Asian Business Research Journal
Vol. 10, No. 3, 33-44, 2025
ISSN: 2576-6759
DOI: 10.55220/25766759.305

The Impact of Fund Characteristics on Environmental, Social, and Governance (ESG) Risks: An Empirical Analysis

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Abstract

This study examines the impact of fund characteristics on Environmental, Social, and Governance (ESG) risks in investment funds. The research focuses on three key factors: fund size, fund category, and investment area. Using regression analysis, the study investigates how these characteristics influence ESG risks across different fund types and geographical regions. The methodology addresses potential statistical issues such as multicollinearity and heteroscedasticity to ensure robust results. The findings reveal significant relationships between fund attributes and ESG risk levels, with notable variations across regions and fund types. Fund size is found to positively influence certain ESG risks, while geographical location and investment focus play crucial roles in determining the level of ESG risks. The study aims to contribute to a better understanding of ESG risk factors in investment portfolios, offering valuable implications for fund managers and investors in their decision-making processes and risk management strategies.

Keywords: Environmental, Social, Governance; Risk, Investment.
JEL Classification: *G34; M14; Q51.*

1. Introduction

The consideration of Environmental, Social, and Governance (ESG) factors has gained significant attention in the investment management industry in recent years (Friede et al., 2015; Eccles & Klimenko, 2019). Numerous studies have explored the relationship between ESG performance and financial outcomes, with mixed results (Margolis et al., 2009; Orlitzky et al., 2003). While these studies have provided valuable insights into the financial implications of ESG integration, they have largely overlooked the specific influence of fund characteristics—such as size, category, and investment area—on ESG risks. This gap in the literature is particularly significant given the growing emphasis on sustainable investing and the increasing sophistication of ESG risk assessment methodologies.

This study aims to address this gap by investigating the impact of fund size, fund category, and investment area on the environmental, social, and governance risks of investment funds. Specifically, the research seeks to answer the following questions: 1. Does the size of the fund influence the environmental, social, and governance risks? 2.How does the fund category (e.g., equity, fixed income) affect the environmental, social, and governance risks?. 3. Does the investment area (e.g., Europe, Asia, global) impact the environmental, social, and governance risks?

By addressing these research questions, this paper contributes to the existing literature on the integration of ESG factors in investment decision-making (Amel-Zadeh & Serafeim, 2018; Dyck et al., 2019). The findings of this study provide insights for fund managers, financial advisors, and investors seeking to incorporate ESG considerations into their investment strategies. Furthermore, the study employs robust regression analysis to examine these relationships, addressing potential econometric issues such as heteroscedasticity and multicollinearity. This methodological ensures that the results are both reliable and actionable.

The significance of this research lies in its ability to bridge the gap between theoretical discussions of ESG integration and practical investment decision-making. While previous studies have focused on the performance implications of ESG factors, this paper shifts the focus to understanding how structural characteristics of funds influence their ESG risk profiles. This perspective is crucial for developing targeted strategies to manage ESG risks and enhance the sustainability of investment portfolios.

The findings of this research have important implications for various stakeholders in the investment community. For fund managers, understanding how structural characteristics influence ESG risks can inform portfolio construction and risk management strategies. For investors, our results provide valuable insights for fund

selection and portfolio optimization, particularly when ESG considerations are paramount. Additionally, our findings contribute to the broader academic discourse on sustainable finance by providing empirical evidence of the relationships between institutional characteristics and ESG risk exposure.

The paper is organized as follows: Section 2 reviews the relevant literature and develops our hypotheses. Section 3 describes our data and methodology. Section 4 presents our empirical results and analysis.Finally, section 5 discusses the implications of our findings and concludes with suggestions for future research.

2. Literature Review

The integration of Environmental, Social, and Governance (ESG) factors into investment decision-making has gained significant traction in recent years. This shift reflects growing awareness of the financial and reputational risks associated with poor ESG performance, as well as the opportunities presented by sustainable investing (Friede et al., 2015; Eccles & Klimenko, 2019). While the relationship between ESG performance and financial outcomes has been extensively studied (Margolis et al., 2009; Orlitzky et al., 2003), the specific influence of fund characteristics—such as size, category, and investment area—on ESG risks remains underexplored. This literature review examines the existing body of research on these themes, highlighting key findings, gaps, and the relevance of this study.

Fund Size and ESG Risks. Fund size is a critical determinant of ESG risk management. Larger funds often have more resources to integrate ESG considerations into their investment processes, enabling them to conduct thorough due diligence and engage with portfolio companies (Dyck et al., 2019; Starks et al., 2017). However, they may also face challenges related to scale, such as increased complexity in maintaining consistent ESG standards across diverse portfolios (Krueger et al., 2020). Hartzmark and Sussman (2019) suggest that economies of scale in ESG implementation may exist, but these benefits can diminish beyond certain thresholds. Despite these insights, the literature offers mixed evidence on the relationship between fund size and ESG performance, necessitating further investigation (Dimson et al., 2015; Pastor et al., 2021).

Fund Category and ESG Risks. The type of investment fund—whether equity, fixed income, or allocation—significantly influences its ESG risk profile. Equity funds, for instance, are often more exposed to environmental and social risks due to their investments in industries with high environmental impact or labor-intensive operations (Friede et al., 2015; Eccles & Klimenko, 2019). In contrast, fixed-income funds may face greater governance risks, particularly in assessing the creditworthiness of issuers with varying ESG practices (Bauer & Hann, 2010; Chava, 2014). Recent studies indicate that bond funds are increasingly incorporating ESG criteria, particularly in evaluating environmental externalities and corporate governance (Henke, 2016; El Ghoul & Karoui, 2021). However, the extent to which these practices mitigate ESG risks across different fund categories remains an open question.

Investment Area and ESG Risks. Geographic considerations play a pivotal role in shaping ESG risk profiles. Funds investing in emerging markets often encounter higher ESG risks due to weaker regulatory frameworks, limited enforcement, and varying corporate practices (Liang & Renneboog, 2017; Dyck et al., 2019). Conversely, European funds are generally more advanced in ESG integration, reflecting the region's stringent regulations and investor demand for sustainable practices (Ferreira et al., 2018). Studies by Krueger et al. (2020) and Berg et al. (2022) highlight significant regional variations in ESG implementation, underscoring the need for context-specific strategies. Despite these findings, the interaction between investment area and other fund characteristics, such as size and category, remains underexplored.

While the existing research provides valuable insights into the relationship between ESG factors and investment performance, several gaps persist. First, the interplay between fund size, category, and investment area in determining ESG risks is not well understood. Second, most studies focus on developed markets, with limited attention to emerging economies and their unique ESG challenges (Liang & Renneboog, 2017). Finally, the role of fund management practices, such as active ownership and engagement, in mitigating ESG risks warrants further investigation (Dimson et al., 2015; Bauer & Hann, 2010).

This literature review underscores the growing importance of ESG factors in investment decision-making and the need to understand the influence of fund characteristics on ESG risks. By addressing the identified gaps, this study aims to contribute to the academic discourse on sustainable finance and provide actionable insights for investors, fund managers, and policymakers.

3. Data and Methodology

The data for this study was sourced from Morningstar Direct, a globally financial analysis platform renowned for its comprehensive coverage of sustainable investment funds and standardized ESG metrics. Morningstar Direct was selected due to its database, which aligns with the stringent regulatory and sustainability standards prevalent in the European market. The dataset provides a detailed view of fund characteristics and ESG performance, making it an resource for analyzing the relationship between fund attributes and ESG risks.

The final dataset comprises 1,737 sustainable investment funds, classified under the Sustainable Finance Disclosure Regulation (SFDR). Of these, 1,635 funds (94.1%) are categorized under Article 8, which promotes environmental or social characteristics, while 102 funds (5.9%) fall under Article 9, targeting specific sustainable investment objectives. The sample spans 31 geographical areas, offering a diverse representation of both developed and emerging markets. Specifically, the dataset includes 887 global funds (51.1%), 415 European funds (23.9%), 161 United States funds (9.3%), 124 global emerging market funds (7.1%), and 65 Asian funds (3.7%), with the remaining 85 funds (4.9%) distributed across other regions.

In terms of asset class composition, the sample is diverse, encompassing 686 equity funds (43.2%), 549 fixed-income funds (34.6%), 267 mixed-asset funds (16.8%), and 91 money market funds (5.4%). This variety allows for a comprehensive analysis of how different investment strategies address ESG risks. The dataset includes 97 variables, capturing both numerical and categorical indicators essential for ESG risk analysis. Key numerical variables include financial performance metrics and portfolio size, which provide insights into the impact of ESG

policies on fund outcomes. Categorical variables offer segmentation based on geographical focus, sustainability classification, and sector exclusion policies.

The assessment of environmental, social, and governance (ESG) risks in funds by Morningstar Direct is facilitated through a structured framework that leverages Sustainalytics' ESG Risk Ratings. This rating system evaluates a company's exposure to ESG risks and its ability to manage them, with scores ranging from 0 to 100. Lower scores indicate better management of these risks. The Sustainalytics ESG Risk Rating is categorized into several risk levels: negligible (0-10), low (11-20), medium (21-30), high (31-40), very high (41-50), and severe (51-100). This risk assessment is then used to inform the Morningstar Sustainability Rating, which is expressed as a number of globes (1 to 5). The rating reflects how well a fund manages financially material ESG risks compared to its peers in the same Morningstar Global Category. The distribution of these globes is as follows: one globe for the lowest 10% of funds, two globes for the next 22.5%, three globes for the middle 35%, four globes for the next 22.5%, and five globes for the top 10%.

The ESG risk assessment itself is composed of three primary components: environmental (E), social (S), and governance (G) risks. Environmental risks are evaluated based on factors such as carbon emissions and resource depletion, with the weight given to these factors varying by industry. Social risks include labor practices and community relations, also industry-specific. Governance risks focus on corporate oversight, board independence, and shareholder rights, which are crucial across industries for maintaining financial stability and investor confidence. While Morningstar does not explicitly use a points system for ESG risks, one could conceptualize it as allocating points across these components. For instance, in a hypothetical scenario, environmental risks might contribute 30 points, social risks another 30 points, and governance risks 40 points, totaling 100 points. However, the actual method involves comparing a fund's ESG risk profile to its peers within the same category, rather than using a fixed points system.

In practice, the Morningstar Sustainability Rating is determined by assessing the ESG risks associated with both corporate and sovereign entities in a fund's portfolio. At least 67% of a fund's assets under management must have an ESG score for it to receive a Morningstar Sustainability Rating. This rating serves as a relative measure, comparing a fund's ESG risk management to that of its peers, rather than an absolute assessment of its ESG performance. This approach provides investors with a clear indication of how well a fund manages ESG risks relative to its industry peers.

The dataset also incorporates detailed information on sector exclusions, which are critical for assessing the alignment of funds with their sustainability objectives. These exclusions cover sectors such as military contracts, small arms, nuclear energy, palm oil, pesticides, tobacco, thermal coal, and fossil fuels. By analyzing these exclusion policies, the study evaluates how such decisions influence ESG risk scores and overall fund performance.

4. Results and Analysis

The variable, Fund Size, is a quantitative and continuous variable; we will treat it as a covariate, that is, control its influence and isolate its effect so that it does not contaminate the conclusions we may obtain about the remaining variables. The remaining variables: Fund Category and Investment Area, are qualitative variables. The aim is to verify whether their presence or absence significantly affects the average Environmental, Social, and Governance risks.

The two options considered for conducting the analysis were ANCOVA and Regression Analysis; ultimately, we opted for the latter methodology. The reasons for this decision are several, but essentially Regression Analysis allows for a more appropriate treatment of potential problems such as heteroscedasticity and multicollinearity, in addition to being able to construct interactions between variables.

The first step has been to estimate the relationship between Government Risk and the explanatory variables. Once the model was formulated, interactions between the variables were sought to determine if any combination among them produces an effect greater than the sum of the individual effects.The heteroscedasticity tests indicate the presence of this problem in the estimated model. In all the tests used, the null hypothesis is rejected, admitting the presence of heteroscedasticity. It was resolved with robust estimators and elimination of non-significant variables.

Table 1. Estimation relationship between Government Risk and the explanatory variables.

Source	SS	df	MS		
				Number of obs	= 1,446
				F(8, 1437)	= 27.59
Model	330.476176	8	41.309522	Prob > F	= 0.0000
Residual	2151.48996	1,437	1.49720944	R-squared	= 0.1332
				Adj R-squared	= 0.1283
Total	2481.96613	1,445	1.71762362	Root MSE	= 1.2236

GovernanceRiskScore	Coefficient	Std. err.	t	P>|t|	Beta
FundSizeBaseCurrency	4.56e-11	1.49e-11	3.07	0.002	.0760006
CHINA	1.036894	.3079451	3.37	0.001	.0877511
EUROPA	-.5449813	.1264027	-4.31	0.000	-.1802057
ASIA	.3589717	.1968683	1.82	0.068	.0524111
GLOBAL	-.4634486	.1182473	-3.92	0.000	-.1766006
GLOBALEMERGINGMARKET	-.7305952	.1568139	-4.66	0.000	-.151478
Fixed	-.7573785	.1032952	-7.33	0.000	-.2565637
Equity	-.0275986	.0926814	-0.30	0.766	-.0104681
_cons	6.943955	.1430724	48.53	0.000	.

Table 2. Heteroskedasticity tests.

```
Breusch-Pagan/Cook-Weisberg test for heteroskedasticity
Assumption: Normal error terms
Variable: Fitted values of GovernanceRiskScore

H0: Constant variance

    chi2(1) =  65.18
Prob > chi2 = 0.0000
```

```
Breusch-Pagan/Cook-Weisberg test for heteroskedasticity
Assumption: i.i.d. error terms
Variable: Fitted values of GovernanceRiskScore

H0: Constant variance

    chi2(1) =  23.87
Prob > chi2 = 0.0000
```

```
Szroeter's test for homoskedasticity

H0: Variance constant
Ha: Variance monotonic in variables
```

Variable	chi2	df	p
FundSizeBa~y	16.63	1	0.0000*
EUROPA	0.03	1	0.8716*
ASIA	1.80	1	0.1801*
GLOBAL	1.25	1	0.2629*
GLOBALEMER~T	1.29	1	0.2553*
Fixed	253.17	1	0.0000*
Equity	72.57	1	0.0000*
FIXEDEUROPA	60.86	1	0.0000*
FIXEDASIA	1.42	1	0.2326*
FIXEDGLOBAL	99.72	1	0.0000*
FIXEDGLOBA~T	34.44	1	0.0000*
EQUITYCHINA	5.69	1	0.0170*
EQUITYEUROPA	44.55	1	0.0000*
EQUITYASIA	3.19	1	0.0742*
EQUITYGLOBAL	7.42	1	0.0065*

* Unadjusted *p*-values

Table 3. Estimation relationship between Government Risk and the explanatory variables.

```
Linear regression                       Number of obs     =      1,446
                                        F(9, 1435)        =          .
                                        Prob > F          =          .
                                        R-squared         =     0.3258
                                        Root MSE          =     1.0798
```

GovernanceRiskScore	Coefficient	Robust HC3 std. err.	t	P>|t|	Beta
FundSizeBaseCurrency	4.47e-11	1.41e-11	3.18	0.001	.0745249
EUROPA	-.3680082	.1560375	-2.36	0.018	-.121687
GLOBAL	-.4616011	.1072079	-4.31	0.000	-.1758966
GLOBALEMERGINGMARKET	.8452152	.1329176	6.36	0.000	.1752427
Fixed	-.4237719	.1032172	-4.11	0.000	-.1435537
FIXEDASIA	-1.336933	.204727	-6.53	0.000	-.0464324
FIXEDGLOBALEMERGINGMARKET	-4.128383	.2758783	-14.96	0.000	-.55302
EQUITYCHINA	1.097098	.1585564	6.92	0.000	.0928461
EQUITYEUROPA	-.4883664	.1329831	-3.67	0.000	-.122471
EQUITYASIA	.5147938	.2045947	2.52	0.012	.0724809
_cons	6.857772	.1066254	64.32	0.000	.

The model does not present multicollinearity problems.This approach has been maintained to explain both Environmental Risk and Social Risk. The presence of heteroscedasticity is detected in both models.

Table 4. Multicollinearity test.

Variable	VIF	1/VIF
EUROPA	4.09	0.244456
GLOBAL	3.18	0.314143
GLOBALEMER~T	2.36	0.424004
EQUITYEUROPA	2.30	0.434280
FIXEDGLOBA~T	1.85	0.539508
Fixed	1.59	0.627692
EQUITYASIA	1.35	0.742034
EQUITYCHINA	1.13	0.888184
FIXEDASIA	1.03	0.969476
FundSizeBa~y	1.02	0.980407
Mean VIF	1.99	

Table 5. Estimation relationship between Environmental Risk/Social Risk and the explanatory variables.

Environmental Risk

Source	SS	df	MS	Number of obs	=	1,446
				F(8, 1437)	=	32.37
Model	357.591289	8	44.6989112	Prob > F	=	0.0000
Residual	1984.05358	1,437	1.38069142	R-squared	=	0.1527
				Adj R-squared	=	0.1480
Total	2341.64486	1,445	1.62051548	Root MSE	=	1.175

EnvironmentalRiskS~e	Coefficient	Std. err.	t	P>|t|	Beta
FundSizeBaseCurrency	1.34e-12	1.43e-11	0.09	0.925	.002296
CHINA	1.133014	.2957197	3.83	0.000	.0987167
EUROPA	.0700532	.1213846	0.58	0.564	.023848
ASIA	.5360452	.1898527	2.84	0.005	.0805752
GLOBAL	.0490964	.1135529	0.43	0.666	.0192689
GLOBALEMERGINGMARKET	1.069855	.1505884	7.10	0.000	.2283678
Fixed	-.6473194	.0991944	-6.53	0.000	-.2257554
Equity	.2606145	.089002	2.93	0.003	.1017694
_cons	3.523924	.1373925	25.65	0.000	.

Social Risk

Source	SS	df	MS	Number of obs	=	1,446
				F(15, 1430)	=	32.28
Model	981.972267	15	60.1314845	Prob > F	=	0.0000
Residual	2670.50349	1,430	1.86748496	R-squared	=	0.2525
				Adj R-squared	=	0.2446
Total	3572.47576	1,445	2.47230156	Root MSE	=	1.3666

SocialRiskScore	Coefficient	Std. err.	t	P>|t|	Beta
FundSizeBaseCurrency	5.59e-11	1.67e-11	3.35	0.001	.0776249
CHINA	0	(omitted)			0
EUROPA	-1.221886	1.38898	-0.88	0.379	-.3367459
ASIA	-1.458948	1.935294	-0.75	0.451	-.1775481
GLOBAL	-1.014468	1.372588	-0.74	0.460	-.3222125
GLOBALEMERGINGMARKET	-.6867624	.2110523	-3.25	0.001	-.1186841
Fixed	-.8455881	1.394704	-0.61	0.544	-.238756
Equity	-.1795882	1.375944	-0.13	0.896	-.0567744
FIXEDCHINA	0	(omitted)			.
FIXEDEUROPA	.3291842	1.417972	0.23	0.816	.0636698
FIXEDASIA	-.9874001	2.105983	-0.47	0.639	-.0285837
FIXEDGLOBAL	.1811209	1.401572	0.13	0.897	.0367332
FIXEDGLOBALEMERGINGMARKET	-3.11513	.3962866	-7.86	0.000	-.3478166
EQUITYCHINA	.7379596	.348667	2.12	0.034	.0520552
EQUITYEUROPA	-.0744282	1.398512	-0.05	0.958	-.0155574
EQUITYASIA	.538962	1.940002	0.28	0.781	.0632581
EQUITYGLOBAL	.2407211	1.381173	0.17	0.862	.0674656
EQUITYGLOBALEMERGINGMARKET	0	(omitted)			0
_cons	9.01996	1.372315	6.57	0.000	.

Table 6. Heteroskedasticity tests.

Environmental Risk

```
Breusch-Pagan/Cook-Weisberg test for heteroskedasticity
Assumption: Normal error terms
Variable: Fitted values of EnvironmentalRiskScore

H0: Constant variance

    chi2(1) =  14.14
Prob > chi2 = 0.0002

Breusch-Pagan/Cook-Weisberg test for heteroskedasticity
Assumption: i.i.d. error terms
Variable: Fitted values of EnvironmentalRiskScore

H0: Constant variance

    chi2(1) =   5.00
Prob > chi2 = 0.0253
```

```
Szroeter's test for homoskedasticity

H0: Variance constant
Ha: Variance monotonic in variables
```

Variable	chi2	df	p
FundSizeBa~y	0.34	1	0.5594*
EUROPA	9.69	1	0.0019*
ASIA	3.64	1	0.0565*
GLOBAL	0.23	1	0.6347*
GLOBALEMER~T	137.94	1	0.0000*
Fixed	56.91	1	0.0000*
Equity	4.83	1	0.0280*
FIXEDEUROPA	0.22	1	0.6375*
FIXEDASIA	0.07	1	0.7988*
FIXEDGLOBAL	0.01	1	0.9297*
FIXEDGLOBA~T	477.72	1	0.0000*
EQUITYCHINA	0.91	1	0.3407*
EQUITYEUROPA	17.73	1	0.0000*
EQUITYASIA	3.29	1	0.0696*
EQUITYGLOBAL	23.41	1	0.0000*

* Unadjusted *p*-values

Social Risk

```
Breusch-Pagan/Cook-Weisberg test for heteroskedasticity
Assumption: Normal error terms
Variable: Fitted values of SocialRiskScore

H0: Constant variance

    chi2(1) =  86.04
Prob > chi2 = 0.0000

Breusch-Pagan/Cook-Weisberg test for heteroskedasticity
Assumption: i.i.d. error terms
Variable: Fitted values of SocialRiskScore

H0: Constant variance

    chi2(1) =  29.09
Prob > chi2 = 0.0000
```

```
Szroeter's test for homoskedasticity

H0: Variance constant
Ha: Variance monotonic in variables

     Variable |      chi2    df       p
--------------+-----------------------------
FundSizeBa~y |     10.26     1    0.0014*
       EUROPA |      4.37     1    0.0366*
         ASIA |      0.42     1    0.5193*
       GLOBAL |      1.11     1    0.2931*
GLOBALEMER~T |      0.04     1    0.8507*
        Fixed |    214.32     1    0.0000*
       Equity |     55.35     1    0.0000*
  FIXEDEUROPA |     90.40     1    0.0000*
    FIXEDASIA |      1.26     1    0.2611*
  FIXEDGLOBAL |     53.51     1    0.0000*
FIXEDGLOBA~T |     33.70     1    0.0000*
  EQUITYCHINA |      4.70     1    0.0302*
EQUITYEUROPA |     28.70     1    0.0000*
    EQUITYASIA |      0.08     1    0.7716*
EQUITYGLOBAL |      0.52     1    0.4697*
--------------+-----------------------------
* Unadjusted p-values
```

To eliminate the problem, they are estimated with heteroscedasticity-robust estimators, and non-significant variables are sequentially eliminated. Both models do not present multicollinearity problems.

Table 7. Estimation relationship between Environmental Risk/Social Risk and the explanatory variables with heteroscedasticity-robust estimators.

Final Environmental Risk Model

```
Linear regression                               Number of obs     =      1,446
                                                F(8, 1437)        =      40.79
                                                Prob > F          =     0.0000
                                                R-squared         =     0.1713
                                                Root MSE          =     1.1621
```

EnvironmentalRiskS~e	Coefficient	Robust HC3 std. err.	t	P>|t|	Beta
ASIA	.6303906	.150048	4.20	0.000	.0947567
GLOBAL	.1601834	.0884872	1.81	0.070	.0628413
GLOBALEMERGINGMARKET	.9296787	.1859404	5.00	0.000	.1984463
Equity	.2206866	.0848258	2.60	0.009	.0861776
FIXEDEUROPA	-.7405457	.1325769	-5.59	0.000	-.1769173
FIXEDGLOBAL	-.6374979	.1080403	-5.90	0.000	-.1596957
EQUITYCHINA	1.265613	.2522426	5.02	0.000	.1102698
EQUITYEUROPA	.4469055	.1041043	4.29	0.000	.1153827
_cons	3.4337	.0944478	36.36	0.000	.

Final Social Risk Model

```
Linear regression                               Number of obs     =      1,446
                                                F(9, 1435)        =          .
                                                Prob > F          =          .
                                                R-squared         =     0.2518
                                                Root MSE          =     1.3648
```

SocialRiskScore	Coefficient	Robust HC3 std. err.	t	P>|t|	Beta
FundSizeBaseCurrency	5.70e-11	1.79e-11	3.18	0.002	.0791529
EUROPA	-1.261423	.1364976	-9.24	0.000	-.3476649
ASIA	-.9339996	.2200955	-4.24	0.000	-.113664
GLOBAL	-.8046352	.1275451	-6.31	0.000	-.2555659
GLOBALEMERGINGMARKET	-.6936723	.1455415	-4.77	0.000	-.1198782
Fixed	-.6982014	.1382505	-5.05	0.000	-.1971407
FIXEDEUROPA	.393866	.2221999	1.77	0.077	.0761803
FIXEDASIA	-1.486803	.4102306	-3.62	0.000	-.0430406
FIXEDGLOBALEMERGINGMARKET	-3.082935	.3436461	-8.97	0.000	-.3442219
EQUITYCHINA	.7308476	.2158011	3.39	0.001	.0515535
_cons	8.84548	.1268131	69.75	0.000	.

Table 8. Multicollinearity test.

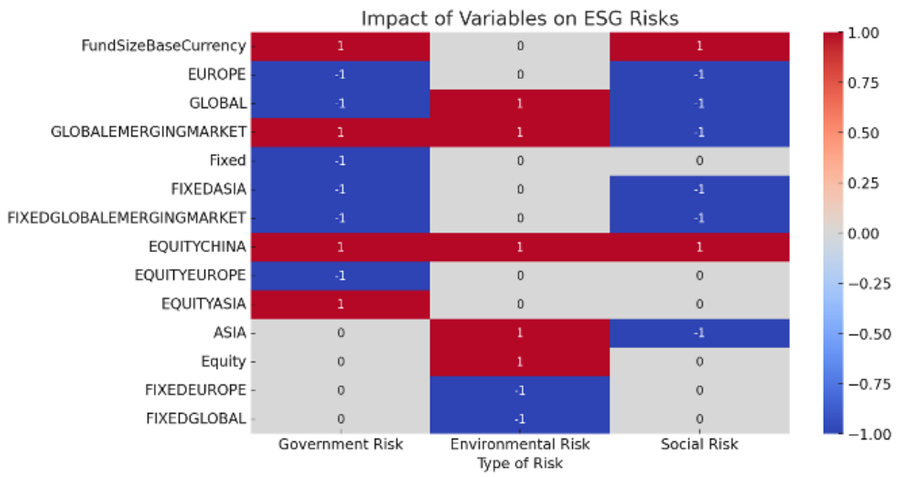
Final Environmental Risk Model

Variable	VIF	1/VIF
GLOBAL	2.76	0.362073
FIXEDEUROPA	1.95	0.512590
EQUITYEUROPA	1.91	0.522235
Equity	1.71	0.583350
GLOBALEMER~T	1.56	0.641439
FIXEDGLOBAL	1.42	0.704893
ASIA	1.30	0.768394
EQUITYCHINA	1.11	0.904358
Mean VIF	1.72	

Final Social Risk Model

Variable	VIF	1/VIF
EUROPA	3.42	0.292132
GLOBAL	3.20	0.312122
FIXEDEUROPA	2.42	0.413997
GLOBALEMER~T	2.37	0.422027
FIXEDGLOBA~T	1.90	0.526200
Fixed	1.89	0.528284
ASIA	1.43	0.696985
EQUITYCHINA	1.13	0.886742
FIXEDASIA	1.08	0.929920
FundSizeBa~y	1.02	0.981023
Mean VIF	1.99	

Table 9. Interpretation of results: comparative summary.



5. Interpretation of the Government Risk Model

The Portfolio Governance Risk Score reaches an average value of 6.86 points. This indicator is influenced by several key variables. The fund size in base currency (FundSizeBaseCurrency) has a direct positive influence. For every euro increase in fund size, the Portfolio Governance Risk Score increases on average by 4.47e-11 points, provided that the other variables remain constant.

Geographic location also plays a crucial role. If the fund is located in Europe, the Portfolio Governance Risk Score decreases on average by 0.368 points, dropping from 6.86 to 6.49 points, with statistically significant differences between both categories compared to funds located in the U.S. On the other hand, if the fund is global, the indicator decreases by 0.4616011 points, resulting in a value of 6.3962 points. In contrast, funds classified as global emerging markets experience an increase in the indicator of 0.8452152 points, raising the average risk to 7.703 points.

Regarding investment categories, fixed funds show a decrease in risk on average of 0.4237719 points, achieving a mean score of 6.434 points compared to Allocation funds. Additionally, interactions between different variables are also significant. For example, the interaction between fixed funds and location in Asia reduces the Portfolio Governance Risk Score to an average value of 5.0971 points. This reduction is even more pronounced for fixed funds in global emerging markets, where the indicator drops to 2.30562 points. On the other hand, equity funds in China experience an increase in risk to an average value of 7.95487 points, while in Europe the risk is reduced to 6.0214 points. Finally, equity funds in Asia present an increase in risk to an average value of 7.37257 points. These interactions and variables demonstrate how different geographic and investment factors influence the governance risk of funds.

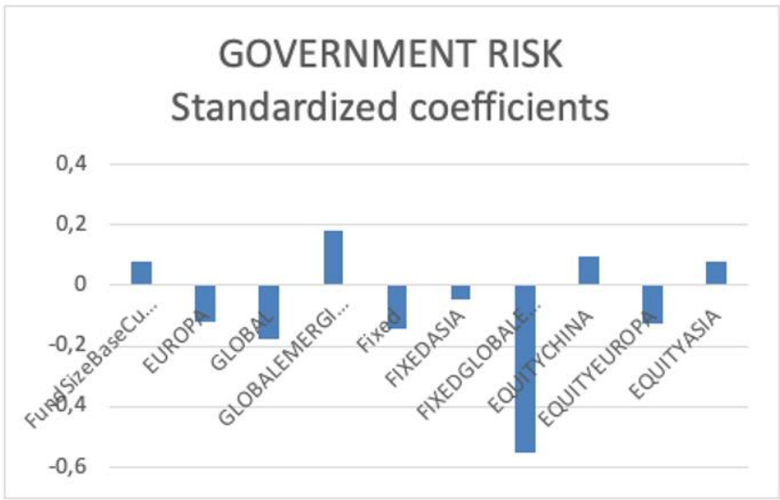


Figure 1. Standardized coefficients.

Table 10. Interpretation of the Government Risk Model.

Explanatory variables	Coefficients	Standardized coefficients
FundSizeBaseCurrency	4.47e-11	0,0745249
EUROPA	-0,3680082	-0,121687
GLOBAL	-0,4616011	-0,1758966
GLOBALEMERGINGMARKET	0,8452152	0,1752427
Fixed	-0,4237719	-0,1435537
FIXEDASIA	-1,336933	-0,0464324
FIXEDGLOBALEMERGINGMARKET	-4,128383	-0,55302
EQUITYCHINA	1,097098	0,0928461
EQUITYEUROPA	-0,4883664	-0,122471
EQUITYASIA	0,5147938	0,0724809
_cons	6,857772	

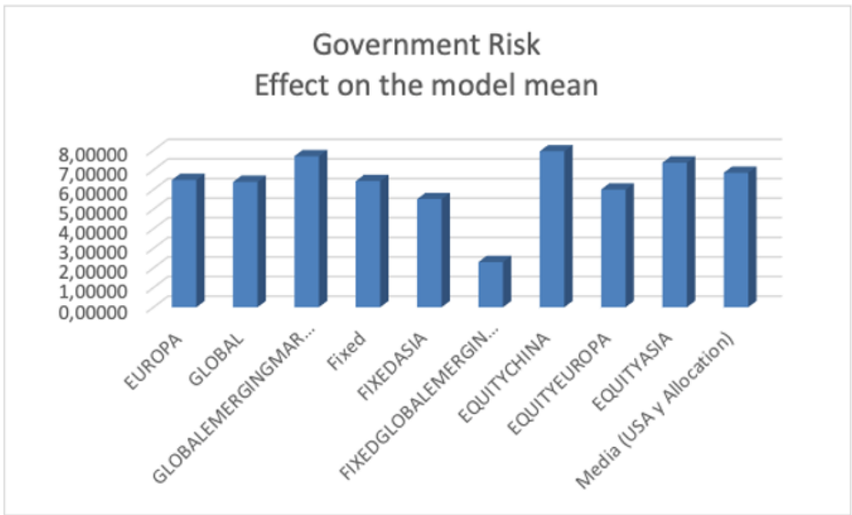


Figure 2. Effect on the model mean.

6. Interpretation of the Environmental Risk Model

The Portfolio Environmental Risk Score variable measures the environmental risk of the portfolio. In this case, the average risk of the different portfolios included in the data reaches a value of 3.4337 points. The variables that significantly influence this variable are several. Geographic location plays a crucial role. If the fund is based in Asia, the average risk increases by 0.6303906 points, so that the average value of the variable, in this case, is 4.064 points, with significant differences between the Asia and USA categories. Similarly, if the fund is categorized as Global, the average risk increases by 0.1601834 points, so that the average value for the Environmental Risk variable is 3.5939 points.

Funds classified as Global Emerging Markets exhibit a more pronounced increase in environmental risk, rising by 0.9296787 points; so that the average value for the studied variable in this type of funds is 4.3633787 points. Additionally, the type of investment also impacts the risk. If the fund is Equity, compared to Allocation, the

average risk increases by 0.2206866 points; so that the average of the Environmental Risk variable is in this case 3.6543866 points, with significant differences between the Equity and Allocation categories.

Interactions between variables further modify the environmental risk. For instance, if the fund is both Fixed and based in Europe, the environmental risk is reduced by 0.7405457 points, so that the average value of the studied variable in this case is calculated as (3.4337 - 0.7405457* FIXEDEUROPE) = 2.6931543 points. A similar reduction occurs for Fixed funds categorized as Global, where the risk decreases by 0.6374979 points. In this case, the variable reaches an average value of (3.4337 - 0.6374979* FIXEDGLOBAL) = 2.7962021 points.

Conversely, equity funds based in China experience a significant increase in environmental risk by 1.265613 points on average, so that in this case, the studied variable reaches an average value of (3.4337 + 1.265613 * EQUITYCHINA) = 4.699313 points.

Equity funds based in Europe also see an increase, albeit smaller, by 0.4469055 points, so that the variable takes an average value of (3.4337 + 0.4469055* EQUITYEUROPE) = 3.8806055 points. These interactions highlight how different geographic and investment factors influence the environmental risk of funds.

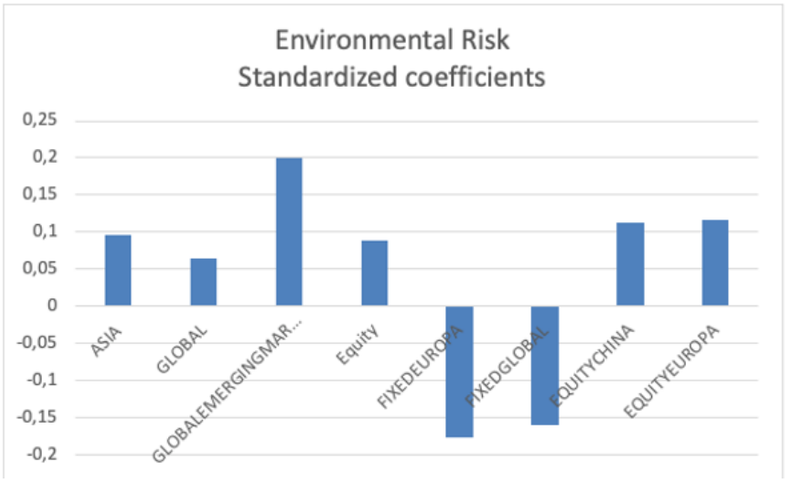


Figure 3. Standardized coefficients.

Table 11. Interpretation of the Environmental Risk model

Explanatory variables	Coefficients	Standardized coefficients
ASIA	.6303906	0,0947567
GLOBAL	.1601834	0,0628413
GLOBALEMERGINGMARKET	.9296787	0,1984463
Equity	.2206866	0,0861776
FIXEDEUROPA	-.7405457	-0,1769173
FIXEDGLOBAL	-.6374979	-0,1596957
EQUITYCHINA	1.265.613	0,1102698
EQUITYEUROPA	.4469055	0,1153827
_cons	34.337	.

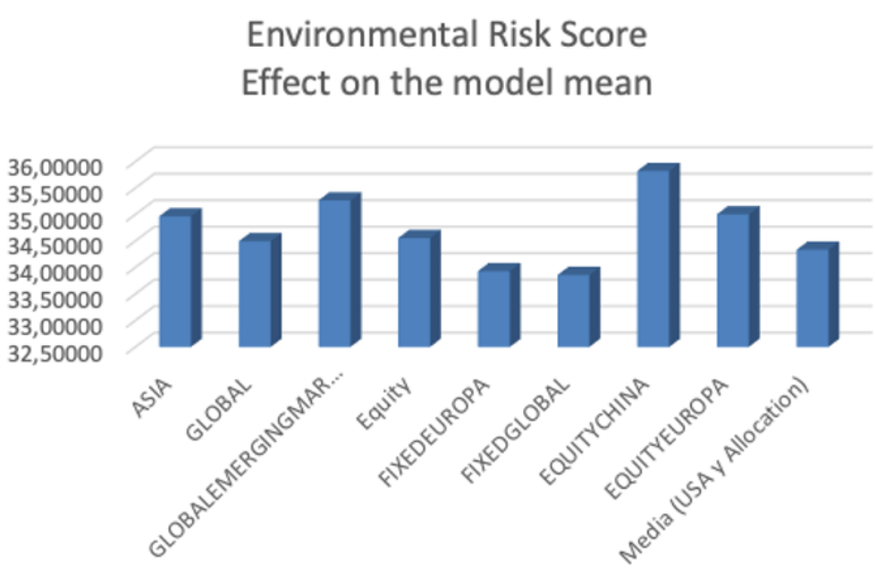


Figure 4. Effect on the model mean.

7. Interpretation of Social Risk Score

The Portfolio Social Risk Score variable measures the social risk of the portfolio; in this case, the average risk of the different portfolios included in the data reaches a value of 8.84548 points. Several variables significantly influence this score. The fund size in base currency (FundSizeBaseCurrency) has a positive or direct influence. For each euro increase in fund size, the Portfolio Social Risk Score variable increases on average by 5.70e-11 points, provided that the remaining variables remain constant.

Geographic location also plays a crucial role in determining social risk. If the fund is based in Europe, the social risk is reduced, on average, by 1.261423 points, resulting in a risk value of 7.584057, which is significantly lower than if it is based in the USA. Similarly, if the fund is based in Asia, the social risk is reduced by 0.9339996 points, with the risk taking a value of 7.9114804, also significantly lower than if the fund is based in the USA. For Global funds, the social risk is reduced by 0.8046352 points, resulting in a risk value of 8.0408448, which is again significantly lower than if the fund is based in the USA. Funds categorized as Global Emerging Markets experience a reduction in social risk by 0.6936723 points, leading to a risk value of 8.1518077, which is also lower than if the fund is based in the USA.

In terms of investment categories, Fixed funds show a reduction in average social risk by 0.6982014 points, reaching a value of 8.1472786, which is significantly lower than if the fund is categorized as Allocation. Interactions between variables further modify the social risk. For instance, if the fund is both Fixed and based in Europe, the average social risk reaches a value of (8.84548 - 0.6982014Fixed + 0.393866FixedEurope) = 8.5411446 points. A more pronounced reduction occurs for Fixed funds based in Asia, where the risk reaches a value of (8.84548 - 0.6982014Fixed - 1.486803 FIXEDASIA) = 6.6604756 points. For Fixed funds categorized as Global in emerging markets, the risk is significantly reduced to (8.84548 - 0.6982014Fixed - 3.082935 FIXEDGLOBALEMERGINGMARKET) = 5.0643436 points. Conversely, equity funds located in China experience an increase in social risk, reaching a value of (8.84548 + 0.7308476* EQUITYCHINA) = 9.5763276 points. These interactions highlight how different geographic and investment factors influence the social risk of funds.

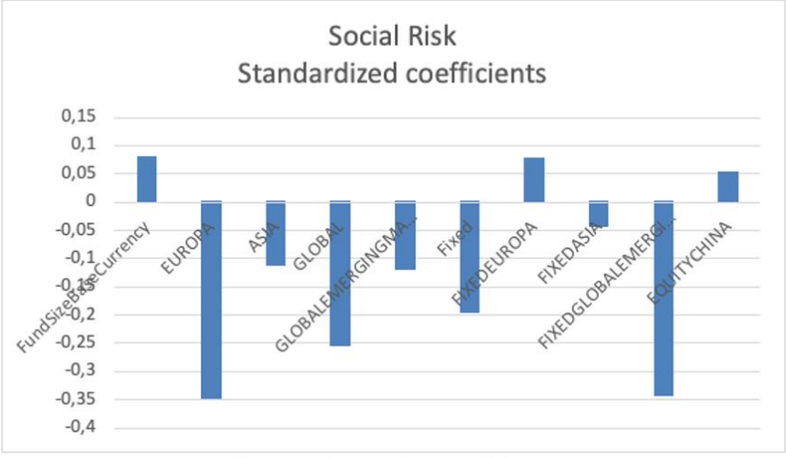


Figure 5. Standardized coefficients.

Table 12. Interpretation of the Social Risk Model.

Explanatory variables	Coefficients	Standardized coefficients
FundSizeBaseCurrency	5.70e-11	0,0791529
EUROPA	-1.261.423	-0,3476649
ASIA	-.9339996	-0,113664
GLOBAL	-.8046352	-0,2555659
GLOBALEMERGINGMARKET	-.6936723	-0,1198782
Fixed	-.6982014	-0,1971407
FIXEDEUROPA	.393866	0,0761803
FIXEDASIA	-1.486.803	-0,0430406
FIXEDGLOBALEMERGINGMARKET	-3.082.935	-0,3442219
EQUITYCHINA	.7308476	0,0515535
_cons	884.548	.

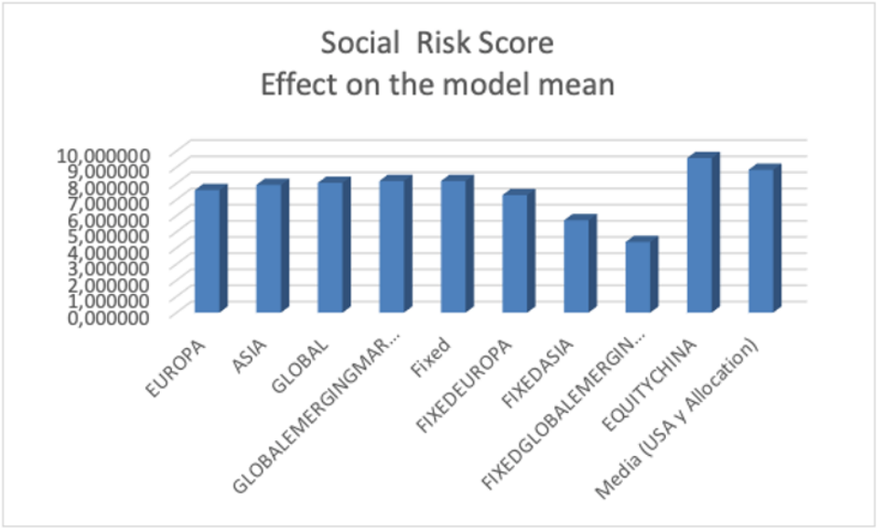


Figure 6. Effect on the model mean.

8. Conclusions

This study makes significant contributions to understanding of how fund characteristics influence Environmental, Social, and Governance (ESG) risks in investment portfolios. Through a comprehensive analysis of 1,737 sustainable investment funds, utilizing data from Morningstar Direct, we have uncovered several important relationships between fund attributes and ESG risk profiles. Our findings have substantial implications for investment decision-making and portfolio management in the context of sustainable finance.

The analysis reveals that fund size significantly impacts governance risk, with larger funds experiencing greater challenges in managing governance-related issues. This finding suggests that as funds grow, they may need to implement more sophisticated governance structures and risk management frameworks. However, the relationship between fund size and environmental or social risks appears to be less pronounced, indicating that these dimensions of ESG risk may be more influenced by other factors.

Our investigation of fund categories yields notable insights, particularly regarding the distribution of ESG risks across different investment vehicles. Global Emerging Market and Equity funds demonstrate higher governance and environmental risks compared to their Allocation and USA-focused counterparts. Conversely, Fixed Income and European funds generally exhibit lower ESG risk profiles, suggesting that these categories may be more effective at managing sustainability-related challenges. These findings highlight the importance of considering fund category when constructing sustainable investment portfolios.

The geographical focus of funds emerges as a crucial determinant of ESG risk exposure. Funds invested in Asian and Global Emerging Markets show elevated environmental and social risks, while those focused on European and Global markets generally demonstrate lower social risk profiles. This geographic variation in ESG risk exposure underscores the need for investors to carefully consider regional factors when making allocation decisions.

The implications of our findings extend beyond academic interest to practical application in investment management. For institutional investors and fund managers, our results suggest the importance of implementing robust ESG risk management frameworks, particularly in larger funds and those with exposure to emerging markets. The study also provides valuable insights for regulatory bodies and policymakers, highlighting areas where additional oversight or guidance may be beneficial in promoting sustainable investment practices.

Looking ahead, several avenues for future research emerge from our findings. First, investigating the temporal dynamics of ESG risks across different fund characteristics could provide insights into how these relationships evolve over time. Second, examining the interaction between fund management strategies and ESG performance could yield valuable insights for optimizing sustainable investment approaches. Finally, exploring the relationship between ESG risks and financial performance at the portfolio level could further enhance our understanding of the risk-return trade-offs in sustainable investing.

This study advances understanding of the complex relationship between fund characteristics and ESG risks, providing a foundation for more effective sustainable investment strategies. As the importance of ESG considerations continues to grow in the investment industry, these insights become increasingly valuable for stakeholders seeking to balance financial returns with sustainability objectives. The findings not only contribute to the academic discourse on sustainable finance but also offer practical guidance for investment professionals navigating the evolving landscape of responsible investing.

Data Statement:

The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

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