

Profit or Planet? Both! ESG Drivers of Efficient Portfolios and the Costs of Disclosure^{*}

Nico Rosamilia[§]

Politecnico di Milano School of Management[‡]

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Abstract

We adopt an asset pricing perspective to highlight ESG-type metrics for the construction of efficient portfolios. Additionally, we show that ESG disclosure may divert company resources toward long-term sustainable investment over investment for growth and profitability in the short term. This study integrates the ESG variables in the portfolio creation process using the five-factor asset pricing model by Fama and French and a model-free methodology represented by machine learning. With the first model, we consider five global markets with rolling time windows. The main focus of the markets for the governance pillar seems related to board characteristics and functions. The social pillar shows the significance of employee-related issues in different markets. For the environmental variables, investors seem to focus on greenhouse emissions within the Asia-Pacific, European, and Northern American markets. The machine learning algorithm is a customized random forest that represents an empirically grounded method to highlight material financial and ESG variables for the creation of efficient sustainable portfolios. The results provide the main drivers yielding the excess returns of the best sustainable portfolios at the sector level. Finally, we test the ESG prediction power of fundamentals and find that governance practices predict higher returns on assets and cash flow generation. On the other hand, ESG disclosure seems to affect capital expenditures and investment negatively.

Keywords: ESG, non-financial information, sustainable finance, asset pricing.

JEL Classification: G12, G24, G32.

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[§]Email: nico.rosamilia@polimi.it

[‡]Via Raffaele Lambruschini, 20156 Milano, Italia

1 Introduction

Valuation of company performances related to non-financial disclosures relies on Environmental, Social, and Governance (ESG) ratings. Numerous empirical studies investigate the relationship between the performance of the firms and the ESG ratings in publicly traded companies (see Lins et al. (2017), Albuquerque et al. (2019), Pástor and Vorsatz (2020), and Bolton and Kacperczyk (2021) among others). Our main objective is to highlight ESG sector-specific metrics to create efficient sustainable portfolios. While different studies trying to identify market alphas and future returns already exist (see Hartzmark and Sussman (2019), Ardia et al. (2020), Cheng and Huang (2024), Chibane and Joubrel (2024), and Prol and Kim (2022) among others), we empirically assess the material indicators for market returns. The paper aims to show the sector and market materiality of row ESG indicators (the single variables in the three pillars). The novelty of the paper is twofold: firstly we study the single ESG metrics factor analysis across different ESG data providers, markets, and sectors. Secondly, we extract key insights for portfolio construction from single ESG indicators.

We explore the asset pricing angle with two models: a traditional approach, the Fama-French five-factor model, FF5 hereafter, (see also Khan et al. (2016)), and a random forest (RF) algorithm à la Lanza et al. (2020). Therefore, our study relates to the literature that adopts innovative methodologies to portfolio theory. Lundberg and Lee (2017) and Lundberg, Erion, et al. (2018) deploy machine learning for feature selection, Erel et al. (2021) use it to predict financial performance, and Michalski and Low (2021) for corporate credit rating prediction. Conversely, we apply RF to identify sector-specific indicators that effectively differentiate in constructing efficient sustainable portfolios. Furthermore, using single indicators allows us to overcome the ESG rating controversies, see Capizzi et al. (2021), Zumente and Bistrova (2021), Berg et al. (2022), and Dumrose et al. (2022), and the possible offsetting effects of scores discussed in Escrig-Olmedo et al. (2014)¹.

Finally, we explore the relationship between ESG scores and future company performance. Pedersen et al. (2021) argue that for ESG information to contribute to superior returns, it must exhibit a significant correlation with the future fundamentals of firms. In this fashion, we aim to answer the following questions: does ESG disclosure divert resources from investments? Does it negatively impact the cash flows of the firms?². We find that governance scores from MSCI, Refinitiv, and Sustainalytics positively predict Free Cash Flow (FCF hereafter) and future returns on assets (ROA). Results for total investments and capital expenditures (capex) vary, with a slight skewness towards negative predictions. This implies that businesses that prioritize ESG disclosure may choose long-term gains from sustainable investments over typical strategies that focus on growth and profitability in the short term. The results support the idea that non-financial disclosure is costly in the short term.

2 Data

We use financial data from Thomson Reuters Eikon and ESG data from three rating providers: MSCI, Refinitiv, and Sustainalytics. Considering the scarcity of reported ESG variables, we highlight relevant variables in a sector if at least 30% of the companies report that variable in a given year. The challenge of eliminating as few correctly reported values as feasible can be reduced to the NP-complete maximum edge biclique problem (see Lanza et al. (2020) and Peeters (2003) for proof). Moreover, we match the observations

¹The authors state that the rating measuring process may lead to a possible offsetting effect of scores because the final rating compounds the main indicators. Therefore, it may be the case that a high score for one domain may shelter poorer scores in other areas.

²For example, industries under the spotlight for carbon emissions may experience considerable expenses for transition risk.

of the three providers to generate a unique dataset with yearly observations from 2003 to 2022. In Table 1 we report the number of ESG variables and scores for each rating agency in the last available year. A detailed description of the dataset is available in the external appendix available upon request.

| Rating agency | Year | Environmental | Social | Governance | ESG scores |
|----------------|------|---------------|--------|------------|------------|
| MSCI | 2022 | 13 | 15 | 55 | 3 |
| Refinitiv | 2021 | 24 | 26 | 36 | 5 |
| Sustainalytics | 2019 | 54 | 55 | 36 | 4 |

Table 1: **Number of ESG variables and scores for each rating agency in the last available year.** The last column reports the number of ratings at each pillar E, S, G, the whole ESG score, and other aggregated scores (e.g., controversies, etc.).

We select the Refinitiv Business Classification as the benchmark due to its consistent sector structure in the time frame. Figure 1 illustrates the temporal and geographical distribution of the observations across different regions from 2003 to 2022.

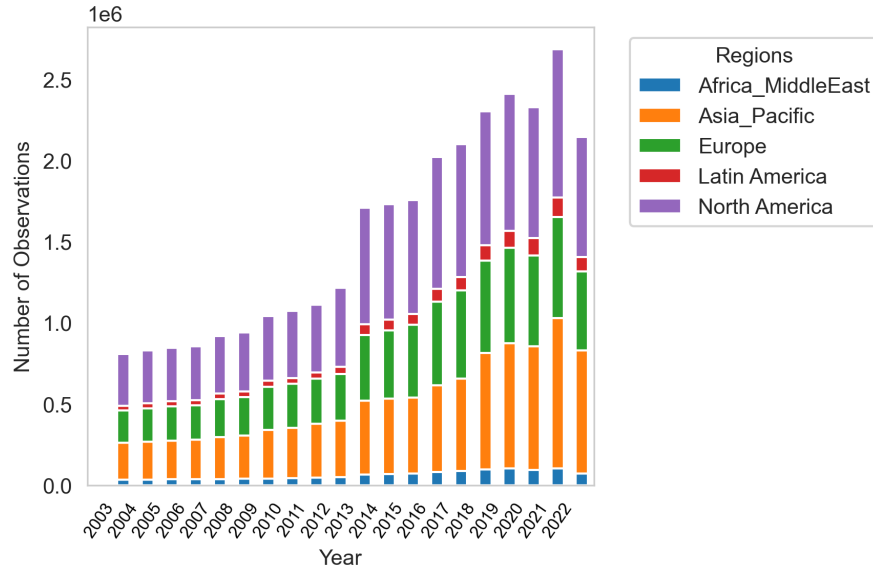


Figure 1: **Number of observations per year and region.** This bar chart illustrates the distribution of observations across different regions from 2003 to 2022. Each bar represents a year, and the height of each segment within the bar corresponds to the number of observations (in millions) in a specific macro area for that year. The x-axis indicates the years from 2003 to 2022, while the y-axis represents the total number of observations. Each color in the stacked bars represents a different region, with the legend on the upper left indicating the corresponding macro area for each color.

3 Empirical models

Firstly, we determine the material ESG indicators to build portfolios with maximum returns using a traditional asset pricing model, the FF5, and a customized machine learning algorithm. This model-free algorithm allows us to explore the non-linearity relation between ESG and stock returns (proven by Bruna et al. (2022)). We improve the decisional tree à la Lanza et al. (2020) by increasing the number of trees (RF) and the depth of each three, splitting over single features (not compounded scores), and feeding the algorithm with 9000 firms on the global market (they use 300 EU companies). Furthermore, we aim to define material ESG indicators for each pillar and each sector. We use multiple decision trees for recursive partitioning with a conditional inference that allows us to create the best portfolios of stocks and highlight the most relevant

financial and ESG variables. The customized RF is less prone to overfitting the data than linear models, leading to more generalizable and robust results. Therefore, the model performs well on unseen data, outside the training and test sets. Furthermore, RF can effectively handle many potential explanatory variables (ESG factors in this case), which could challenge linear models. A detailed description of the customized algorithm is in the external appendix.

Finally, similarly to Pedersen et al. (2021), we conduct several theory-driven empirical studies to assess the prediction power of ESG performances for the future fundamentals of companies. We run pooled regression with year-fixed effects (pooled) and with standard errors clustered at the firm level.

4 Results

4.1 ESG into the Fama French five-factor model

The FF5 regressions are sector-specific and in a 7-year rolling window for consistency (e.g., non-linearity of intratemporal ESG disclosure), availability, and multicollinearity reasons. In the tables below we eliminate the temporal dimensions for simplicity and report the variables associated with consistent (significant for at least 7 years) positive abnormal returns across different sectors.

Table 2 shows the relevance of governance-related ESG issues in the banking and investment services and the real estate industries. Board structure and characteristics seem consistently material among Refinitiv indicators. Environmental concerns receive less attention than governance and social aspects. Indeed, the market focuses only on "carbon emissions" and "product carbon footprint" in two sectors. Sustainable Development Goal 2, SDG2: "End hunger, achieve food security and improved nutrition and promote sustainable agriculture", reflects a broader interest in holistic sustainability.

| Sector | Variable | Pillar | RatingAgency |
|-------------------------------|---|--------|----------------|
| Banking & investment services | Board percentile global/home | G | MSCI |
| | Carbon emissions | E | MSCI |
| | CEO chairman duality | G | Refinitiv |
| | CSR sustainability committee | G | Refinitiv |
| | Executive compensation linked to long-term objectives | G | Refinitiv |
| | Human capital development | S | MSCI |
| | Shareholders vote on exec. pay | G | Refinitiv |
| Mineral resources | Water stress | E | MSCI |
| | Accounting percentile | G | MSCI |
| Real estate | Chairman is ex CEO | G | Refinitiv |
| | Community engagement | S | Sustainalytics |
| | CSR quality reporting | G | Sustainalytics |
| | CustomerRelationships controv. | S | Sustainalytics |
| | Non-executive/Independent board members | G | Refinitiv |
| | Policy on discrimination elim. | S | Sustainalytics |

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Table 2 – *Continued from previous page*

| Sector | Variable | Pillar | RatingAgency |
|-----------|--|--------|----------------|
| | Programs to increase workforce diversity | S | Sustainalytics |
| | Shareholders approval of stock compensation plan | G | Refinitiv |
| | SDG2 | S | Refinitiv |
| | Whistleblower programs | S | Sustainalytics |
| Retailers | Product carbon footprint | E | MSCI |

Table 2: **Material ESG variables from the FF5 model for the Africa-Middle East market.** The table shows the variables associated with consistent positive abnormal returns across different sectors, with their corresponding pillars and rating agencies.

Table 3 for the Asia-Pacific market, shows a predominance of the governance dimension, closely followed by social considerations and, more recently, a growing interest in environmental practices.

| Sector | Variable | Pillar | RatingAgency |
|-------------------------------------|--|--------|----------------|
| Automobiles & auto parts | Labor management | S | MSCI |
| | Business ethics and fraud | G | MSCI |
| Banking & investment services | Board experience policy | G | Refinitiv |
| | Board size | G | Refinitiv |
| | CEO compensation related to total shareholders return | G | Refinitiv |
| | Human capital development | S | MSCI |
| | Shareholders approval of stock com- pensation plan | G | Refinitiv |
| Chemicals | Healthy and safety certifications | S | Sustainalytics |
| | Supply chain monitoring system | S | Sustainalytics |
| Cyclical consu- mer products | Environmental supply chain incidents | E | Sustainalytics |
| Cyclical consumer services | Environmental policy | E | Sustainalytics |
| | Green procurement | E | Sustainalytics |
| | Health and safety policy | S | Refinitiv |
| Energy-Fossil fuels | CSR reporting quality | G | Sustainalytics |
| | Governance related controversies | G | Sustainalytics |
| | Health and safety policy | S | MSCI |
| | Net employment creation | S | Refinitiv |
| | Operations related controversies | G | Sustainalytics |
| Food & beverages | Anti competition controversies | G | Refinitiv |
| | Anti-takeover devices above two | G | Refinitiv |

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Table 3 – *Continued from previous page*

| Sector | Variable | Pillar | RatingAgency |
|-------------------------------------|---|--------|----------------|
| | Average board tenure | G | Refinitiv |
| | Bribery and corruption contro. | G | Refinitiv |
| | Environmental expenditures | E | Refinitiv |
| | ESG compensation policy | G | Refinitiv |
| Healthcare serv- ice & equipment | Board specific skills | G | Refinitiv |
| | Net employment creation | S | Refinitiv |
| Industrial & commercial ser. | Anti-takeover devices above two | G | Refinitiv |
| | Board size | G | Refinitiv |
| Industrial goods | Toxic waste emissions | E | MSCI |
| Insurance | Access to financing | G | MSCI |
| | Board size | G | Refinitiv |
| | Executive compensation linked to long-term objectives | G | Refinitiv |
| | | | |
| Mineral resources | Layoffs over total employees | G | Refinitiv |
| | Executive compensation linked to long-term objectives | G | Refinitiv |
| | | | |
| Pharmaceutical | Executive members gender diversity | G | Refinitiv |
| Real estate | Anti-takeover devices above two | G | Refinitiv |
| | Board size | G | Refinitiv |
| | Executive individual compensat. | G | Refinitiv |
| Retailers | Whistleblower programs | S | Sustainalytics |
| Software & IT services | Board size | G | Refinitiv |
| | Board structure policy | G | Refinitiv |
| Technology equipment | Anti-competition controversies | G | Refinitiv |
| | Board independence policy | G | Refinitiv |
| | CSR reporting quality | S | Sustainalytics |
| | Layoffs over total employees | S | Refinitiv |
| | Resource reduction policy | E | Refinitiv |
| | Water use | E | Refinitiv |
| | Whistleblower programs | S | Sustainalytics |
| Telecommunicat. | Policy on human rights | S | Sustainalytics |
| Transportation | Anti-takeover devices above two | G | Refinitiv |
| Utilities | Community engagement | S | Sustainalytics |

Table 3: **Material ESG variables from the FF5 model for the Asia-Pacific market.** The table shows the variables associated with consistent (significant in the last time window and two or more windows - at least 7 years) positive abnormal returns across different sectors, with their corresponding pillars and rating agencies.

Table 4 for the European market highlights governance practices for Refinitiv variables related to board characteristics: diversity, specific skills, and independence. For the environmental pillar, we find chemical safety in the chemicals sector and carbon emission reduction in transportation. Social materiality revolves around employee issues, like human capital development, labor management, and responsible layoffs, signaling that investors value attention to workers. In the European market, we witness a broader evaluation of ESG issues with a dynamic similar to the Asia-Pacific market, where governance presence is consistent, and social and environmental pillars gain consideration over time.

| Sector | Variable | Pillar | RatingAgency |
|------------------------------------|---|--------|------------------|
| Banking & investment services | Average board tenure | G | Refinitiv |
| | Board gender diversity | G | Refinitiv |
| | Board size policy | G | Refinitiv |
| | Board specific skills | G | Refinitiv |
| | CEO board member | G | Refinitiv |
| | Chairman is ex CEO | G | Refinitiv |
| | CSR sustainability committee | G | Refinitiv |
| | Environmental & social assessment in credit | E/S | Sustainabilitycs |
| | Governance related controversies | G | Sustainabilitycs |
| Chemicals | Human capital development | S | MSCI |
| | Chemical safety | E | MSCI |
| | Participation in carbon disclosure project | E | Sustainabilitycs |
| Cyclical consumer products | Resource reduction targets | E | Refinitiv |
| | Environmental expenditures | E | Refinitiv |
| Cyclical consumer services | Independent board members | G | Refinitiv |
| | Average board tenure | G | Refinitiv |
| | Board specific skills | G | Refinitiv |
| | Layoffs over total employees | S | Refinitiv |
| Industrial & commercial services | Board members affiliations | G | Refinitiv |
| | Layoffs over total employees | S | Refinitiv |
| | Net employment creation | S | Refinitiv |
| | Resource reduction policy | E | Refinitiv |
| Industrial goods | Layoffs over total employees | G | Refinitiv |
| | Net employment creation | S | Refinitiv |
| Insurance | Business ethics and fraud | S | MSCI |
| | Insuring climate change risk | E | MSCI |
| | Labor management | S | MSCI |
| Pharmaceuticals & medical research | Executive compensation link to long-term objectives | G | Refinitiv |
| | Net employment creation | S | Refinitiv |
| Real estate | CEO board member | G | Refinitiv |

Continued on next page

Table 4 – *Continued from previous page*

| Sector | Variable | Pillar | RatingAgency |
|------------------------|------------------------------------|--------|----------------|
| Retailers | Executive individual compensat. | G | Refinitiv |
| | Executive members gender diversity | G | Refinitiv |
| | Privacy and data security | S | MSCI |
| | Salary gap | G | Refinitiv |
| | Shareholders vote on exec. pay | G | Refinitiv |
| Software & IT services | Average board tenure | G | Refinitiv |
| | Board specific skills | G | Refinitiv |
| Technology equipment | Executive compensation policy | G | Refinitiv |
| | Layoffs over total employees | S | Refinitiv |
| | Health and safety policy | S | Refinitiv |
| Telecommunicat. | Water stress | E | MSCI |
| Transportation | Carbon emission | E | MSCI |
| Utilities | Employment related controver. | S | Sustainalytics |
| | Layoffs over total employees | S | Refinitiv |

Table 4: **Material ESG variables from the FF5 model for the European market.** The table shows the variables associated with consistent (three or more time windows or more than 7 years) positive abnormal returns across different sectors, along with their corresponding pillars and rating agencies.

The Latin American market shows a different dynamic. SDG goals (decent work and economic growth, and climate action) are significant factors in the banking & investment services (see Table 5). Key drivers of positive abnormal returns across several sectors include board structure, environmental policies, water management, and responsible labor practices.

| Sector | Variable | Pillar | RatingAgency |
|-------------------------------|--------------------------------|--------|----------------|
| Banking & investment services | Board attendance policy | G | Refinitiv |
| | Board percentile home | S | MSCI |
| | Chairman is ex CEO | G | Refinitiv |
| | Financing environmental impact | E | MSCI |
| | Human capital development | S | MSCI |
| | SDG8/SDG13 | G | Refinitiv |
| Food & beverages | Executive compensation policy | G | Refinitiv |
| Industrial goods | Labor management | S | MSCI |
| Mineral resources | Environmental policy | E | Sustainalytics |
| | Labor management | S | MSCI |
| | Program to reduce water use | E | Sustainalytics |
| | Water stress | E | MSCI |
| Retailers | Chemical safety | E | MSCI |
| Utilities | CSR sustainability committee | G | Refinitiv |

Table 5: **Material ESG variables from the FF5 model for the Latin American market.** The table shows the variables associated with consistent positive abnormal returns across different sectors, with their corresponding pillars and rating agencies. SDG 8: Decent work and economic growth, SDG 13: Climate action.

In the North American market (table 6) carbon emissions and resource reduction are prominent in the E pillar, while board composition, executive compensation, and shareholder involvement are in the G. Additionally, human capital development, labor management, and health and safety play a significant role in the S.

| Sector | Variable | Pillar | RatingAgency |
|-------------------------------------|---|--------|----------------|
| Automobiles & auto parts | Board diversity policy | G | Refinitiv |
| | Board meeting attendance | G | Refinitiv |
| | Net employment creation | S | Refinitiv |
| | Shareholders vote on exec. pay | G | Refinitiv |
| Banking & investment services | Access to financing | G | MSCI |
| | Financial system instability | G | MSCI |
| | Human capital development | S | MSCI |
| Chemicals | ESG policy compensation | G | Refinitiv |
| | Environmental management system | E | Sustainalytics |
| Cyclical consumer products | Anti takeover devices above two | G | Refinitiv |
| | Board gender diversity | G | Refinitiv |
| | Chairman is ex CEO | G | Refinitiv |
| | Executive members gender diversity | G | Refinitiv |
| | layoffs over total employees | S | Refinitiv |
| | Net employment creation | S | Refinitiv |
| | Resource reduction policy | E | Refinitiv |
| Energy-Fossil fuel | Biodiversity and land use | E | MSCI |
| | Carbon emissions | E | MSCI |
| | Executive compensation link to long-term objectives | G | Refinitiv |
| | layoffs over total employees | G | Refinitiv |
| | Resource reduction policy | E | Refinitiv |
| | Training & development policy | S | Refinitiv |
| Food & beverages | Board specific skills | G | Refinitiv |
| | Health and safety policy | S | Refinitiv |
| | Product impact minimization | E | Refinitiv |
| | Shareholders vote on exec. pay | G | Refinitiv |
| Healthcare serv- ice & equipment | Labor management | S | MSCI |
| Households product | Health and safety | S | MSCI |
| | Labor management | S | MSCI |
| | Carbon emissions | E | MSCI |
| Industrial&com- mercial services | Board function policy | G | Refinitiv |
| | Environmental expenditures | E | Refinitiv |
| Industrial goods | Board structure policy | G | Refinitiv |
| | CEO board member | G | Refinitiv |
| | Executive compensation policy | G | Refinitiv |

Continued on next page

Table 6 – *Continued from previous page*

| Sector | Variable | Pillar | RatingAgency |
|----------------------|--|--------|----------------|
| | Health and safety policy | S | Refintiv |
| | Indipendent board member | G | Refintiv |
| | Layoffs over total employees | S | Refintiv |
| | Net employment creation | S | Refintiv |
| Insurance | Anti takeover devices above two | G | Refintiv |
| | Business ethics-related controvr. | S | Sustainalytics |
| | Governance related controversies | G | Sustainalytics |
| | Labor management | S | MSCI |
| Mineral resources | Independent board members | G | Refintiv |
| | Whistleblower programs | S | Sustainalytics |
| Retailers | Layoffs over total employees | S | Refintiv |
| | Net employment creation | S | Refintiv |
| Technology equipment | Board independence policy | G | Refintiv |
| | CEO board member | G | Refintiv |
| | Net employment creation | S | Refintiv |
| | Quality management system | S | Refintiv |
| Transportation | CO ₂ emissions | E | Refinitiv |
| | Customer controversies | S | Refinitiv |
| | Social supply chain incidents | S | Sustainalytics |
| Utilities | Customer relationship controvr. | S | Sustainalytics |
| | Labor management | S | MSCI |
| | Lost time incident rate trend | S | Sustainalytics |
| | Policy on freedom of association | S | Sustainalytics |
| | Program to increase renewable energy use | E | Sustainalytics |

Table 6: **Material ESG variables from the FF5 model for the North American market.** The table shows the variables associated with consistent (three or more time windows or more than 7 years) positive abnormal returns across different sectors, with their corresponding pillars and rating agencies.

4.2 The customized RF for efficient sustainable portfolios

The RF is a model-free methodology with a forward-looking glance to create efficient sustainable portfolios. We overcome the linearity issues and limitations of the factors models. The decision trees split the firms into best and worst portfolios. Additionally, it ranks the variables based on their *CumulativeScore*. This score represents the sum of the differences between the return of the best portfolios R_B and the return of the worst portfolio R_W :

$$CumulativeScore_i = \sum_t R_{Bit} - R_{Wit}$$

where t is the number of trees and i is the ESG variable. In other words, it is the excess returns of the most sustainable portfolios over the least sustainable. In Table 7 below we report the twenty most important variables ranked by the average cumulative score of each sector. We choose the number of variables to report

considering the ones that are above one standard deviation in the probability density function of the average distribution of the cumulative score of all the variables across all sectors³.

| Variable | Area | Description | Polarity |
|---------------------------------------|------|--|----------|
| 1.PB | F | Market Price to Book Ratio | |
| 2.Revenues 1yr gr | F | One year growth in revenues | |
| 3.Asset var perc | F | One year variation in total assets | |
| 4.Employees 1yr gr | S | One year growth in employees | Positive |
| 5.Net employment creation | S | Employment growth rate over previous year | Positive |
| 6.ROA | F | Return On Asset | |
| 7.s ex com LT obj | G | Executives compensation policy linked to long-term objectives | Positive |
| 8.s ex find com | G | Executives individual compensation related to ESG | Positive |
| 9.EBIT margin | F | Measure of operating profit as a percentage of revenue | |
| 10.s Board attendance | G | Average % of board members attending board meetings | Positive |
| 11.Board cult div per | G | Percentage of cultural diversity on board | Positive |
| 12.Salary gap | S | Highest salary value divided by average salary. | Negative |
| 13.Mrkt CAP | F | Market capitalization | |
| 14.Total donation to revenues | S | Total effort in terms of donations, over revenues | Positive |
| 15.Renewable energy use ratio | E | Proportion of renewable energy used in its operations | Positive |
| 16.EBIT | F | Earnings Before Interest and Taxes | |
| 17.Training costs per employee | S | Expenses for training per employee | Positive |
| 18.Water use to revenues | E | Amount of water used over revenue | Negative |
| 19.s wages work condition controversy | S | Wages Working Condition Controversy: Number of controversies published in the media linked to the company's relations with employees or relating to wages or wage disputes | Negative |
| 20.Board specific skills | G | Percentage of board members with a strong industry-specific background | Positive |

³In the external appendix we report the histogram with probability density function of the average distribution of the cumulative score of all the variables across all sectors

Table 7: **Top 20 Refinitiv ESG variables ranked by the average cumulative score of each sector.** The first column shows the name of the variable as reported in the Refinitiv dataset. The second column specifies the area and ESG pillar (F=financial, E=environmental, S=social, G=governance). The third describes the indicator and the last reports the polarity, which defines the sustainable direction of an ESG variable (e.g., a high salary gap has a negative sustainable direction because higher values correspond to a lower ESG score).

The numbers for each variable and sector in Figures 2 and 3 report the spread that exists in the return of the stocks for a specific sector. In other words, the first cell for the variable price-to-book ratio (PB) in the sector energy-fossil fuel tells us that the portfolios of firms best performing in PB experience an average 4.70% higher return than the portfolios of firms underperforming for that variable.

To have a punctual view of each sector, we have single sectors rank in the same fashion as Table 8 below for the energy-fossil fuels sector. The ranks for all the sectors are available upon request.

| Variable | Pillar | Cumulative score |
|------------------------------------|--------|------------------|
| PB | F | 4.07 |
| ROA | F | 3.20 |
| Employment 1 year growth | S | 2.72 |
| Net employment creation | S | 2.19 |
| Revenues 1 year growth | F | 2.03 |
| Asset variation | F | 1.68 |
| Total donations to revenues | S | 1.17 |
| EBIT | F | 1.15 |
| Shareholders vote on executive pay | G | 1.12 |
| Training cost per employee | S | 1.02 |
| Quality management system | G | 0.99 |
| Lost days to total days | S | 0.98 |
| Market cap | F | 0.95 |
| ESG compensation policy | G | 0.88 |
| Board cultural diversity | G | 0.86 |
| EBT | F | 0.80 |
| Salaray gap | G | 0.77 |
| Board member affiliations | G | 0.62 |
| Number of employees | F | 0.56 |
| CEO compensation link to | G | 0.55 |
| Total shareholders return | | |

Table 8: **Top 20 most important variables by the cumulative score for the energy-fossil fuels sector.** Table 7 provides a detailed description of the variables. The second column specifies the area and ESG pillar (F=financial, E=environmental, S=social, G=governance)

4.3 The prediction power of ESG for future fundamentals

Correlation with future fundamentals seems a prerequisite for ESG-type information to produce positive abnormal returns. On the other hand, Pedersen et al. (2021) state that if investors become more attentive and focused on ESG disclosure, prices may increase even without a corresponding fundamentals channel. This does not result in a steady return premium over the long run and is probably more likely in the near term. In this model, we employ aggregate scores rather than individual ESG variables (adopted previously in the FF5 and RF models). We regress the financial variables on the ESG pillar scores for the three rating agencies and find that ESG information is relevant in predicting future fundamentals. In the following



Figure 2: **The 10 most important variables by the average cumulative score for the Refinitiv dataset.** The sectors are on the x-axis and the variables (described in Table 7) are on the y-axis. The scale of colors from dark red (lowest cumulative score) to dark green (highest cumulative score). Each cell of the map represents the average cumulative score that portfolios of firms best performing in the corresponding variable (on the y-axis) experience in the corresponding sector (on the x-axis). Grey cells indicate that there are no results for the combination sector variable, i.e. not enough firms in that sector disclose that ESG variable.

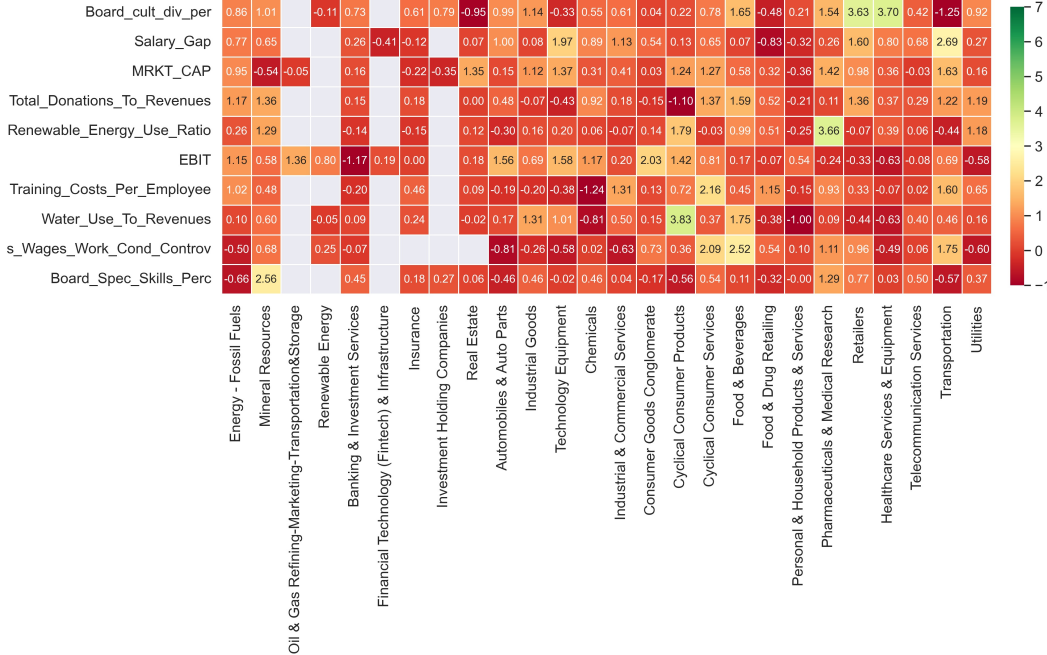


Figure 3: **From the 11th to the 20th most important variables by the average cumulative score for the Refinitiv dataset.** The sectors are on the x-axis and the variables (described in Table 7) are on the y-axis.

sections, capex, revenues, FCF, and total financial and property investments are in percentage of total assets. The results show that sustainable disclosure may be costly and divert company resources towards long-term sustainable investment over traditional investment for growth and profitability. While the model identifies statistically significant relationships, its explanatory power is limited. This is not a major concern, because we aim to identify significant relationships with potential future exploration. Therefore, despite a low R-squared, this initial model can serve as a foundation for further investigation into additional factors influencing the observed relationship. Conversely, we believe that a model-free methodology or nonlinear approach may enhance predictive accuracy and provide a deeper understanding of the phenomena under investigation.

4.3.1 ESG prediction of profitability and investor demand

This section tests for a correlation between ESG scores and future profitability (measured with return on assets, ROA) and investor demand (measured with institutional ownership, IO). We examine a measure of profitability and investor demand in Table 9 with Refinitiv data (for consistency with the RF algorithm). Refinitiv ratings present two additional pillars: the controversies score (CONT)⁴ and the ESG combined score (ESGC) which combines the ESG and controversies scores. Results for MSCI and Sustainalytics are available upon request. All the scores but social predict higher operational profitability. That is not the case for investor demand, positively predicted by the E and Controversies pillars. This finding aligns with expectations, given that these areas attract significant media attention, influencing investor perceptions and decisions. Indeed, scandals and controversies bring tangible financial consequences for companies, affecting their overall financial performance⁵.

| | ROA _{t+1} | | | | | | IO _{t+1} | | | | | |
|----------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
| | (1) | (2) | (3) | (4) | (5) | (6) | (1) | (2) | (3) | (4) | (5) | (6) |
| Environmental | 0.015** (0.005) | | | | | | 0.009 (0.010) | | | | | |
| Social | | -0.009 (0.005) | | | | | | -0.060** (0.023) | | | | |
| Governance | | | 0.021*** (0.005) | | | | | | -0.161*** (0.048) | | | |
| Controversies | | | | 0.016*** (0.005) | | | | | | 0.075*** (0.020) | | |
| ESG Combined | | | | | 0.016** (0.005) | | | | | | -0.076* (0.030) | |
| ESG | | | | | | 0.011* (0.005) | | | | | | -0.105** (0.037) |
| β | -0.925* (0.448) | -0.963* (0.453) | -0.961* (0.451) | -0.941* (0.450) | -0.939* (0.450) | -0.947* (0.451) | -3.768*** (1.003) | -3.789*** (1.001) | -3.744*** (0.969) | -3.667*** (0.973) | -3.845*** (1.019) | -3.838*** (1.012) |
| ln(market cap) | 0.686*** (0.176) | 0.902*** (0.187) | 0.754*** (0.166) | 0.904*** (0.183) | 0.747*** (0.171) | 0.762*** (0.180) | 0.040 (0.200) | 0.531* (0.226) | 0.781** (0.251) | 0.451* (0.180) | 0.547* (0.236) | 0.844** (0.301) |
| ln(P/B) | 0.611* (0.285) | 0.463 (0.260) | 0.544* (0.268) | 0.446 (0.262) | 0.538* (0.269) | 0.531* (0.270) | -1.878*** (0.415) | -2.117*** (0.437) | -2.392*** (0.497) | -2.124*** (0.430) | -2.204*** (0.468) | -2.379*** (0.509) |
| ROA | 0.495*** (0.079) | 0.495*** (0.079) | 0.494*** (0.079) | 0.494*** (0.079) | 0.495*** (0.079) | 0.495*** (0.079) | | | | | | |
| IO | | | | | | | 0.321 (0.186) | 0.319 (0.186) | 0.313 (0.184) | 0.320 (0.185) | 0.319 (0.186) | 0.318 (0.185) |
| Constant | -12.586*** (3.497) | -16.257*** (3.608) | -14.470*** (3.333) | -18.168*** (3.960) | -13.973*** (3.388) | -14.095*** (3.513) | 21.314** (7.114) | 13.617* (5.651) | 13.925* (5.457) | 5.655 (4.719) | 14.019* (5.556) | 8.990 (4.784) |
| Observations | 19519 | 19519 | 19519 | 19519 | 19519 | 19519 | 26158 | 26158 | 26158 | 26158 | 26158 | 26158 |
| R-squared | 0.372 | 0.371 | 0.372 | 0.371 | 0.371 | 0.371 | 0.303 | 0.304 | 0.315 | 0.305 | 0.304 | 0.306 |

Table 9: **ESG prediction of profitability (measured with ROA) and investor demand (measured with institutional ownership, IO) with Refinitiv data.** The table shows the prediction model results with financial variables on the left-hand side of the regression 1 year into the future. The estimation method is a pooled regression with year-fixed effects (pooled). Standard errors are in parentheses. We denote 95%, 99%, and 99.9% significant levels with * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$ respectively

⁴Using 23 ESG controversy issues, Refinitiv computes the ESG Controversies Category Score. Any scandal occurring within the year leads to a penalty for the affected company, thereby impacting the overall ESG Combined Score and grading.

⁵For example lawsuits, ongoing legislation disputes, or fines. Refinitiv controversies score addresses the issue related to large-cap firms suffering from market cap bias since they garner greater media attention than smaller-cap companies.

4.3.2 ESG prediction of cash flow and financial health

We measure cash flow with FCF and financial health with revenues (Sales). In Table 10 we observe that an increase in the social score correlates with decreased cash generation, thereby indicating a potential investment strategy shift towards social initiatives. On the other hand, this shift limits the ability of the companies to invest in market research, pay dividends, or repurchase shares. Additionally, the social coefficient is positive for sales, indicating that customers value the social effort of the company. Similar positive considerations are valid for the E pillar on both FCF and Sales. Better performance at the governance level predicts higher FCF which could translate to better decision-making, leading to more efficient use of resources and investments. Finally, effective governance frameworks might minimize mismanagement, corruption, and inefficiencies, preventing unnecessary losses and improving cash flow generation.

| | FCF _{t+1} | | | | | | Sales _{t+1} | | | | | |
|----------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|
| | (1) | (2) | (3) | (4) | (5) | (6) | (1) | (2) | (3) | (4) | (5) | (6) |
| Environmental | 0.012*** (0.003) | | | | | | 0.256*** (0.031) | | | | | |
| Social | | -0.001 (0.003) | | | | | | 0.202*** (0.033) | | | | |
| Governance | | | 0.012** (0.004) | | | | | | 0.277*** (0.035) | | | |
| Controversies | | | | 0.004 (0.003) | | | | | | -0.080** (0.027) | | |
| ESG Combined | | | | | 0.012** (0.004) | | | | | | 0.350*** (0.040) | |
| ESG | | | | | | 0.012** (0.004) | | | | | | 0.382*** (0.041) |
| β | -0.476 (0.253) | -0.496 (0.255) | -0.505* (0.257) | -0.490 (0.254) | -0.483 (0.253) | -0.488 (0.254) | -6.117*** (1.186) | -6.483*** (1.192) | -6.623*** (1.192) | -6.620*** (1.196) | -6.222*** (1.188) | -6.317*** (1.187) |
| ln(market cap) | 0.167* (0.073) | 0.298*** (0.081) | 0.243** (0.074) | 0.307*** (0.086) | 0.223** (0.073) | 0.208** (0.075) | -6.579*** (0.642) | -5.397*** (0.606) | -5.175*** (0.573) | -4.392*** (0.571) | -5.988*** (0.604) | -6.643*** (0.629) |
| ln(P/B) | 0.201 (0.178) | 0.095 (0.166) | 0.131 (0.170) | 0.089 (0.163) | 0.140 (0.173) | 0.148 (0.174) | 11.995*** (0.893) | 10.413*** (0.850) | 10.641*** (0.858) | 10.111*** (0.860) | 11.030*** (0.856) | 11.400*** (0.862) |
| FCF | 0.721*** (0.078) | 0.722*** (0.078) | 0.721*** (0.078) | 0.722*** (0.078) | 0.721*** (0.078) | 0.721*** (0.078) | | | | | | |
| REVENUES_new | | | | | | | 0.017 (0.018) | 0.017 (0.018) | 0.017 (0.018) | 0.017 (0.018) | 0.017 (0.018) | 0.017 (0.018) |
| Constant | -2.599 (1.443) | -4.892** (1.522) | -4.360** (1.430) | -5.483** (1.846) | -3.869** (1.419) | -3.522* (1.465) | 214.840*** (13.920) | 191.028*** (13.233) | 180.882*** (12.678) | 185.346*** (13.759) | 197.213*** (13.093) | 209.735*** (13.489) |
| Observations | 20538 | 20538 | 20538 | 20538 | 20538 | 20538 | 24152 | 24152 | 24152 | 24152 | 24152 | 24152 |
| R-squared | 0.506 | 0.506 | 0.506 | 0.506 | 0.506 | 0.506 | 0.070 | 0.065 | 0.070 | 0.061 | 0.070 | 0.072 |

Table 10: **ESG prediction of cash flow (measured with FCF) and financial health (measured with revenues - Sales) with Refinitiv data.** The table shows the prediction model results with financial variables on the left-hand side of the regression 1 year into the future. The estimation method is a pooled regression with year-fixed effects (pooled). Standard errors are in parentheses. We denote 95%, 99%, and 99.9% significant levels with * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$ respectively

4.3.3 ESG prediction of capital allocation and investment

We measure capital allocation with capital expenditure (Capex). The performance of all pillars but E for Capex indicates that firms might invest less in expanding capacity or acquiring new assets, see Table 11. This aligns with improving environmental practices if companies prioritize sustainability expansion. Social and ESG scores also predict negative investment. Therefore, higher ESG performances may indicate long-term sustainability strategies, which may incur higher costs and divert investment from short-term gains.

| | Capex _{t+1} | | | | | | Investments _{t+1} | | | | | |
|----------------|----------------------|---------------------|---------------------|---------------------|---------------------|---------------------|----------------------------|----------------------|---------------------|---------------------|----------------------|----------------------|
| | (1) | (2) | (3) | (4) | (5) | (6) | (1) | (2) | (3) | (4) | (5) | (6) |
| Environmental | 0.011 (0.013) | | | | | | -0.026*** (0.007) | | | | | |
| Social | | -0.018 (0.021) | | | | | | -0.018*** (0.005) | | | | |
| Governance | | | -0.043 (0.036) | | | | | | -0.020** (0.006) | | | |
| Controversies | | | | -0.049* (0.023) | | | | | | -0.005 (0.014) | | |
| ESG Combined | | | | | -0.050 (0.040) | | | | | | -0.035*** (0.007) | |
| ESG | | | | | | -0.030 (0.035) | | | | | | -0.032*** (0.008) |
| β | -1.084 (0.954) | -1.111 (0.951) | -1.078 (0.932) | -1.182 (0.964) | -1.155 (0.976) | -1.123 (0.960) | 0.001 (0.255) | 0.027 (0.256) | 0.017 (0.255) | 0.005 (0.280) | -0.007 (0.257) | 0.015 (0.256) |
| ln(market cap) | -1.708* (0.822) | -1.474 (0.771) | -1.429 (0.755) | -1.833 (0.951) | -1.330 (0.688) | -1.392* (0.685) | 0.075 (0.118) | -0.064 (0.099) | -0.098 (0.101) | -0.206 (0.143) | 0 (0.086) | 0.036 (0.106) |
| ln(P/B) | -0.409 (0.450) | -0.546 (0.411) | -0.610 (0.441) | -0.370 (0.357) | -0.658 (0.475) | -0.621 (0.483) | -0.200 (0.104) | -0.022 (0.101) | -0.034 (0.101) | 0.032 (0.095) | -0.088 (0.106) | -0.108 (0.103) |
| Capex | 0.008*** (0.001) | 0.008*** (0.001) | 0.008*** (0.001) | 0.008*** (0.001) | 0.008*** (0.001) | 0.008*** (0.001) | | | | | | |
| Investments | | | | | | | 0.777*** (0.016) | 0.780*** (0.016) | 0.780*** (0.016) | 0.781*** (0.016) | 0.778*** (0.016) | 0.778*** (0.016) |
| Constant | 44.940* (19.479) | 41.107* (18.865) | 41.535* (19.483) | 52.745* (23.560) | 39.405* (17.949) | 39.886* (17.545) | 0.695 (2.656) | 3.322 (2.384) | 4.334 (2.450) | 6.160 (4.445) | 2.718 (2.199) | 1.873 (2.432) |
| Observations | 21286 | 21286 | 21286 | 21286 | 21286 | 21286 | 17703 | 17703 | 17703 | 17703 | 17703 | 17703 |
| R-squared | 0.008 | 0.008 | 0.009 | 0.009 | 0.009 | 0.008 | 0.537 | 0.537 | 0.537 | 0.536 | 0.537 | 0.537 |

Table 11: **ESG prediction of capital allocation (measured with capex) and investments with Refinitiv data.** The table shows the prediction model results with financial variables on the left-hand side of the regression 1 year into the future. The estimation method is a pooled regression with year-fixed effects (pooled). Standard errors are in parentheses. We denote 95%, 99%, and 99.9% significant levels with * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$ respectively

5 Conclusions

This research highlights the ESG variables related to higher returns and efficient sustainable portfolios. Additionally, it shows that ESG scores predict future fundamentals of firms and divert company resources towards long-term sustainable investment over investment for growth and profitability in the short term.

Overall, investors seek ESG information for investment decisions; however, interest diminishes in Latin America and the Africa-Middle East region, where ESG disclosure is less robust compared to the principal markets of Asia-Pacific, Europe, and North America. Investors attribute remarkable importance to the governance structure. Within the social pillar, the market seems to focus especially on labor-oriented practices, while carbon emissions, management of water resources, and reduction of input production resources are relevant E factors in recent years.

The RF algorithm highlights material financial and non-financial variables to create efficient sustainable portfolios. These portfolios experience the highest differential returns in their corresponding sector. The algorithm overcomes the traditional key limitation of risk-return frameworks relying primarily on backward-looking time-series analysis, allowing us to define the best forward-looking and optimized portfolios for future market conditions.

Furthermore, we study the prediction power of ESG scores on future financial performances and find that companies engaging in ESG disclosure prioritize long-term sustainable investments over investments for growth and profitability. This finding aligns well with our expectations regarding the costly nature of non-financial disclosure in the short term.

Limitations relate to the structure of the ESG data. First, staggered or absent disclosure limits the balance of the time series and cross-sections. Finally, the imminent availability of ESG standardized formats could allow studies to explore the heterogeneity of investors across different dimensions and, therefore, clearly

understand the ESG relevance in the investment decision process.

References

- Albuquerque, Rui, Yrjö Koskinen, and Chendi Zhang (2019). “Corporate social responsibility and firm risk: Theory and empirical evidence”. In: *Management Science* 65.10, pp. 4451–4469.
- Ardia, David, Keven Bluteau, Kris Boudt, and Koen Inghelbrecht (2020). “Climate change concerns and the performance of green versus brown stocks”. In: *National Bank of Belgium, Working Paper Research* 395.
- Berg, Florian, Julian F Koelbel, and Roberto Rigobon (2022). “Aggregate confusion: The divergence of ESG ratings”. In: *Review of Finance* 26.6, pp. 1315–1344.
- Bolton, Patrick and Marcin Kacperczyk (2021). “Do investors care about carbon risk?” In: *Journal of Financial Economics*.
- Bruna, Maria Giuseppina, Salvatore Loprevite, Domenico Raucci, Bruno Ricca, and Daniela Rupo (2022). “Investigating the marginal impact of ESG results on corporate financial performance”. In: *Finance Research Letters* 47, p. 102828.
- Capizzi, Vincenzo, Eleonora Gioia, Giancarlo Giudici, and Francesca Tenca (2021). “The Divergence of ESG Ratings: An Analysis of Italian Listed Companies”. In: *Journal of Financial Management, Markets and Institutions*, p. 2150006.
- Cheng, Shi and Shan Huang (2024). “ESG combined score effects on stock performance of S&P 500-listed firms”. In: *Finance Research Letters*, p. 105686.
- Chibane, Messaoud and Mathieu Joubrel (2024). “The ESG-efficient frontier under ESG rating uncertainty”. In: *Finance Research Letters* 67, p. 105881.
- Dumrose, Maurice, Sebastian Rink, and Julia Eckert (2022). “Disaggregating confusion? The EU Taxonomy and its relation to ESG rating”. In: *Finance research letters* 48, p. 102928.
- Erel, Isil, Léa H Stern, Chenhao Tan, and Michael S Weisbach (2021). “Selecting directors using machine learning”. In: *The Review of Financial Studies* 34.7, pp. 3226–3264.
- Escrig-Olmedo, Elena, María Jesús Muñoz-Torres, María Ángeles Fernández-Izquierdo, and Juana María Rivera-Lirio (2014). “Lights and shadows on sustainability rating scoring”. In: *Review of Managerial Science* 8.4, pp. 559–574.
- Hartzmark, Samuel M and Abigail B Sussman (2019). “Do investors value sustainability? A natural experiment examining ranking and fund flows”. In: *The Journal of Finance* 74.6, pp. 2789–2837.
- Khan, Mozaffar, George Serafeim, and Aaron Yoon (2016). “Corporate sustainability: First evidence on materiality”. In: *The accounting review* 91.6, pp. 1697–1724.
- Lanza, Ariel, Enrico Bernardini, and Ivan Faiella (2020). “Mind the gap! machine learning, esg metrics and sustainable investment”. In: *Machine Learning, ESG Metrics and Sustainable Investment (June 26, 2020). Bank of Italy Occasional Paper* 561.
- Lins, Karl V, Henri Servaes, and Ane Tamayo (2017). “Social capital, trust, and firm performance: The value of corporate social responsibility during the financial crisis”. In: *the Journal of Finance* 72.4, pp. 1785–1824.
- Lundberg, Scott M, Gabriel G Erion, and Su-In Lee (2018). “Consistent individualized feature attribution for tree ensembles”. In: *arXiv preprint arXiv:1802.03888*.
- Lundberg, Scott M and Su-In Lee (2017). “A unified approach to interpreting model predictions”. In: *Advances in neural information processing systems* 30.

- Michalski, Lachlan and Rand Kwong Yew Low (2021). “Corporate credit rating feature importance: Does ESG matter?” In: *Available at SSRN 3788037*.
- Pástor, L’uboš and M Blair Vorsatz (2020). “Mutual fund performance and flows during the COVID-19 crisis”. In: *The Review of Asset Pricing Studies* 10.4, pp. 791–833.
- Pedersen, Lasse Heje, Shaun Fitzgibbons, and Lukasz Pomorski (2021). “Responsible investing: The ESG-efficient frontier”. In: *Journal of Financial Economics* 142.2, pp. 572–597.
- Peeters, René (2003). “The maximum edge biclique problem is NP-complete”. In: *Discrete Applied Mathematics* 131.3, pp. 651–654.
- Prol, Javier López and Kiwoong Kim (2022). “Risk-return performance of optimized ESG equity portfolios in the NYSE”. In: *Finance Research Letters* 50, p. 103312.
- Zumente, Ilze and Jūlija Bistrova (2021). “Do Baltic investors care about environmental, social and governance (ESG)?” In: *Entrepreneurship and Sustainability Issues* 8.4, p. 349.