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ESG SCORES AND ARBITRAGE OPPORTUNITIES IN RIGHTS ISSUES: EVIDENCE FROM INTERNATIONAL EQUITY MARKETS

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Abstract

This study examines the extent to which Environmental, Social, and Governance (ESG) performance influences the emergence of arbitrage opportunities in rights-based equity offerings, starting with the idea that firms with stronger sustainability indicators might display greater pricing efficiency. Using a sample of 258 rights issues conducted between 2000 and 2023 in 41 countries, we identify arbitrage conditions through a trading strategy that compares the theoretical and market price of shares acquired via subscription rights. We complement this analysis with OLS, logit, and probit estimations to evaluate whether ESG scores - interpreted as quantitative measures of firms' sustainability practices - help explain the probability of these market anomalies arising. The results show a positive and statistically significant association between ESG scores and the likelihood of arbitrage, contrary to the usual expectation that higher ESG performance enhances market efficiency. Further, Granger causality tests provide complementary evidence that variations in ESG scores may precede the emergence of these anomalies. These results suggest that firms with stronger ESG profiles may experience temporary overvaluation during rights offerings, limiting the market's ability to immediately absorb price discrepancies. This study provides one of the first empirical assessments linking sustainability metrics to pricing inefficiencies in rights offerings, highlighting the need for deeper analysis of how ESG information interacts with market-pricing mechanisms. To the best of the authors' knowledge, this is one of the few articles that examines the emergence of arbitrage opportunities in equity offerings with subscription rights, and the first to introduce sustainability factors as an explanatory variable for those market anomalies

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Introduction

An equity offering is a corporate strategy where companies issue new shares to raise capital instead of taking on debt, serving various strategic purposes. Previously, Eckbo and Masulis (1995) conducted an analysis of the factors that might influence the decision to undertake an equity offering. More recently, Lin and Wu (2013) expanded this analysis by incorporating the liquidity risk perceived by the company's managers as a factor, while Shu and Chiang (2014) added information regarding agents' expectations, including variables related to the management of the profits generated by the issuing company in the equation. This process requires extensive information disclosure, impacting both the issuing firm and the market. Recent research underscores the importance of these information flows in shaping market dynamics. Liao et al. (2022) emphasizes the effects that the available information about Directors and Officers can have on the valuation of the new shares. Meanwhile, Sun et al. (2020) highlights the presence of a certain level of optimism among investors during these processes, which ultimately also impacts the pricing of the new shares in the markets.

Equity offerings often involve strategic decisions by the issuing firm. Yu et al. (2022) link these processes to increased innovation, while Tong (2010) investigates ownership structure changes and their market impact. Elliott and Songur (2016) highlight arbitrage risk and its effect on demand elasticity during such offerings. Due to the complexity of these transactions, market anomalies may emerge, as noted by Kumar et al. (2018) as well as Dutta (2017). Henry and Koski (2010) focuses on the higher volume of short positions observed in the context of these processes, noting that a higher volume of these positions appears to be associated with greater discounts in the issuance. Additionally, they document a scenario in which an increased presence of short selling reduces market efficiency. Meanwhile, Liu et al. (2016) analyzes the market reaction to the announcement of these equity offerings, concluding that the reaction tends to be negative, although it may depend on factors specific to the equity offering or the issuing company itself. Finally, Oh and Kim (2018) emphasizes the positive effect of external analysts' involvement in these processes.

In the landscape of equity offerings, rights issues are a significant mechanism that allows existing shareholders to purchase additional shares, often at a discount. However, this process can introduce complexities, especially regarding potential control over company decisions. As stated by Burkart and Zhong (2023), the choice between equity offerings with and without subscription rights is influenced by various factors, including the firm's investment opportunities and market conditions. For its part, Ofer (2023) states that rights offerings can sometimes be used as a tool for controlling shareholders to gain a disproportionate level of influence, posing governance challenges.

Market anomalies often appear in equity offerings, characterized by different types of offerings that carry varying signals about a firm's future prospects. Heron and Lie (2004) point out that regular equity offerings may signal negative future performance, whereas market manipulations around seasoned equity offerings (SEOs) can result in both pre-issue positive returns and poorer long-term performance, as explained by Banerjee et al. (2019). Finally, Viswanath (1993) emphasized that such market anomalies might stem from strategic considerations based on asymmetric information.

Focusing on equity offerings involving the issuance of subscription rights, it can be stated that these cases create two avenues for acquiring the company's shares: (1) purchasing the outstanding shares, and (2) purchasing and subsequently exercising the subscription rights to obtain the new shares. Despite the substantial volume of research analyzing equity offerings, there are very few studies that delve deeply into the potential arbitrage opportunities that may arise in these processes. Only Marzal and Montes (2000), Verdú et al. (2024) as well as Verdú et al. (2025) underscore arbitrage opportunities in processes involving subscription rights. Furthermore, these latter studies propose a specifically designed strategy to exploit the potential profits of identified arbitrage opportunities. By applying this strategy to past equity offerings, it is possible to determine whether a market opportunity indeed arose that was not absorbed by the market, providing a clear indicator of the presence of such market anomalies.

Existing literature consistently links sustainability practices to financial market performance. Hardiningsih et al. (2020) and Maletic et al. (2015) argue that high-quality sustainability reporting boosts market performance, while Lourenço et al. (2012) indicate that firms neglecting sustainability may face market valuation penalties. In the same sense, Przychodzen and Przychodzen (2013) found that companies with robust corporate sustainability practices are seen to have enhanced market valuations and can experience abnormal returns. However, Cristófalo et al. (2016) affirm that the correlation between sustainability practices and financial performance may vary across sectors. Furthermore, Aydoğan and Kara (2023) point out that sustainability investments could affect dynamic changes in market value faster than other financial performance indicators.

Research shows that ESG scores affect market reactions, with Cui and Docherty (2020) noting potential overreactions to ESG shifts and Cao et al. (2023) identi-

fying positive biases toward high ESG-scoring firms. Bofinger et al. (2022) expands on this information, suggesting that a higher ESG score could exacerbate the pre-existing overvaluation of a company's shares. In contrast, Wu et al. (2022) indicates that, for the Chinese companies analyzed, a higher ESG score is typically associated with greater efficiency in the valuation of their shares. Liu et al. (2022) conclude that changes in ESG ratings can lead to substantial impacts on stock pricing, with higher ESG scores sometimes corresponding with lower future returns; nonetheless, they do offer lower volatility and risk exposure. Additionally, Cho (2023) finds that, during economic downturns, high ESG-rated stocks may perform better compared to their poorly rated counterparts.

The evidence collected so far indicates that the potential effects of ESG ratings on equity offerings could be multifaceted. Chen et al. (2020) are already pointing out that ESG ratings can influence investor demand and pricing strategies, where higher ratings might attract more investor willingness and perhaps lower the cost of equity offerings. However, Rzeźnik et al. (2022) note that different economic conditions and perceptions of ESG ratings can create diverse impacts on stock pricing and investor behaviors during equity offerings. These insights provide a detailed overview of current research and knowledge around equity offerings and the intricate roles played by market anomalies and sustainability factors, particularly ESG considerations. Each theme discussed highlights essential considerations within contemporary financial markets and reflects ongoing shifts towards understanding the broader implications of corporate strategies and environmental responsibility. It is worth noting that, across this strand of the literature, the explanatory power of ESG-based models tends to be modest: Cui and Docherty (2020) report R^2 values in the range of 15% in several specifications, Bofinger et al. (2022) document values frequently below 10%, and Cao et al. (2023) find that certain specifications do not exceed 5%. This pattern reflects the inherently multifactorial nature of stock pricing and the diffuse informational channels through which ESG scores operate and is therefore expected to characterize empirical models in this area.

The relationship between ESG (Environmental, Social, and Governance) practices and market efficiency is an intricate one, influencing various facets of financial markets. For instance, Mervelskemper and Streit (2017) affirmed that the adoption of integrated reporting of ESG performance can enhance market valuation and efficiency by improving investors' perceptions of a company's true value. This implies that how ESG information is disclosed can significantly impact investor decisions, potentially leading to improved market efficiency. This relationship between ESG performance and market efficiency is further evident in studies like the one made by Ali et al. (2022), which show ESG firms providing higher technical efficiency in social responsibility contributions, as compared to non-ESG firms. Research such as Mio et al. (2023) has also demonstrated that ESG ratings can act as an important signal influencing investor risk perception, consequently affecting corporate valuations and, thus, market efficiency. Overall, Jin and Lei (2023) concluded that the integration of ESG factors into corporate practices and reporting not only contributes to market value but also plays a crucial role in enhancing market efficiency by reducing uncertainty and improving investment decisions.

As observed, the adoption of more responsible and sustainable behaviors by companies, and their effects on financial market performance, has become a highly relevant topic in the literature, particularly in recent years. Numerous studies measure the effects of the disclosure of information in this regard and examine the impact of metrics such as the ESG score, providing empirical evidence of their versatile effects, especially in financial markets. However, to date, it has not been studied whether this score might influence market anomalies observed in equity offerings, such as the emergence of arbitrage opportunities. This study aims to contribute to this area by defining and testing the following null (H_0) and alternate (H_1) hypotheses:

H_0: ESG scores reduce the occurrence and significance of arbitrage opportunities.

H_1: ESG scores do not reduce the occurrence and significance of arbitrage opportunities.

To test these hypotheses, a set of equity offerings with preferential subscription rights is examined, applying an arbitrage strategy to determine whether any arbitrage opportunities arose that were not identified and/or absorbed by the market. Once these results are established, an attempt will be made to explain the likelihood of such market anomalies occurring based on the ESG scores of the issuing company. This analysis will provide further insight into the effects of ESG scores on corporate behavior in financial markets, with a particular focus on the complex processes of equity offerings and the potential market anomalies that may arise during these events. The results obtained point to the alternative hypothesis, where companies with higher ESG levels do not show greater market efficiency, in terms of lower probability of arbitrage opportunities. Moreover, the results indicate a positive relationship of these anomalies with higher levels of ESG, pointing to a possible overvaluation in the shares' price as a possible source for the market anomalies.

Once this introduction is completed, Section 2 will detail the data utilized and the methodology chosen to test the proposed hypotheses. Section 3 presents and explains the results obtained, interpreting them within the context of this research. Finally, Section 4 summa-

rizes the conclusions derived from this work and their implications, as well as the limitations encountered during this project and the future research avenues that emerge.

Data

This study examines 258 equity offerings, conducted between the years 2000 and 2023, inclusive, and from companies located in 41 countries. All data comes from the LSEG Refinitiv Database and consists of the following datasets:

1) Price series of closing prices of subscription rights and the shares of issuing companies, on the days when both assets are traded simultaneously.
2) Characteristics of the equity offering, the issuing company and the country, such as the issuance premium of the new shares or the number of new shares relative to those already in circulation, the Book-to-Market ratio of the issuing company, and the level of development (as measured by the World Bank) of the country where it is located.
3) ESG score, as well as each of its components (Environmental, Social, and Governance), of the issuing company in the year it conducted the equity offering.
   A) They range from 0 (worst) to 100 (best). Although the focus will be on the overall quantitative score, its qualitative classification, as defined by the Database criteria, will also be used. Specifically: a score below 25 will be assigned a value of D, scores between 25 and 50 will receive a C, scores between 50 and 75 will be classified as B, and scores above 75 will receive an A.
   B) The ESG scores used have been estimated by the database itself, through a rigorous process of analyzing different variables of the issuing firms. For the "Environmental" pillar, aspects such as "Resource Use," "Emissions," and "Environmental Innovation" are analyzed. Meanwhile, for the "Social" pillar, the management of the "Workforce" and the focus on "Human Rights," "Community," and "Product Responsibility" are examined. Finally, to calculate the "Governance" pillar, "Shareholders," "Management" systems, and "CSR Strategy" are analyzed.

Although the final sample size is modest, this is a result of a stringent selection and filtering process that prioritized data quality over quantity. This approach ensures that the final sample is robust and reliable, thereby enhancing the credibility of the study's findings. The information selection and filtering process consisted of the following stages:

1) Missing values: First, all observations with missing values for the key factors in this analysis were excluded from the sample. Notably, the largest reduction in available observations resulted from missing ESG score data, both for the overall score and its individual components. The availability of ESG scores for companies undertaking equity offerings is considerably limited, contributing significantly to the sample size reduction. After this step, the number of processes was reduced from 27,348 to 760.
2) Time series of subscription rights prices: Secondly, for each remaining equity offering, time series data for subscription rights prices were obtained, and any processes lacking this data were removed from the sample. This step also resulted in a substantial reduction in information, as subscription rights prices are confined to a limited and specific time frame, making them challenging to locate.
3) Time series of stock prices covering the same days as the subscription rights: For the final sample of processes, time series data for the issuing company's stock prices were collected for the days on which subscription rights prices were available. This step did not result in a substantial information loss. Following these procedures, the final sample comprised 258 equity offerings. It should be noted that it was verified that the issuance price and the prices for rights and shares were expressed in the same currency. Likewise, when dealing with returns the results are also robust to exchange rate fluctuations.

Once this process is completed, the resulting sample of equity offerings, though limited in size, compensates with the robustness and quality of the information it contains. The selection of the factors to be analyzed, the different control variables, and the methodology in general, is based on the conclusions obtained by Verdú et al. (2024) and Verdú et al. (2025).

Although the filtering process results in a substantial reduction from the initial dataset, this decrease does not imply the presence of strong selection bias. Most exclusions arise from missing ESG information and the unavailability of price series for subscription rights - variables whose absence is unrelated to the presence or absence of arbitrage opportunities. Existing empirical evidence supports this interpretation. Verdú et al. (2025) show that arbitrage opportunities in rights issues appear consistently across firms with heterogeneous characteristics, including industry, country of origin, and market development level. Their findings indicate that these anomalies are driven by the structural mechanics of rights offerings rather than by firm-specific attributes. Therefore, the restriction to observations for which complete ESG and price information is available should not materially distort the representativeness of the sample.

The interpretation of the results should also consider the broad time span of the sample (2000–2023), which covers major episodes such as the dot-com downturn, the global financial crisis, the COVID19 pan-

demic, and the Russian invasion of Ukraine. However, the identification of arbitrage opportunities in rights issues is based on short-horizon pricing discrepancies between old shares and subscription rights, whose mechanics are largely independent of long-term macroeconomic regimes. Verdú et al. (2025) show that these anomalies arise consistently across different market conditions and regulatory settings, suggesting that they stem from the structural features of rights offerings rather than from specific economic periods.

Table 1: Code and sample size for each covered country

Group	Country	Code	Observations	Outliers	2000-2007	2008-2015	2016-2023
Africa and Middle East	Kuwait	KWT	2	1	0	0	0
	Mauritius	MUS	2	2	2	0	0
	Morocco	MAR	1	0	0	0	1
	Oman	OMN	4	1	0	1	3
	Saudi Arabia	SAU	1	1	0	0	1
	South Africa	ZAF	15	8	1	4	10
	United Arab Emirates	ARE	5	0	0	0	5
	Total		30	13	3	5	22
Americas	Brazil	BRA	3	0	0	1	2
	Canada	CAN	3	2	1	2	0
	Colombia	COL	1	1	0	1	0
	Mexico	MEX	1	0	0	0	1
	United States of America	USA	3	2	0	2	1
	Total		11	5	1	6	4
Asia and Oceania	Australia	AUS	34	5	1	14	19
	China (Mainland)	CHN	3	2	0	0	3
	Hong Kong	HKG	9	7	0	5	4
	India	IND	3	2	1	0	2
	Indonesia	IDN	3	3	0	2	1
	Japan	JPN	4	3	0	1	3
	Malaysia	MYS	9	0	1	4	4
	New Zealand	NZL	3	0	0	0	3
	Philippines	PHL	3	2	0	0	3
	South Korea	KOR	8	7	1	4	3
	Taiwan	TWN	4	0	0	1	3
	Thailand	THA	1	1	0	0	1
	Vietnam	VNM	4	4	0	1	3
	Total		88	36	4	32	52
Europe	Austria	AUT	3	1	0	1	2
	Belgium	BEL	7	3	2	1	4
	Denmark	DNK	2	2	0	0	2
	Finland	FIN	6	1	0	2	4
	France	FRA	16	3	1	6	9
	Germany	DEU	10	2	2	5	3
	Greece	GRC	2	1	0	1	1
	Italy	ITA	17	3	1	6	10
	Netherlands	NLD	2	0	0	1	1
	Norway	NOR	2	1	0	1	1
	Spain	ESP	11	0	0	2	9
	Russia	RUS	4	3	0	1	3
	Sweden	SWE	34	10	3	5	26
	Switzerland	CHE	4	0	1	1	2
	Turkey	TUR	1	0	1	0	0
	United Kingdom	GBR	8	7	0	6	2
	Total		129	37	11	39	79
Total			258	91	19	82	157

Source: Authors own work.

Tables 1 and 2 present the number of equity offerings by country and by the economic sector. The distribution of observations across countries reveals that arbitrage opportunities arise in both developed and emerging markets. The predominance of cases from Europe and Oceania, driven by countries such as Sweden, Italy, France, and Australia, underscores the relevance of rights offerings in more mature equity markets with active secondary trading of subscription rights. Nonetheless, the presence of observations from regions with differing levels of market development, including Africa, the Middle East, and Latin America, suggests that the mechanisms leading to price discrepancies between shares and rights are not confined to specific regulatory or economic environments. This supports the idea that the structural features of rights issues, rather than country-level factors, drive the emergence of arbitrage opportunities, in line with findings such as those of Verdú et al. (2025). The sectoral distribution indicates that arbitrage opportunities occur across a wide range of industries, from financials and basic materials to technology and consumer-related sectors. However, the detection of arbitrage across diverse industries suggests that sector-specific fundamentals are not the primary drivers of these pricing anomalies.

Table 2: Codes and Sample for each Economic Sector

Economic Sector	Code	Observations	Outliers	2000-2007	2008-2015	2016-2023
Academic and Educational Services	ACA	1	1	0	0	1
Basic Materials	BAS	28	15	4	13	11
Consumer Cyclicals	CYC	21	7	2	9	10
Consumer Non-Cyclicals	NCY	18	7	2	10	6
Energy	ENE	9	1	0	2	7
Financials	FIN	74	31	7	20	47
Healthcare	HEA	14	3	0	3	11
Industrials	IND	27	6	1	8	18
Real Estate	EST	26	11	1	9	16
Technology	TEC	27	8	2	4	21
Utilities	UTI	13	1	0	4	9
Total		258	91	19	82	157

Source: Authors own work.

Methodology

When a company opts for an equity offering through subscription rights, two access points to its shares emerge: (1) purchasing existing shares on the open market and (2) acquiring new shares via subscription rights. This dual access remains as long as the subscription rights are publicly listed. Consequently, the price of the company's shares can diverge between these two methods. Should this price gap become substantial, it may present an arbitrage opportunity where investors could exploit the difference until it narrows, constituting a market anomaly. Prior studies (e.g., Gajewski & Ginglinger, 2002; Rantapuska & Knüpfer, 2008; Massa et al., 2013) document the activities of investors engaging in such arbitrage, while Marzal and Montes (2000), Verdú et al. (2024) as well as Verdú et al. (2025) specifically outline applicable strategies. This study employs the strategy from Verdú et al. (2024) and Verdú et al. (2025) to identify arbitrage in the analyzed equity offerings.

The strategy involves taking a long position in new shares through purchasing and exercising subscription rights, paired with an equivalent short position in the issuing company's shares. However, due to asset constraints, the reverse operation isn't feasible. The long position must consider the rights required for one new share, as well as the price of these rights and the issue premium on new shares. With this framework, the theoretical price of the shares and the net return of the arbitrage strategy will be calculated as follows:

$$P_{Theory,t} = \frac{Rights_i * P_{Right,t} + N_i * P_{Offering,i}}{N_i} \quad (1)$$

$$NR_{i,t} = \frac{P_{Share,t} - P_{Theory,t}}{P_{Theory,t}} - c \quad (2)$$

where $P_{Theory,\,t}$ refers to the theoretical price of the shares; $Rights_i$ to the number of rights required to obtain N_i new shares to the price of the rights; $P_{Offerings,\,i}$ to the issue premium of the new shares; $NR_{i,\,t}$ to the net return of the arbitrage strategy; $P_{Shares,\,t}$ to the share price; and c to the effect of commissions (estimated at 2 percentage points, as explained below). This procedure will generate a net return for each trading day of subscription rights, after which the average of all these returns will be calculated. An arbitrage opportunity is deemed present if the strategy's average net return is positive.

Since short positions aren't always accessible in every company's shares, an equivalent position in Contracts for Differences (CFDs) is considered to be used in these cases, yielding comparable results and facilitating the strategy. The estimation of the effect of commissions (factor c in Equation (2)) is a complex task due to the multitude of factors that can influence this value. These factors may include, among others, the various entities or brokers involved in the transactions and the regulatory framework of each country. Consequently, a conservative estimation approach was adopted, which also serves to make the identification of arbitrage opportunities more stringent.

This estimation was conducted by analyzing a sample of arbitrage opportunities identified in equity offerings, simulating the strategy that would be employed to exploit these opportunities, and incorporating information on fees from several brokers and investment banks. As a result of this process, the impact of commissions was determined to be equal to 2 percentage points, aligning with Marzal and Montes (2000), Verdú et al. (2024) as well as Verdú et al. (2025). This estimation includes brokerage commissions, exchange/clearing fees, bid–ask spreads, and (when applicable) borrowing/financing costs for the short leg; only the first two are country- and venue-specific. Using a conservative all-in cost proxy reduces false positives and makes arbitrage identification robust to cross-country differences in trading frictions.

As occurs in the study conducted by Verdú et al. (2025), some of the returns from this strategy are significantly high, and may be considered as outliers, which should be removed from the sample to prevent them from contaminating the analysis. This additional filtering is carried out using the Median Absolute Deviation (MAD) methodology, as described in Leys et al. (2013), which involves removing approximately 91 observations. To prevent this loss of sample from being a problem, the study will not only analyze these average returns, but also the probability of the emergence of an arbitrage opportunity (measured as a positive average return). By transforming the target variable into a dummy, the outliers cease to have an effect, and the entire sample can be retained.

After identifying the occurrence of arbitrage opportunities in each sample process, the study aims to evaluate whether the ESG scores impact the likelihood of such market anomalies. For this purpose, the following models (to be estimated using OLS with standard errors robust to heteroscedasticity) are proposed.

$$\begin{aligned}\mathrm{RET_i} &= \alpha_0 + \alpha_1 * \mathrm{ESG_i} + \alpha_2 * \mathrm{RAT_i} + \alpha_3 * \mathrm{DLR_i} \\ &+ \alpha_4 * \mathrm{DIL_i} + \alpha_5 * \mathrm{RAT_i} * \mathrm{DIL_i} + \alpha_6 * \mathrm{BTM_i} \\ &+ \alpha_7 * \mathrm{ILI_i} + \alpha_8 * \mathrm{HIG_i} + \mu_i\end{aligned} \quad (3)$$

$$\begin{aligned}RET_i &= \beta_0 + \beta_1 ENV_i + \beta_2 SOC_i + \beta_3 GOV_i + \beta_4 RAT_i \\ &+ \beta_5 DLR_i + \beta_6 DIL_i + \beta_7 RAT_i * DIL_i + \beta_8 BTM_i \\ &+ \beta_9 ILI_i + \beta_{10} HIG_i + u_i\end{aligned} \quad (4)$$

Additionally, to study the probability of the emergence of an arbitrage opportunity, the following binary response models (estimated using logit and probit methodologies) are proposed:

$$\begin{aligned}ARB_i &= \alpha_0 + \alpha_1 ESG_i + \alpha_2 RAT_i + \alpha_3 DLR_i + \alpha_4 DIL_i \\ &+ \alpha_5 RAT_i * DIL_i + \alpha_6 BTM_i + \alpha_7 ILI_i + \alpha_8 HIG_i + u_i\end{aligned} \quad (5)$$

$$\begin{aligned}ARB_i &= \beta_0 + \beta_1 ENV_i + \beta_2 SOC_i + \beta_3 GOV_i + \beta_4 RAT_i \\ &+ \beta_5 DLR_i + \beta_6 DIL_i + \beta_7 RAT_i * DIL_i + \beta_8 BTM_i \\ &+ \beta_9 ILI_i + \beta_{10} HIG_i + u_i\end{aligned} \quad (6)$$

where RET_i is the average net return associated with each capital increase, and ARB_i is a Dummy, taking the value 1 if an arbitrage opportunity is detected (that is, if RET_i is positive). ESG_i is the total ESG score; while ENV_i, SOC_i and GOV_i are, respectively, the "Environmental", "Social" and "Governance" pillars from the ESG score. Regarding the control variables, RAT_i is the ratio of the issue price of new shares to the ex-right price (that is, the day on which the corresponding price adjustment of the stock series is made, prior to the start of trading of the subscription rights) of existing shares; DLR_i is the ratio between the new issued shares and the ones already in circulation; DIL_i is a dummy equal to 1 if the latter ratio is 50% or higher; BTM_i is the Book-to-Market ratio of the issuing company; ILI_i is the Amihud (2002) illiquidity factor, which accounts for differences in company liquidity), calculated following the methodology described in Martínez et al. (2005), as the ratio between the absolute value of the return and the trading volume of the issuing company; and HIG_i is a dummy that equals 1 if the country had a high development level at the time of the equity offering, being the complementary variable MDM_i, which includes the other development levels.

The authors are aware of the issues associated with potentially low R2 values that may arise when estimating these models. Although variables such as firm betas, market volatility measures, or crisis-period dummies could mechanically increase the R^2, they would also blur the focus on the rights-offering specific mechanics and substantially reduce degrees of freedom in a relatively small sample. For this reason, we restrict attention to variables that are directly related to the structure of rights issues and the ESG performance of the issuing firm.

As a robustness test, and to reinforce the conclusions regarding the correct specification of the proposed models, a series of additional tests, proposed in Cameron and Trivedi (2005), will be conducted on the

results of the binary response models (logit and probit). First, the estimated arbitrage probabilities will be obtained, and it will be considered that the model predicts arbitrage when said probability is equal to or greater than 0.5, and that the model predicts an absence of arbitrage otherwise, comparing the predicted results with the actual ones. Furthermore, employing the estimated probabilities, the following statistic is proposed:

$$S = \sum_{i=1}^{n} \frac{(ARB_i - \widehat{P_l})^2}{\widehat{P_l} * (1 - \widehat{P_l})} \quad (7)$$

where $\widehat{P_l}$ is the probability estimated by the model. Under the Null Hypothesis that the model is sound, this statistic should follow a chi-squared distribution with n—k degrees of freedom (where k is the number of explanatory variables). As emphasized by Cameron and Trivedi (2005), the usual R^2 is not an informative goodness-of-fit measure for non-linear binary response models. For this reason, we rely instead on pseudo-R^2 (ρ^2), classification accuracy, and specification tests based on the S-statistic. Finally, employing the aforementioned estimated probabilities, an alternative coefficient of determination will be estimated following the formula below:

$$\rho^2 = \frac{\sum_{i=1}^{n} (ARB_i - \overline{ARB})^2}{\sum_{i=1}^{n} (ARB_i - P_i)^2} \quad (8)$$

The primary objective of the econometric analysis is not to maximize the R^2 of the regressions, but to assess whether ESG scores contribute to explaining the probability of arbitrage opportunities once the main structural determinants of rights issues are controlled for. In this context, modest R^2 and pseudo-R^2 values are standard in ESG-related asset pricing studies (as seen in Cui and Docherty (2020), Bofinger et al. (2022) and Cao et al. (2023)) and do not imply model misspecification.

As a final robustness test, and to evaluate whether the total ESG scores causally influence the probability of arbitrage opportunities, a Granger Causality Test is employed. This test assesses whether changes in the ESG score have a tangible impact on the emergence of market anomalies, thereby strengthening the study's findings. While the limited sample size is a noted limitation that warrants careful interpretation, these results can still provide meaningful insights. To ensure that the results are robust with respect to sample size, only the results corresponding to the first three lags will be presented. Although the study does not aim to establish a structural causal model, potential endogeneity concerns-such as reverse causality between ESG policies and market efficiency - are mitigated by the short-horizon nature of the pricing discrepancies examined. Arbitrage opportunities arise mechanically from the coexistence of rights and shares and therefore are unlikely to be driven by the firm's sustainability practices. Nonetheless, the empirical results should be interpreted as associations rather than causal estimates.

Results and discussion

The following sections detail the results obtained and the main conclusions drawn from them. First, it is crucial to review the data distribution. Table 3 summarizes key statistics for the arbitrage opportunity series, the overall ESG score series, and its components.

Table 3: Main Statistics of the relevant variables

Variable	Average	St. Dev.	Median	Observations	Maximum	Minimum	Skewness	Kurtosis
RET	3.4206	5.7136	1.3765	167	24.017	-1.0000	1.6813	2.1705
ARB	0.7481	0.4350	1.0000	258	1.0000	0.0000	-1.1495	-0.6840
ESG	44.1663	24.3762	42.9787	258	95.7357	2.6848	0.2012	-1.0058
ENV	42.9358	32.4192	36.9900	258	98.3927	0.0000	0.1599	-1.4016
SOC	44.6346	26.4498	43.5789	258	97.6508	0.7727	0.1409	-1.1140
GOV	47.0622	24.0781	45.9246	258	94.9769	2.8750	0.0886	-1.0897

Note: For RET, outliers are excluded from the sample

Source: Authors own work.

The descriptive statistics reveal that arbitrage opportunities are present in a substantial proportion of the sample, with the ARB dummy taking the value of one in nearly three-quarters of the observations. This confirms that the coexistence of rights and old shares frequently produces short-term price discrepancies large enough to sustain positive net returns after transaction costs. The average ESG score is moderate and exhibits high variability, indicating significant heterogeneity in sustainability performance across issuing firms.

This heterogeneity is essential for the econometric analysis, as it provides sufficient variation to assess the relationship between ESG levels and market efficiency. This analysis is further expanded with Table 4, which categorizes these opportunities by ESG grades. Arbitrage opportunities have an average above 0.5, indicating a significant number of identified cases. The sample is fairly balanced across ESG grades, notably highlighting that, contrary to expectations, the proportion of arbitrage is higher at the upper levels.

Table 4: Distribution of sample size and arbitrages by ESG grade

ESG	Observations	ARB	%	nARB	%	Outliers
A	34	26	76.47%	8	23.53%	16
B	73	60	82.19%	13	17.81%	29
C	80	57	71.25%	23	28.75%	23
D	71	50	70.42%	21	29.58%	23
Total	258	193	74.81%	65	25.19%	91

Note: ARB refers to observations in which arbitrages were detected, while nARB refers to those where these anomalies were not detected

Source: Authors own work.

The distribution of arbitrage opportunities across ESG grades offers preliminary evidence regarding the relationship between sustainability performance and market anomalies. Although ESG grades A and B correspond to firms with stronger sustainability practices, these groups exhibit some of the highest proportions of detected arbitrage. Conversely, lower ESG grades do not show disproportionately higher arbitrage frequencies. This pattern, while descriptive, is consistent with the econometric results presented later, which point toward a positive, rather than negative, association between ESG performance and the likelihood of arbitrage opportunities. These patterns suggest that higher ESG levels may coincide with temporary overvaluation or slower price adjustment mechanisms in rights markets. Additionally, although ESG grades (A, B, C, D) help classify the sample descriptively, they do not add informational content beyond the numerical ESG score. As the grades are a deterministic transformation of the underlying score, including both variables would duplicate information and introduce redundancy into the econometric specification. For these reasons, we rely on the continuous ESG score as the relevant explanatory measure.

Once the sample and the arbitrage opportunities detected within it are better understood, we proceed to present the results obtained from the econometric tests applied. Table 5 shows estimation results from the Logit and Probit regressions. Only the overall ESG score, and not its pillars, has a statistically significant, albeit modest, positive effect, implying a potential link between the overall ESG score and market anomalies, and therefore, again against our null hypothesis. Lastly, Table 6 reports the Granger causality test results, calculated for the first three lags due to the sample size. The test indicates significant results for Environmental and Social scores, to a lesser extent for the overall ESG and non-significant for the Governance score. This suggests that these scores could indeed have a causal effect on the emergence of arbitrages.

When analyzing all the results collectively, two main conclusions emerge regarding the relationship between arbitrage opportunities and ESG scores. First, the proposed arbitrage strategy indicates the presence of arbitrage opportunities within the context of equity offerings conducted by companies worldwide, and reveals that such anomalies arise in a high percentage of the processes studied rather than being isolated cases. These findings are consistent with prior evidence showing that arbitrage opportunities in rights issues tend to arise across firms operating in different countries and economic sectors. Verdú et al. (2025) document that these pricing discrepancies are largely driven by the structural features of rights-based offerings rather than by sectoral or geographical characteristics, which helps contextualize the dispersion of arbitrage events in our sample. Second, the results indicate that the ESG score (and, to a lesser extent, its components) could play a significant role in the emergence of such market anomalies. However, contrary to expectations, the effect of this factor appears to be positive, as higher ESG scores seem to be associated with an increased likelihood of arbitrage opportunities arising during these processes.

Table 5: Model estimation results

Variables	OLS		Logit		Probit	
	Model [3]	Model [4]	Model [5]	Model [6]	Model [5]	Model [6]
Intercept	5.9074***	6.5173***	2.1598***	2.3389***	1.2381***	1.2305***
	(1.7190)	(0.1831)	(0.5640)	(0.6740)	(0.3040)	(0.3340)
ESG	0.0408**		0.0130*		0.0074**	
	(0.0180)		(0.0060)		(0.0040)	
ENV		0.0140		0.0013		-7.596e-05
		(0.0240)		(0.0230)		(0.0060)
SOC		0.0429		0.0107		0.0067
		(0.0300)		(0.0160)		(0.0070)

Variables	OLS		Logit		Probit	
	Model [3]	Model [4]	Model [5]	Model [6]	Model [5]	Model [6]
GOV		-0.0261		-0.0019		0.0006
		(0.0200)		(0.0110)		(0.0050)
RAT	-0.0047***	-0.0039***	-0.0266***	-0.0275**	-0.0158***	-0.0153**
	(0.0010)	(0.0010)	(0.0100)	(0.0120)	(0.0060)	(0.0060)
DLR	-4.309e-07***	-4.949e-07	-0.0711	-0.0693	-0.0411	-0.0403
	(1.44e-07)	(1.56e-07)	(0.0550)	(0.0750)	(0.0290)	(0.0290)
DIL	-2.1284**	-2.1177**	-1.2977***	-1.3538**	-0.7293***	-0.7197***
	(0.9570)	(0.9490)	(0.0376)	(0.5730)	(0.2060)	(0.2060)
RAT*DIL	0.0057	0.0054	0.0248**	0.0258**	0.0146**	0.0143**
	(0.0060)	(0.0070)	(0.0110)	(0.0130)	(0.0060)	(0.0060)
BTM	0.0002**	0.0001***	-0.0009***	-0.0007	-0.0004***	-0.0004***
	(7.19e-05)	(6.91e-05)	(0.0000)	(0.0010)	(7.94e-05)	(8.18e-05)
ILI	1878.6307	-997.5454	2.724e+04	-5.403e+04	7922.2439	8447.3908
	(1757.8660)	(2968.7870)	(3.88e+04)	(1.31e+06)	(6494.0100)	(7711.1370)
HIG	-3.3751*	-3.6030**	-0.7533	-0.6647	-0.4035	-0.4028
	(1.7410)	(1.7610)	(0.4750)	(0.9870)	(0.2570)	(0.2630)
R-Squared	0.1100	0.1270	0.1582	0.1536	0.1562	0.1569
N	167	167	258	258	258	258
Prediction	-	-	77.910%	76.7400%	77.9100%	77.5200%
S	-	-	239.5019	252.2344	239.0774	241.1050
P-Value	-	-	0.6884	0.4133	0.6953	0.6112
ρ	-	-	0.1812	0.1346	0.1784	0.1796

Note: For each coefficient, significance at the 1% (***), 5% (**) or 10% (*) level is indicated

Source: Authors own work.

The results suggest that companies with higher ESG scores experience more inefficient market behavior during capital increase processes. This could imply that the newly issued shares may not be appropriately valued. At the same time, these anomalies do not appear to dissipate over time, contrary to what would typically be expected of arbitrage opportunities. This further indicates that markets are unable to absorb and self-correct these anomalies effectively.

A deeper examination of the mechanisms underlying this positive association between ESG scores and arbitrage likelihood warrants consideration. One plausible channel is that firms with high ESG ratings tend to attract a specific investor clientele (notably ESG-oriented institutional investors) whose demand is driven not solely by fundamental valuation but also by non-financial preferences (Cao et al. (2023) and Rzeźnik et al. (2022) point in this direction). This preference-driven demand may inflate share prices beyond levels justified by financial fundamentals, creating a wedge between market prices and intrinsic values that is particularly pronounced during the short trading window of subscription rights. In this context, the overvaluation documented by Bofinger et al. (2022) and the positive biases identified by Cao et al. (2023) may be amplified during rights offerings, as the simultaneous trading of old shares and rights exposes pre-existing pricing inefficiencies.

Table 6: Results for the Granger causality test

		ESG	ENV	SOC	GOV
RET	1st lag	0.8801	0.7974	0.9743	0.8729
	2nd lag	0.8241	0.6204	0.7952	0.8623
	3rd lag	0.9372	0.7289	0.9278	0.7870
ARB	1st lag	0.0278**	0.0059***	0.0110**	0.5604
	2nd lag	0.0824*	0.0242**	0.0371**	0.1736
	3rd lag	0.1689	0.0558*	0.0746*	0.2874

Note: The results correspond to P-Values. For each one, significance at the 1% (***), 5% (**) or 10% (*) level is indicated

Source: Authors own work.

Furthermore, high-ESG firms may exhibit greater price sensitivity to non-fundamental shocks, including shifts in ESG sentiment, regulatory announcements, or broader sustainability-related market narratives, precisely because a larger component of their market valuation reflects intangible, non-financial attributes. This interpretation is also compatible with the notion that high-ESG stocks may exhibit stronger price swings when ESG-related sentiment or macroeconomic conditions change, as a larger fraction of their valuation reflects intangible and reputation-based components rather than purely financial fundamentals (as seen in Bofinger et al. (2022) and Liu et al. (2022)). During bear markets or periods of financial stress, these intangible premiums may dissipate rapidly, generating larger price swings relative to firms whose valuations are anchored more exclusively to financial fundamentals. If this mechanism is operative, it would imply that the arbitrage opportunities documented in our sample are not merely a product of the rights-offering mechanics but also reflect a structural feature of high-ESG firm pricing: a higher sensitivity to sentiment-driven revaluations that temporarily distort the relative pricing of old shares and subscription rights. While a direct test of this hypothesis lies beyond the scope of the present study, it represents a promising avenue for future research.

These results should also be interpreted in light of prior empirical research. The moderate R^2 values obtained in our OLS and binary response models, together with the limited significance of some ESG components, are consistent with findings reported in the ESG-efficiency and ESG-valuation literature. For example, Cui and Docherty (2020) show that market reactions to ESG controversies display low explanatory power due to the diffuse nature of ESG-related informational, with some specifications yielding R^2 values in the range of 15%. Likewise, Bofinger et al. (2022) document that ESG scores correlate with misvaluation measures but explain only a modest proportion of the variance, reflecting the multifactor structure underlying price, with many specifications reporting R^2 values below 10%. Cao et al. (2023) also report that only some ESG dimensions reach statistical significance when studying return patterns associated with institutional trading preferences, with certain specifications not exceeding 5%. Taken together, these studies suggest that modest R^2 values and partial ESG significance are typical outcomes in this literature, which contextualizes our own results and supports their plausibility.

It is further important to note that, as stated in Cameron and Trivedi (2005), for the binary response models (logit and probit), the standard R^2 is not an appropriate goodness-of-fit measure, as these are non-linear models. Accordingly, Table 5 reports the results for the robustness tests. Firstly, the percentage of correctly predicted outcomes approaches 78% across all specifications. Secondly, considering the P-Values associated with the S statistics, we consistently fail to reject the null hypothesis of model adequacy. Finally, the ρ^2 coefficient yields similar or even higher values compared to the adjusted-R2. These indicators collectively suggest that the binary response models provide a statistically sound characterization of the probability of arbitrage emergence.

Conclusions

This study investigates the relationship between arbitrage opportunities in equity offerings and the issuing company's sustainability level, as measured by the ESG scores. Arbitrage strategies were simulated on 258 global processes. The results, although capable of detecting a relationship between the emergence of arbitrage opportunities and the ESG scores of the issuing company, indicate that companies with better ESG levels have a higher likelihood of creating an arbitrage opportunity in these processes, suggesting that these higher ESG scores are associated with reduced market efficiency and contradicting the results obtained by Wu et al. (2022). This evidence leads us to suggest a possible overvaluation of the shares in companies with high ESG levels, which, in line with Cui and Docherty (2020), Bofinger et al. (2022) and Cao et al. (2023), may stem from positive biases or overreactions towards companies with strong ESG scores. These reactions could drive market inefficiencies, specifically in the form of arbitrage opportunities, as high ESG ratings potentially lead to valuations that temporarily exceed intrinsic values. These findings provide a basis for further research.

Our results contradict those obtained by Mervelskemper and Streit (2017), as they point out that financial markets are not correctly valuing the issuing company's shares. While Mio et al. (2023) and Jin and Lei (2023) suggested that ESG scores can serve as a signal in markets and reduce uncertainty, our evidence indicates that, in the context of equity offerings, these signals could have a negative effect. They may hinder the markets' ability to correctly value new issuances and prevent them from absorbing anomalies that might arise during these processes. In summary, this study concludes that equity offerings may create a framework in which ESG scores reverse their role, shifting from enhancing market efficiency to diminishing it. This prevents investors from accurately determining the fair value of both the issuing company's existing and newly issued shares. Alternative explanations cannot be fully ruled out. For example, high-ESG firms may attract investor clienteles with specific preferences, potentially slowing adjustment speeds during rights trading. These mechanisms complement the structural explanation proposed in our analysis.

Although our results indicate a positive association between ESG scores and the likelihood of arbitrage opportunities, this evidence should be interpreted with caution due to the limited sample size and heterogeneity of available ESG data. Rather than contradicting prior studies, our findings suggest the possibility that, in the context of rights offerings, sustainability scores may interact with pricing mechanisms in a way that differs from patterns documented in other settings.

The main challenge and limitation of this research is the relatively small sample size, due to the limited availability of equity offerings with comprehensive ESG data. This constraint calls for cautious interpretation of the findings. However, the rigorous data selection and filtering process helps mitigate this limitation, ensuring a high-quality, reliable sample. While the sample-selection process inevitably excludes a large number of offerings, existing evidence (e.g., Verdú et al., 2025) suggests that arbitrage opportunities in rights issues are pervasive across firms, sectors and market conditions, reducing the likelihood that the sample restrictions systematically bias the identification of anomalies. Even so, the possibility of residual selection effects cannot be completely dismissed.

On the other hand, an additional challenge has been managing information from different countries and, consequently, different regulatory frameworks. However, the data collection process and the methodology employed for the analyses ensure that the results remain robust despite these differences. It is important to acknowledge that the restricted sample-driven primarily by the scarce availability of complete ESG information for rights-issuing firms-limits the generalizability of the results. While the filtering process ensures high-quality data, the final sample size constrains the strength of the inferences and invites caution when extrapolating these findings to broader market settings.

Overall, the study provides preliminary evidence that invites further research rather than definitive conclusions, and it highlights the importance of considering ESG-related valuation dynamics in the specific context of rights offerings.

Future access to additional data could facilitate further study, enabling re-evaluation and potentially confirming the results or uncovering new patterns and factors. Additionally, it would be highly interesting to analyze intraday price series to better understand how the returns from the arbitrage strategy evolve and whether their behavior varies depending on the time of observation (e.g., whether they behave differently at the beginning or end of the trading period for subscription rights). Furthermore, it would also be valuable to determine whether the ESG score might be related to other types of market anomalies similarly identified in these processes, such as the generation of abnormal returns following significant events.

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