.Score +
##     HUMAN.RIGHTS.SCORE_y + PRODUCT.RESPONSIBILITY.SCORE_y + RESOURCE.USE.SCORE_y +
##     SOCIAL.SCORE.Score + WORKFORCE.SCORE_y, data = Dataset)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -23.1006  -3.6609  -0.6077   2.8917  27.7869
##
## Coefficients:
##                                  Estimate Std. Error t value Pr(>|t|)
## (Intercept)                        3.0560     0.8534   3.581 0.000354 ***
## COMMUNITY.SCORE_y                  4.7092     1.4713   3.201 0.001401 **
## ENVIRONMENT.PILLAR.SCORE.Score   -17.5874     1.9931  -8.824  < 2e-16 ***
## ESG.CONTROVERSIES.SCORE.Score      2.2217     0.4340   5.119 3.48e-07 ***
## ESG.SCORE.Score                   38.6355     7.3060   5.288 1.43e-07 ***
## GOVERNANCE.SCORE.Score           -12.2053     2.5886  -4.715 2.65e-06 ***
## HUMAN.RIGHTS.SCORE_y               5.9266     1.0926   5.424 6.82e-08 ***
## PRODUCT.RESPONSIBILITY.SCORE_y     3.9815     1.0913   3.648 0.000273 ***
## RESOURCE.USE.SCORE_y               5.6739     1.0829   5.240 1.85e-07 ***
## SOCIAL.SCORE.Score               -32.8829     4.6347  -7.095 2.03e-12 ***
## WORKFORCE.SCORE_y                  8.4923     1.4991   5.665 1.78e-08 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
##
## Residual standard error: 5.763 on 1438 degrees of freedom
## Multiple R-squared:  0.1487, Adjusted R-squared:  0.1428
## F-statistic: 25.13 on 10 and 1438 DF,  p-value: < 2.2e-16
```

```
##              COMMUNITY.SCORE_y ENVIRONMENT.PILLAR.SCORE.Score
##                       3.576240                      13.254290
##  ESG.CONTROVERSIES.SCORE.Score               ESG.SCORE.Score
##                       1.147010                      89.799070
##         GOVERNANCE.SCORE.Score          HUMAN.RIGHTS.SCORE_y
##                      13.294246                       6.968927
## PRODUCT.RESPONSIBILITY.SCORE_y          RESOURCE.USE.SCORE_y
##                       5.697383                       5.581127
##             SOCIAL.SCORE.Score             WORKFORCE.SCORE_y
##                      42.623280                       4.532089
```

```
## [1] 4.294653
```

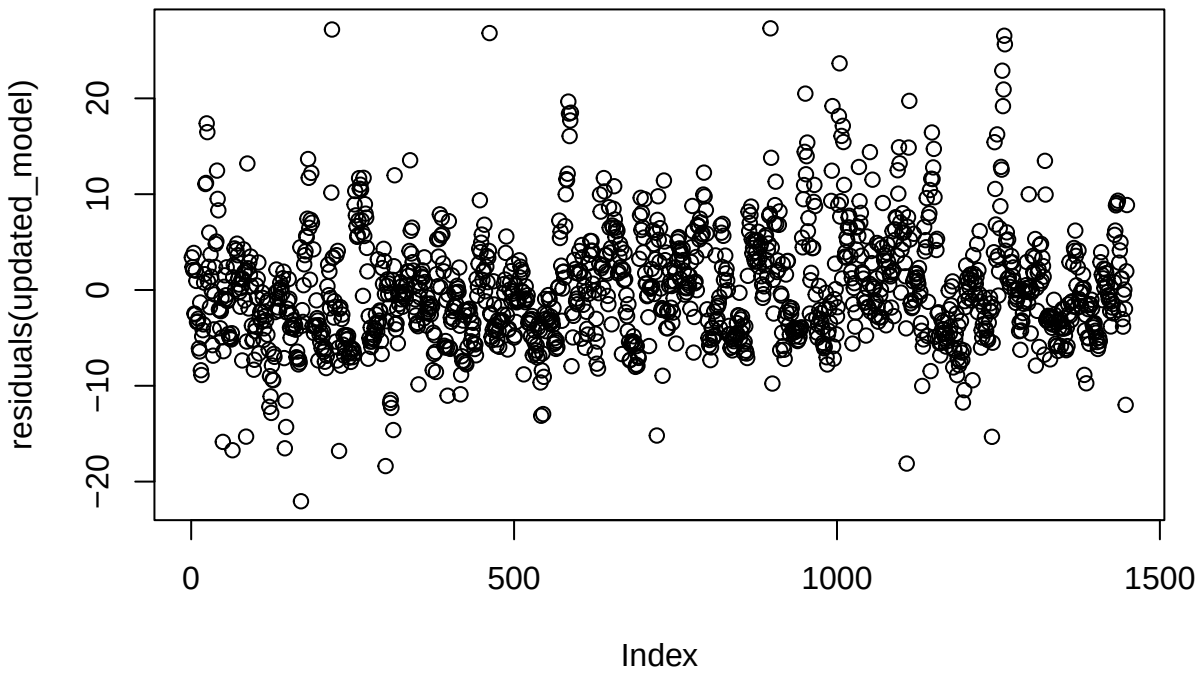



```
##
## Call:
## lm(formula = ROA ~ COMMUNITY.SCORE_y + ENVIRONMENT.PILLAR.SCORE.Score +
##     ESG.CONTROVERSIES.SCORE.Score + GOVERNANCE.SCORE.Score +
##     HUMAN.RIGHTS.SCORE_y + PRODUCT.RESPONSIBILITY.SCORE_y + RESOURCE.USE.SCORE_y +
##     WORKFORCE.SCORE_y, data = Dataset)
##
```

```
## Residuals:
##      Min       1Q   Median       3Q      Max
## -22.0515  -3.9899  -0.6806   3.1294  27.3099
##
## Coefficients:
##                                 Estimate Std. Error t value Pr(>|t|)
## (Intercept)                       2.8548     0.8658   3.297    0.001 ***
## COMMUNITY.SCORE_y                -0.3561     0.9739  -0.366    0.715
## ENVIRONMENT.PILLAR.SCORE.Score -11.1504     1.2672  -8.800  < 2e-16 ***
## ESG.CONTROVERSIES.SCORE.Score    2.5486     0.4378   5.821 7.20e-09 ***
## GOVERNANCE.SCORE.Score           1.2043     0.8443   1.426    0.154
## HUMAN.RIGHTS.SCORE_y             2.7943     0.5664   4.933 9.03e-07 ***
## PRODUCT.RESPONSIBILITY.SCORE_y   0.3933     0.5815   0.676    0.499
## RESOURCE.USE.SCORE_y             7.6208     1.0676   7.138 1.50e-12 ***
## WORKFORCE.SCORE_y                4.1858     1.0101   4.144 3.61e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 5.866 on 1440 degrees of freedom
## Multiple R-squared:  0.1169, Adjusted R-squared:  0.1119
## F-statistic: 23.82 on 8 and 1440 DF,  p-value: < 2.2e-16
```

```
##              COMMUNITY.SCORE_y ENVIRONMENT.PILLAR.SCORE.Score
##                       1.512475                       5.171086
##  ESG.CONTROVERSIES.SCORE.Score         GOVERNANCE.SCORE.Score
##                       1.126907                       1.365129
##           HUMAN.RIGHTS.SCORE_y PRODUCT.RESPONSIBILITY.SCORE_y
##                       1.807749                       1.561308
##           RESOURCE.USE.SCORE_y              WORKFORCE.SCORE_y
##                       5.236035                       1.985805
```

```
## [1] 4.294653
```

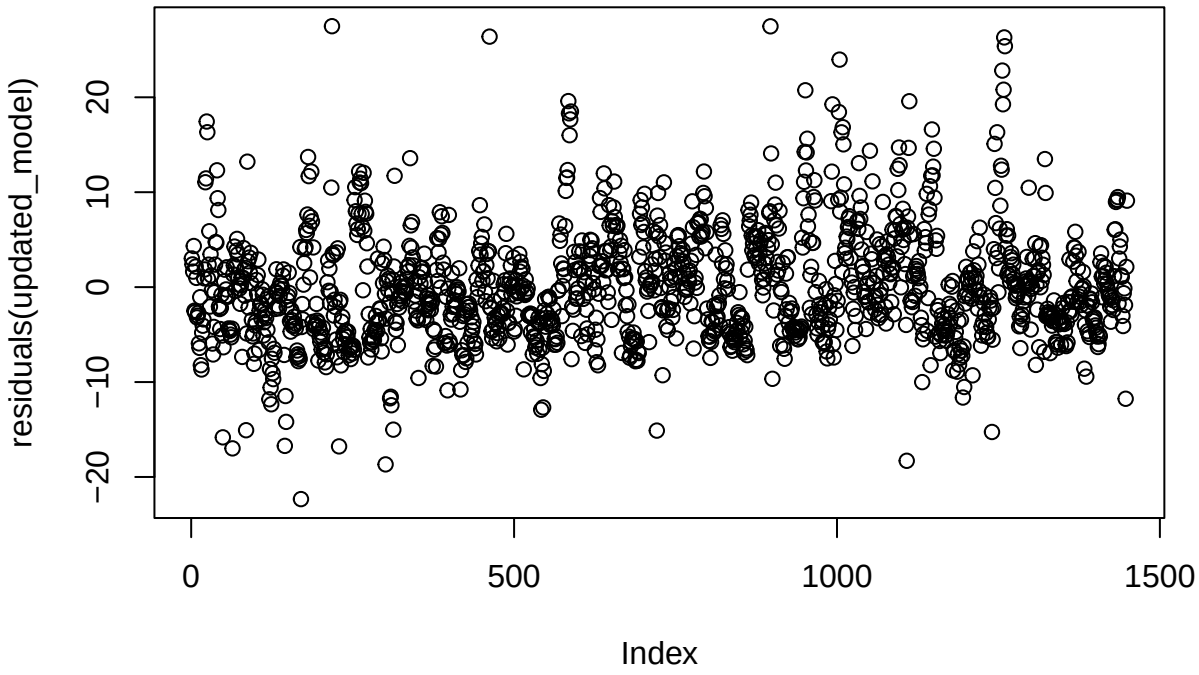



```
##
## Call:
## lm(formula = ROA ~ ENVIRONMENT.PILLAR.SCORE.Score + ESG.CONTROVERSIES.SCORE.Score +
##     HUMAN.RIGHTS.SCORE_y + RESOURCE.USE.SCORE_y + WORKFORCE.SCORE_y,
##     data = Dataset)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -22.330  -4.030  -0.648   3.128  27.487
##
## Coefficients:
##                                Estimate Std. Error t value Pr(>|t|)
## (Intercept)                      3.1579     0.6736   4.688 3.01e-06 ***
## ENVIRONMENT.PILLAR.SCORE.Score -10.8874     1.2370  -8.802  < 2e-16 ***
## ESG.CONTROVERSIES.SCORE.Score    2.5318     0.4370   5.793 8.48e-09 ***
## HUMAN.RIGHTS.SCORE_y             2.9658     0.5561   5.333 1.12e-07 ***
## RESOURCE.USE.SCORE_y             7.7047     1.0650   7.234 7.57e-13 ***
## WORKFORCE.SCORE_y                4.3183     0.9335   4.626 4.07e-06 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 5.866 on 1443 degrees of freedom
## Multiple R-squared:  0.1151, Adjusted R-squared:  0.112
## F-statistic: 37.52 on 5 and 1443 DF,  p-value: < 2.2e-16

## ENVIRONMENT.PILLAR.SCORE.Score  ESG.CONTROVERSIES.SCORE.Score
```

```
##                     4.927739                     1.122928
##          HUMAN.RIGHTS.SCORE_y          RESOURCE.USE.SCORE_y
##                     1.742670                     5.210877
##             WORKFORCE.SCORE_y
##                     1.696339
```

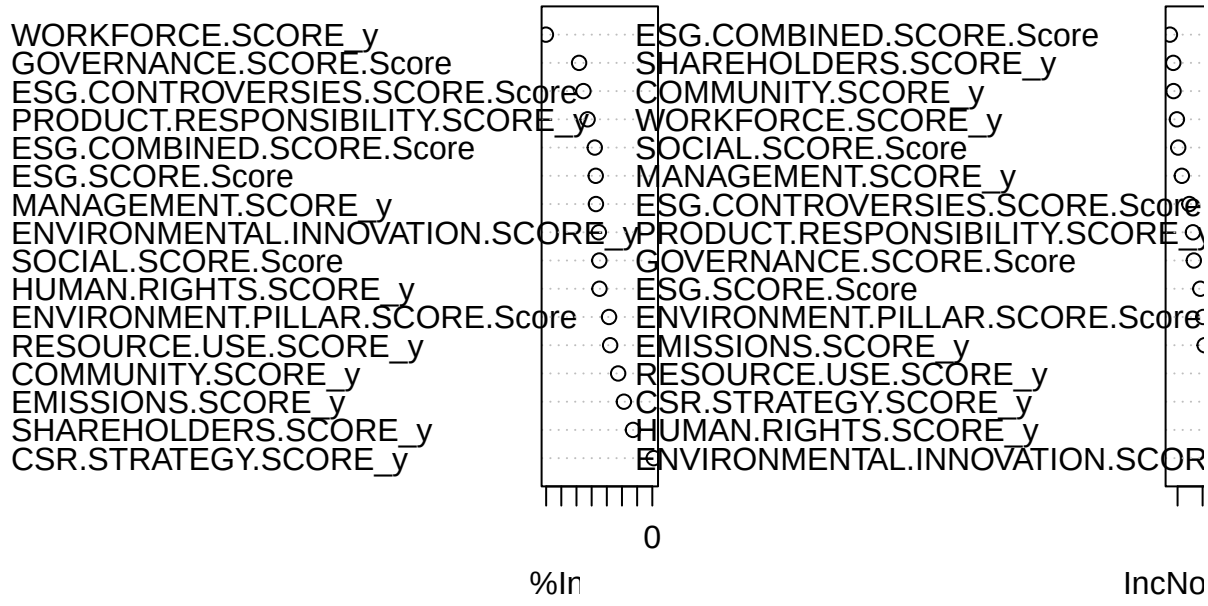
```
## [1] 4.294653
```



DO ESG SCORES EXPLAIN ROA, ROE OR RETURNS? (random forest)

```
##
## Call:
##  randomForest(formula = returns ~ . - Year - Primary.Ticker -      ROA - ROE, data = Dataset, importa
##                Type of random forest: regression
##                      Number of trees: 500
## No. of variables tried at each split: 5
##
##           Mean of squared residuals: 0.0880351
##                     % Var explained: -10.39
```

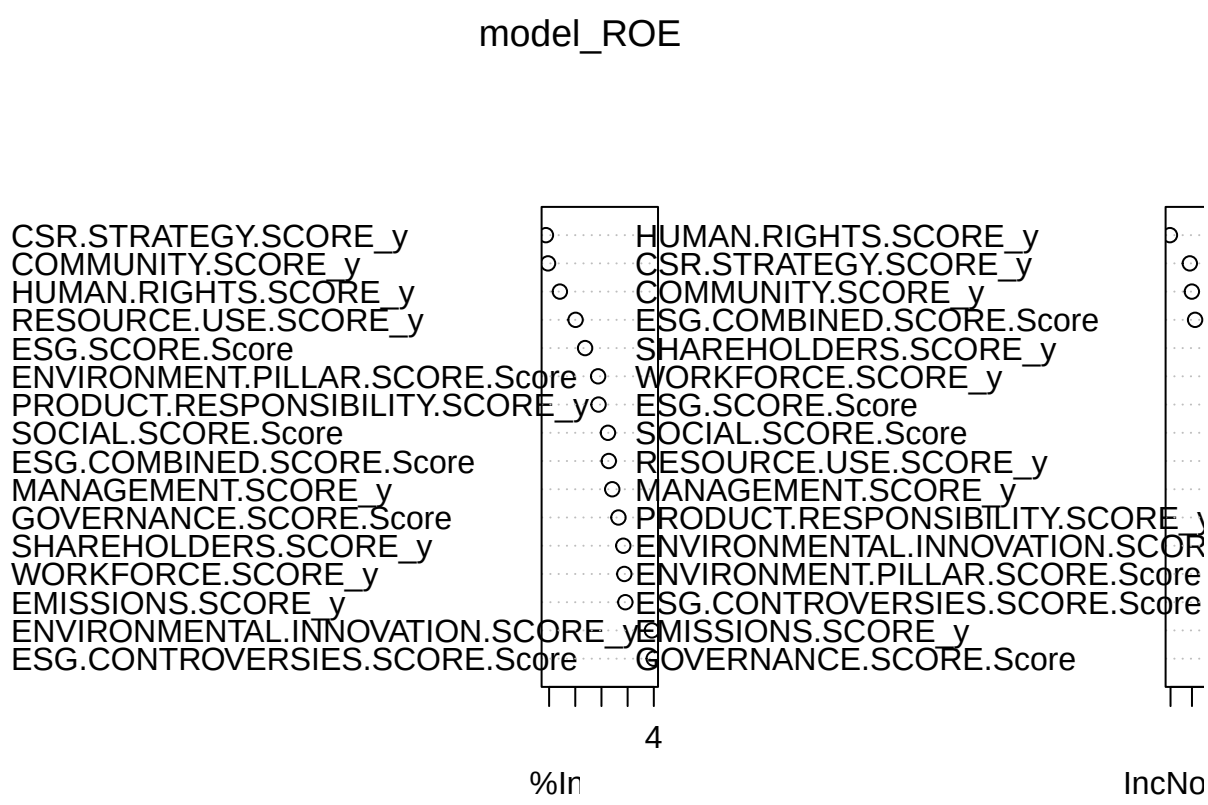
	%IncMSE	IncNodePurity
COMMUNITY.SCORE_y	4.505096	8.321733
CSR.STRATEGY.SCORE_y	-0.183271	4.790884
EMISSIONS.SCORE_y	3.747862	5.838952
ENVIRONMENT.PILLAR.SCORE.Score	5.706514	5.950523
ENVIRONMENTAL.INNOVATION.SCORE_y	7.053802	4.262141
ESG.COMBINED.SCORE.Score	7.589193	8.612910
ESG.CONTROVERSIES.SCORE.Score	9.086379	7.060841
ESG.SCORE.Score	7.461819	6.183414
GOVERNANCE.SCORE.Score	9.656833	6.702799
HUMAN.RIGHTS.SCORE_y	6.970684	4.592217
MANAGEMENT.SCORE_y	7.432184	7.659850
PRODUCT.RESPONSIBILITY.SCORE_y	8.535684	6.773703
RESOURCE.USE.SCORE_y	5.559117	4.966973
SHAREHOLDERS.SCORE_y	2.547269	8.344541
SOCIAL.SCORE.Score	6.987308	7.949844
WORKFORCE.SCORE_y	14.031976	8.054934




```
##
## Call:
##  randomForest(formula = ROE ~ . - Year - Primary.Ticker - ROA -      returns, data = Dataset, importa
##                Type of random forest: regression
##                      Number of trees: 500
## No. of variables tried at each split: 5
##
##           Mean of squared residuals: 5379.191
##                     % Var explained: 15.88

##                                   %IncMSE IncNodePurity
## COMMUNITY.SCORE_y                12.083240      801064.5
## CSR.STRATEGY.SCORE_y             12.244315      820289.2
## EMISSIONS.SCORE_y                 6.176215      325247.7
## ENVIRONMENT.PILLAR.SCORE.Score    8.254661      369727.8
## ENVIRONMENTAL.INNOVATION.SCORE_y  4.145974      377246.3
## ESG.COMBINED.SCORE.Score          7.439646      770989.1
## ESG.CONTROVERSIES.SCORE.Score     4.007837      334426.2
## ESG.SCORE.Score                   9.250602      494799.1
## GOVERNANCE.SCORE.Score            6.701876      325093.2
## HUMAN.RIGHTS.SCORE_y             11.177414     1005923.9
## MANAGEMENT.SCORE_y                7.175685      390860.2
## PRODUCT.RESPONSIBILITY.SCORE_y    8.223749      389732.3
## RESOURCE.USE.SCORE_y              9.978171      408846.7
## SHAREHOLDERS.SCORE_y              6.332682      603560.3
```

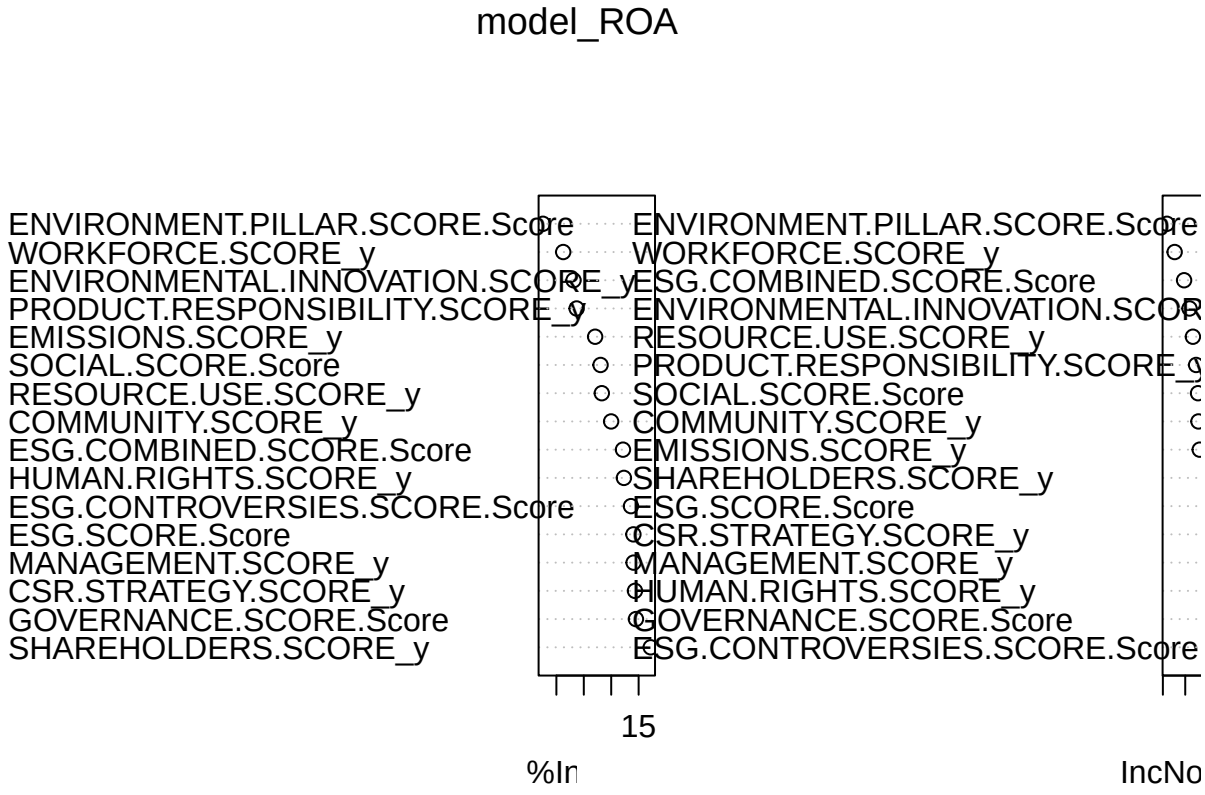
```
## SOCIAL.SCORE.Score                7.503128      428157.0
## WORKFORCE.SCORE_y                 6.253965      563090.1
```




```
##
## Call:
##  randomForest(formula = ROA ~ . - Year - Primary.Ticker - ROE -      returns, data = Dataset, importa
##                Type of random forest: regression
##                      Number of trees: 500
## No. of variables tried at each split: 5
##
##           Mean of squared residuals: 25.93302
##                     % Var explained: 33.03

##                                   %IncMSE IncNodePurity
## COMMUNITY.SCORE_y                20.01447      3407.948
## CSR.STRATEGY.SCORE_y             15.66824      2819.684
## EMISSIONS.SCORE_y                22.93501      3352.414
## ENVIRONMENT.PILLAR.SCORE.Score   32.45824      4819.304
## ENVIRONMENTAL.INNOVATION.SCORE_y 26.87503      3808.839
## ESG.COMBINED.SCORE.Score         17.85652      4050.556
## ESG.CONTROVERSIES.SCORE.Score    16.39721      2318.266
## ESG.SCORE.Score                  15.95569      2895.381
## GOVERNANCE.SCORE.Score           15.49448      2565.131
## HUMAN.RIGHTS.SCORE_y             17.68606      2689.748
## MANAGEMENT.SCORE_y               15.91945      2812.634
```

```
## PRODUCT.RESPONSIBILITY.SCORE_y   26.30826      3512.954
## RESOURCE.USE.SCORE_y             21.72010      3657.275
## SHAREHOLDERS.SCORE_y             12.79908      2913.752
## SOCIAL.SCORE.Score               21.94449      3427.713
## WORKFORCE.SCORE_y                28.75722      4473.377
```



CONCLUSIONS, RESULTS AND METHODS EMPLOYED

Initially, the ESG scores of companies in the SEP500 index underwent scrutiny. However, the analysis revealed a lack of significant qualitative data for many companies. Consequently, after multiple data cleaning stages involving the elimination of missing values and suspicious data points, a more robust sample of 69 companies was deemed suitable for further analysis.

The dataset was categorized into two distinctive segments:

Variables encompassing ESG scores graded from A+ to D-. Numeric values representing ESG scores on a scale from 0 to 1.

Considered ESG Score Variables:

The analysis encompassed several ESG score variables, including COMMUNITY.SCORE, CSR.STRATEGY.SCORE, EMISSIONS.SCORE, ENVIRONMENT.PILLAR.SCORE, ENVIRONMENTAL.INNOVATION.SCORE, ESG.COMBINED.SCORE, ESG.CONTROVERSIES.SCORE, ESG.SCORE, GOVERNANCE.SCORE, HUMAN.RIGHTS.SCORE, MANAGEMENT.SCORE, PRODUCT.RESPONSIBILITY.SCORE, RESOURCE.USE.SCORE, SHAREHOLDERS.SCORE, SOCIAL.SCORE, and WORKFORCE.SCORE. Initially, we focused on core variables such as ESG score, ESG combined score, ESG controversies score, environmental pillar score, governance score, and social score for analysis, later integrating other variables into regression models.

Relationship with ROE and ROA:

A notable correlation is evident between changes in ESG scores over time and the returns of the 69 companies, particularly concerning Return on Equity (ROE) and Return on Assets (ROA). Higher ESG scores appear linked to greater ROE and ROA, while lower scores correlate with reduced returns.

ESG Scores Over Time:

There's an observed increase in average ESG scores over the years, notably post the 2007-2008 financial crisis. However, the Combined ESG Score doesn't show a consistent upward trend; instead, there's a decline post the COVID-19 crisis. Trends of Specific ESG Scores: While the Controversial Score diminishes over time, scores pertaining to Environmental, Social, and Governance exhibit an upward trend.

Returns Regression Analysis:

The stepwise regression technique was employed to assess the relationship between ESG scores (EMISSIONS.SCORE_y, ENVIRONMENT.PILLAR.SCORE.Score, ESG.COMBINED.SCORE.Score, HUMAN.RIGHTS.SCORE_y, WORKFORCE.SCORE_y) and returns. However, the resulting model displays a relatively low R-squared value of 0.008526, indicating that the included ESG scores explain only about 0.85% of the variance in returns. Despite employing stepwise selection, only the ESG.COMBINED.SCORE.Score exhibits significant impact (p-value: 0.03303). Low R-squared: An R-squared of 0.85% for the ESG Combined Score indicates that only 0.85% of the variance in financial returns can be explained by this specific ESG score, suggesting a weak or insignificant correlation. In our inference analysis, ESG scores do not directly predict returns. Therefore, we could assert that Eugene Fama's theory, stating that prices incorporate all necessary information, cannot be confirmed solely by ESG factors in our case. There are likely other influencing factors on prices and returns. It might be necessary to incorporate macroeconomic and microeconomic data (control factors) to achieve more relevant results. Regarding the VIF (Variance Inflation Factor), we do not have multicollinearity. Through stepwise selection, we observe that only two features are significant: ESG combined score and human rights score. Particularly, the human rights score shows a highly significant p-value, with a very small p-value from the F-test. However, the R-squared indicates a poor explanatory capacity of the model.

ROE Regression Analysis:

Using stepwise regression, the model investigating Return on Equity (ROE) shows an R-squared value of 0.02433. This implies that the ESG.COMBINED.SCORE.Score and HUMAN.RIGHTS.SCORE_y

together explain approximately 2.43% of the variance in ROE. However, only the coefficient for HUMAN.RIGHTS.SCORE_y demonstrates significant impact (p-value: 3.09e-05), while ESG.COMBINED.SCORE.Score shows marginal significance (p-value: 0.0591).

ROA Regression Analysis:

Similarly employing stepwise regression, the model examining Return on Assets (ROA) shows a more substantial R-squared value of 0.1487, indicating that the included ESG scores collectively explain around 14.87% of the variance in ROA. Most ESG scores exhibit statistical significance, suggesting their substantive impact on explaining variations in ROA. This result seems to be really good for our analysis. These findings highlight that other unmeasured variables or complex relationships may significantly influence financial outcomes, warranting further investigation into a broader range of factors to comprehensively understand their impact on financial performance. As for the regression of ROA (Return on Assets) on ESG factors, we detect high multicollinearity among the following features: ESG.SCORE.Score and SOCIAL.SCORE.Score. Given that these are the main categories, it is normal for them to be affected by multicollinearity since the dataset includes subcategories. Therefore, we eliminate these factors and also remove the non-significant factors (COMMUNITY.SCORE_y, GOVERNANCE.SCORE.Score and PRODUCT.RESPONSIBILITY.SCORE_y). We still have an RSquared equal to almost 12%. Therefore we lose a little bit of information, but the coefficients will be more stable.

Possible Considerations:

Complexity of Relationships: Relationships between ESG scores and financial returns might be intricate and nonlinear, making their identification through linear analysis challenging. CONSIDERING OTHER VARIABLES: Consideration of additional variables: Evaluating the inclusion of other pertinent variables that might influence financial returns, such as macroeconomic indicators, sector-specific data, or alternative financial metrics.

Random Forest:

Through the implementation of the Random Forest as a machine learning model, we observed a significant improvement in the explained variance percentage compared to other approaches. The Random Forest used to predict ROE demonstrated an explained variance percentage of 14.97%, suggesting a good ability of the model to capture data patterns. This model, consisting of 500 trees, resulted in a mean squared error of 5437.287, indicating a reasonable fit of the data to the model. Analysis on variable importance revealed that factors such as combined ESG score, community score, aspects related to human rights, and CSR strategy are among the most relevant in determining ROE. These findings suggest that assessments related to corporate social responsibility, along with strategic and governance aspects, could play a crucial role in predicting equity returns. The Random Forest model trained to predict ROA showed an explained variance percentage of 32.63%, emphasizing the robustness of the model in interpreting data patterns. Comprising 500 trees, the model highlighted a mean squared error of 26.08658, indicating a good level of adaptation to the data. From the analysis of variable importance, factors like environmental score, environmental innovation, resource management, and workforce score stand out as some of the most influential in predicting Return on Assets. These results suggest that indicators related to environmental management, resource efficiency, and workforce involvement could significantly impact determining a company's asset profitability.

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Team Members Contribution

Lorenzo Ausiello: My skills and my knowledge were applied to perform stepwise linear regression in order to assess relationship between financial performances and ESG factors. My contribution was related to discover changes of ESG scores over time as well.

Fabrizio Dimino: In this work, my contribution was related to creating a strong topic, since I have a strong interest in sustainable finance. Furthermore, I applied all the skills that I learned during the course and I care more about random forest technique.

Samuele Mugnai: In this work, my skills and my Knowledge were applied to conduct many steps of Exploratory Data Analysis and the build-up of the Paper and Presentation. After performing statistics analysis about the distribution of ESG scores over time, I used my time to create a insightful and clear pdf report.

Sun Bo: mainly responsible for processing basic data, standardizing the report output format, and improving the report content.

APPENDIX

Summary Dataset.csv

```
##       Year      Primary.Ticker     COMMUNITY.SCORE_y CSR.STRATEGY.SCORE_y
##  Min.   :2002   Length:1449        Min.   :0.01053   Min.   :0.0000
##  1st Qu.:2007   Class :character   1st Qu.:0.78387   1st Qu.:0.3185
##  Median :2012   Mode  :character   Median :0.90464   Median :0.6977
##  Mean   :2012                      Mean   :0.83473   Mean   :0.5886
##  3rd Qu.:2017                      3rd Qu.:0.96354   3rd Qu.:0.8790
##  Max.   :2022                      Max.   :0.99942   Max.   :0.9994
##  EMISSIONS.SCORE_y ENVIRONMENT.PILLAR.SCORE.Score
##  Min.   :0.0000    Min.   :0.0000
##  1st Qu.:0.5096    1st Qu.:0.4487
##  Median :0.7634    Median :0.6879
##  Mean   :0.6540    Mean   :0.6060
##  3rd Qu.:0.9028    3rd Qu.:0.8227
##  Max.   :0.9992    Max.   :0.9855
##  ENVIRONMENTAL.INNOVATION.SCORE_y ESG.COMBINED.SCORE.Score
##  Min.   :0.0000                   Min.   :0.03467
##  1st Qu.:0.0000                   1st Qu.:0.38806
##  Median :0.4375                   Median :0.48599
##  Mean   :0.3995                   Mean   :0.50367
##  3rd Qu.:0.7429                   3rd Qu.:0.62950
##  Max.   :0.9944                   Max.   :0.93579
##  ESG.CONTROVERSIES.SCORE.Score ESG.SCORE.Score   GOVERNANCE.SCORE.Score
##  Min.   :0.006173              Min.   :0.03467   Min.   :0.05516
##  1st Qu.:0.166667              1st Qu.:0.50235   1st Qu.:0.48172
##  Median :0.551282              Median :0.68140   Median :0.65571
##  Mean   :0.548488              Mean   :0.62745   Mean   :0.62312
##  3rd Qu.:1.000000              3rd Qu.:0.77246   3rd Qu.:0.79969
##  Max.   :1.000000              Max.   :0.95162   Max.   :0.98527
##  HUMAN.RIGHTS.SCORE_y MANAGEMENT.SCORE_y PRODUCT.RESPONSIBILITY.SCORE_y
##  Min.   :0.0000       Min.   :0.006329   Min.   :0.0000
##  1st Qu.:0.0000       1st Qu.:0.423234   1st Qu.:0.3333
##  Median :0.5000       Median :0.674888   Median :0.6842
##  Mean   :0.4397       Mean   :0.627844   Mean   :0.5839
##  3rd Qu.:0.7951       3rd Qu.:0.860917   3rd Qu.:0.8723
##  Max.   :0.9900       Max.   :0.999496   Max.   :0.9961
##  RESOURCE.USE.SCORE_y SHAREHOLDERS.SCORE_y SOCIAL.SCORE.Score WORKFORCE.SCORE_y
##  Min.   :0.0000       Min.   :0.001152     Min.   :0.01387    Min.   :0.01351
##  1st Qu.:0.5000       1st Qu.:0.457416     1st Qu.:0.52645    1st Qu.:0.62548
##  Median :0.8012       Median :0.681343     Median :0.69806    Median :0.79333
##  Mean   :0.6670       Mean   :0.630380     Mean   :0.65703    Mean   :0.74201
##  3rd Qu.:0.9299       3rd Qu.:0.837739     3rd Qu.:0.82171    3rd Qu.:0.91327
##  Max.   :0.9992       Max.   :0.999502     Max.   :0.98118    Max.   :0.99878
##     returns              ROA                ROE
##  Min.   :-3.59451   Min.   :-15.135   Min.   :-134.27
##  1st Qu.:-0.03938   1st Qu.:  2.638   1st Qu.:  11.24
##  Median : 0.10887   Median :  7.046   Median :  18.66
##  Mean   : 0.08229   Mean   :  7.596   Mean   :  33.21
##  3rd Qu.: 0.24197   3rd Qu.: 11.213   3rd Qu.:  28.56
##  Max.   : 1.18467   Max.   : 36.798   Max.   :1048.62
```

Summary Dataset2.csv

```
##       Year      Primary.Ticker     COMMUNITY.SCORE_x  CSR.STRATEGY.SCORE_x
##  Min.   :2002   Length:1449        Length:1449        Length:1449
##  1st Qu.:2007   Class :character   Class :character   Class :character
##  Median :2012   Mode  :character   Mode  :character   Mode  :character
##  Mean   :2012
##  3rd Qu.:2017
##  Max.   :2022
##
##  EMISSIONS.SCORE_x  ENVIRONMENT.PILLAR.SCORE.Value
##  Length:1449        A-     :260
##  Class :character   A      :253
##  Mode  :character   B+     :190
##                     B      :161
##                     D-     :130
##                     B-     :106
##                     (Other):349
##  ENVIRONMENTAL.INNOVATION.SCORE_x ESG.COMBINED.SCORE.Value
##  Length:1449                      C+     :303
##  Class :character                 C      :263
##  Mode  :character                 B-     :232
##                                   B      :158
##                                   B+     :147
##                                   C-     :101
##                                   (Other):245
##  ESG.CONTROVERSIES.SCORE.Value ESG.SCORE.Value GOVERNANCE.SCORE.Value
##  A+     :400                   B+     :323     A-     :243
##  D-     :218                   A-     :259     B+     :204
##  D      :134                   A      :167     B      :192
##  D+     :124                   B      :165     A      :191
##  A      :113                   B-     :158     B-     :152
##  B+     : 98                   C+     :121     C+     :120
##  (Other):362                   (Other):256     (Other):347
##  HUMAN.RIGHTS.SCORE_x MANAGEMENT.SCORE_x PRODUCT.RESPONSIBILITY.SCORE_x
##  Length:1449          Length:1449        Length:1449
##  Class :character     Class :character   Class :character
##  Mode  :character     Mode  :character   Mode  :character
##
##
##
##
##  RESOURCE.USE.SCORE_x SHAREHOLDERS.SCORE_x SOCIAL.SCORE.Value
##  Length:1449          Length:1449          B+     :239
##  Class :character     Class :character     A-     :236
##  Mode  :character     Mode  :character     A      :208
##                                            B      :184
##                                            B-     :143
##                                            A+     :122
##                                            (Other):317
##  WORKFORCE.SCORE_x     returns              ROA                ROE
##  Length:1449        Min.   :-3.59451   Min.   :-15.135   Min.   :-134.27
##  Class :character   1st Qu.:-0.03938   1st Qu.:  2.638   1st Qu.:  11.24
##  Mode  :character   Median : 0.10887   Median :  7.046   Median :  18.66
```

```
##                     Mean   : 0.08229   Mean   :  7.596   Mean   :  33.21
##                     3rd Qu.: 0.24197   3rd Qu.: 11.213   3rd Qu.:  28.56
##                     Max.   : 1.18467   Max.   : 36.798   Max.   :1048.62
##
```

Summary Ratios.xlsx

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
## -15.135   2.638   7.046   7.596  11.213  36.798
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
## -134.27   11.24   18.66   33.21   28.56 1048.62
```