



Detecting, characterizing, and predicting arbitrage opportunities in international rights issues

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ABSTRACT

Capital increases through the issuance of subscription rights are a financing tool employed by many companies as an alternative to debt issuance. In a process with numerous implications for both the company itself and the financial markets, market anomalies, such as arbitrage opportunities, may arise. To examine whether this issue occurs, a sample of 2583 capital increases carried out by companies located in 27 different countries was collected, and a strategy aimed at exploiting potential discrepancies between the prices of newly issued shares and existing ones was applied. The returns obtained will be subjected to various statistical and econometric tests to explain which factors may play a significant role in their formation. The results confirm the presence of these market anomalies and indicate that a higher proportion of new shares relative to existing ones increases the likelihood of these anomalies, whereas their occurrence appears to be weaker or absent when the company is listed on a stock index. These and other minor or control factors (the objective of the process or the economic sector of the firm) enable a high success rate in predicting when such anomalies are likely to form. These findings provide relevant information to all economic agents involved on how to mitigate these market anomalies.

1. Introduction

Equity offerings are a tool that companies use to raise funds to meet their financial needs. As Klein et al. (2002) state, unlike the issuance of debt instruments, which requires repayment with interest, equity offerings provide funds that do not need to be repaid, as they become part of the company's equity rather than its liabilities. As in the case of the issuance of fixed-income instruments, equity offerings are subject to the regulations established by each country. Although the regulations are generally similar, specific features in each jurisdiction can give these processes unique characteristics, potentially leading to different outcomes across territories.

In recent years, the topic of capital increases has attracted significant attention in both academic and financial circles, as companies continually seek new ways to finance growth, reduce debt, or improve liquidity. A capital increase, through methods such as rights issues or secondary offerings, can have a profound impact on stock prices and the overall market perception of a firm. Understanding the mechanisms behind price adjustments during capital increases is crucial, as it offers insights into market efficiency, investor behavior, and the balance of information flows across different exchanges. This issue becomes even more complex when companies are

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cross-listed on multiple exchanges, where price discovery and market reactions may differ.

Eun and Sabherwal (2003), in their analysis of Canadian stocks cross-listed on U.S. exchanges, found that U.S. markets contribute an average of 38.1 % to price discovery, indicating the significant role U.S. exchanges play. On the other hand, Su and Chong (2007) demonstrated that for Chinese stocks cross-listed on the NYSE and SEHK, the SEHK dominated the price discovery process, contributing between 81.6 % and 89.4 %. These findings underline the importance of understanding how capital market structures and trading volumes affect price discovery, a crucial consideration when analyzing the implications of capital increases in a cross-border context.

In a well-functioning market, equity offerings should closely align with a firm's underlying fundamentals, resulting in a stock price that accurately reflects value post-offering. However, numerous studies have documented inefficiencies in the pricing and performance of equity offerings. One of the most studied inefficiencies is the underpricing of IPOs, where newly listed companies tend to offer shares at a price below the subsequent trading price. In the study conducted by Loughran and Ritter (2004), this anomaly is often attributed to factors such as asymmetric information, investor sentiment, and institutional influences.

Similarly, market inefficiencies in seasoned equity offerings (SEOs) are well-documented. Several studies, like the one conducted by Eckbo et al. (2007), show that companies issuing additional equity frequently experience abnormal stock returns during the announcement period, suggesting that investors may perceive the offering as a signal of overvaluation or financial distress. Moreover, firms undergoing SEOs often exhibit suboptimal post-offering performance, with market timing being identified as a key factor. Huang and Ritter (2022) detected that firms typically issue equity when market valuations are high, which can lead to long-term underperformance as the market corrects initial overvaluations.

These anomalies challenge the efficient market hypothesis (EMH), which asserts that stock prices reflect all available information at any given time. The consistent detection of anomalies in equity offerings suggests that behavioral biases, information asymmetry, and other market imperfections significantly shape outcomes. Recent research, like Baker et al. (2012), continues to investigate these inefficiencies, offering fresh insights into the forces driving deviations from market efficiency in the context of equity offerings.

When new shares are issued in an equity offering, existing shareholders may see their ownership percentage diluted. One method to avoid this dilution is the allocation of Preferential Subscription Rights (PSRs) to existing shareholders. These rights allow shareholders to maintain their proportional ownership. They can either exercise their rights to purchase new shares or sell them on the market. This creates a scenario where two methods of acquiring the same shares coexist: (1) buying existing shares on the market or (2) purchasing and exercising the subscription rights. When the cost of acquiring shares through these two methods differs significantly, arbitrage opportunities may arise.

The objective of this paper is to study global rights issues, analyzing the occurrence of arbitrage opportunities and identifying factors that influence their emergence. A sample of 2583 processes conducted by companies from 27 different countries will be examined, applying a series of tests to detect and analyze these arbitrage opportunities individually and collectively.

To achieve this, a strategy was implemented to capitalize on these arbitrage opportunities, followed by statistical tests to identify the main factors influencing the returns. Probabilistic models were also developed to explain and predict the occurrence of arbitrage in different countries. The results indicate the presence of arbitrage opportunities in rights issues across most countries studied. Furthermore, factors such as stock index listing and the size of the capital increase (measured as the ratio of new to old shares) were found to significantly influence the occurrence of these anomalies. Being listed on a stock index appears to reduce arbitrage opportunities, while larger capital increases seem to promote them. These patterns were observed to varying degrees in all regions analyzed. Additionally, models capable of predicting arbitrage occurrences were developed, with accuracy depending on the country.

This work is the first to jointly study arbitrage opportunities in rights issues across multiple countries. The scope of the time period and the volume of information analyzed allow for robust conclusions at both the general and regional level. Furthermore, the proposed arbitrage strategy was tested in real trading scenarios, yielding positive results in many cases and aligning with theoretical expectations, further validating the findings. In summary, this study aims to establish a general framework for analyzing equity offerings at an international level.

The findings of this paper point to the existence of arbitrage opportunities in equity offerings with subscription rights in all countries analyzed. Moreover, these anomalies seem to persist over time, contrary to expectations. Further analysis identified several factors that significantly explain the occurrence and magnitude of these returns, suggesting that the occurrence of arbitrage opportunities may be influenced not only by the characteristics of the capital increase but also by the attributes of the issuing company. In conclusion, this paper is the first to identify these behaviors in a large and diverse sample of equity offerings worldwide.

Section 2 reviews the literature related to the study's objectives and discusses preliminary conclusions. Section 3 defines the dataset used and the methods applied to gather and filter the information, while Section 4 outlines the applied methodology. Finally, Sections 5 and 6 present the most relevant results and conclusions of the study, respectively.

2. Literature review

The literature on equity offerings is extensive, as these processes can be analyzed from various perspectives, including legal, financial, and decision-making. Equity offerings are complex and have implications across capital markets, regulation, and corporate finance. Regarding the focus of this paper, which is centered on financial markets, a review of the literature reveals two main gaps: (1) most studies on the financial implications of rights issues are dated, with few recent articles addressing this topic, and (2) there is a scarcity of in-depth research on the emergence of arbitrage opportunities in these processes.

For instance, Marzal and Montes (2000) analyze equity offerings in the Spanish market and apply an arbitrage strategy that yields an average return of 6.55 % (net of transaction costs), with returns increasing over time. This indicates that arbitrage opportunities not

only exist but also persist. Other papers, such as those by Gajewski and Ginglinger (2002), Rantapuska and Knüpfer (2008), and Massa et al. (2013), discuss arbitrage strategies in rights issues and their potential effects. The first explains how various arbitrage operations that investors can execute within these processes contribute to the negative reaction in the issuing company's share price following the announcement. The second emphasizes the critical role that the ability to take short positions on the issuing company's shares plays in the success of such strategies. Lastly, the third addresses an arbitrage strategy that values subscription rights by treating them as call options, again underscoring the importance of being able to take short positions on the issuing company's shares.

Similarly, Verdú et al. (2024) study capital increases in Spain from an arbitrage and event-study perspective, confirming the presence of significant arbitrage opportunities that do not diminish over time.

While direct studies on arbitrage in rights issues are limited, other research examines market inefficiencies in these contexts. Hietala (1994) found that 58 % of subscription rights in the Finnish market were undervalued. Poitras (2002) observed that rights listed on Singapore markets often trade below their theoretical price, a situation exacerbated by short-selling restrictions.¹

Market inefficiencies are not confined to subscription rights but they can also affect the pricing of newly issued shares and the stock price of the issuing company. Naveen Kumar et al. (2018) found that new shares in Indian equity offerings are typically undervalued. Literature also suggests that equity offerings tend to have negative effects on stock prices, as seen in Dutta (2017) for Australia and Andrikopoulos (2009) for the UK. However, Fung et al. (2008) discovered short-lived positive abnormal returns in Chinese markets following certain events preceding rights trading.

Regulation plays a crucial role in equity offerings. Differences in regulatory environments may explain variations in outcomes and market behavior across countries. For example, Fauver et al. (2017) demonstrate that regulation significantly impacts both the results of equity offerings and the subsequent performance of the company. Melia et al. (2020) argue that regulations shape financing decisions and warn that regulators must carefully consider the market efficiency and behavioral consequences of new legislation.

Building on this literature, the main hypothesis of this study is formulated as follows:

H_0 : Equity offerings with subscription rights generate arbitrage opportunities.

H_1 : Equity offerings with subscription rights do not generate arbitrage opportunities.

In mathematical terms, the null hypothesis (H_0) can be written in the following terms:

$$H_0 : \overline{NR}_i > 0$$

$$H_1 : \overline{NR}_i \leq 0$$

where $\overline{NR}_i$ refers to the average net arbitrage return. In this particular case, the proposed arbitrage strategy only works in a unidirectional way. That is, the inverse strategy is not feasible, so there will only be an arbitrage opportunity when the average net return is significantly positive (and not significantly different from zero). This is explained in more detail in the methodology section.

Recent studies have examined how sustainability efforts by companies and the level of development in a country affect market efficiency. Bofinger et al. (2022) highlight that ESG compliance significantly influences company valuation, while Siew et al. (2016) found that higher levels of ESG disclosure reduce market asymmetries. Similarly, Cao et al. (2019) suggest that companies incorporating ESG objectives tend to have more predictable returns.

The relationship between arbitrage opportunities and market efficiency is central to this discussion. Dothan (2008) reminds us that for markets to be efficient, prices must reflect all available information, and no strategy should consistently yield positive results. Hogan et al. (2004) explore statistical arbitrage and its incompatibility with market efficiency. Akbas et al. (2016) emphasize that the absence of arbitrage is essential for efficient markets, proposing strategies to exploit such opportunities. A key takeaway from these studies is that arbitrage opportunities do exist in some capital increases, highlighting market inefficiencies. Characterizing these opportunities and identifying the factors that drive their occurrence is vital for issuers, investors, and regulators to enhance market functionality.

This study contributes to the literature by analyzing arbitrage opportunities in rights issues across multiple countries, identifying common patterns and differences. It is the first to analyze rights issues across five continents using a consistent methodology, covering the largest number of countries to date. Moreover, econometric models are built to capture the effects of process-related factors on arbitrage, estimating the probability of these anomalies based on information available at the time of the equity offering announcement. These findings extend the literature by identifying key factors linked to arbitrage opportunities and their potential impact.

3. Data

The data collection process for this study posed significant challenges due to the necessity of compiling information from multiple countries, each with distinct regulations and market characteristics. Despite these differences, all rights offering processes share an equivalent set of relevant characteristics across all countries, to ensure consistency.

The primary data source for this research is the Thomson Reuters Refinitiv database, from which all the information on equity

¹ **Theoretical price** refers to the price at which an investor is indifferent between purchasing shares on the market or acquiring them through subscription rights.

offerings has been extracted, including the price series used throughout the work. Due to the large volume of information, a database has been built in which all the variables obtained were organized, and some simple calculations were performed.² Although data from different years is available, this entire sample is treated as cross-sectional data.

The initial data set comprises 5991 rights issues, conducted by 4298 companies across 65 countries. This covers a period of 20 years, spanning from January 1, 2000, to December 31, 2020. However, this is not the final sample, as many of these processes have had to be removed from the sample for different reasons, among which the following stand out:

1. Not having the series of share prices and subscription rights available.
2. Data recorded with errors (e.g., negative issue prices, among others).
3. Net returns of the arbitrage strategy considered as outliers, following the definition explained later.

The net sample, after eliminating observations with this type of error, consists of 2583 rights issues from 27 countries on 5 continents. Specifically, data are available for Egypt, Saudi Arabia and Tunisia (Africa); Brazil, Canada and the United States of America (America); Australia, Hong Kong, India, Malaysia, New Zealand, Pakistan, Singapore and Sri Lanka (Asia and Oceania); and Austria, Belgium, Denmark, Finland, France, Germany, Greece, Italy, Norway, Poland, Spain, Sweden and the United Kingdom (Europe). Since the analyses will be carried out mainly by country, the number of observations for each of the procedures will be indicated when the results are shown. Table 1 shows the codes used to identify each continent and country, which will be used to display the results.

All the variables collected for each of the rights issues are detailed below. Before that, the relevant factors are not only those obtained directly from the data source, but also others that are derived from the former. Table 2 summarizes these factors, indicating also the code used to represent them in General Terms, at the Main Statistics or and Econometric Models.

The selection of these factors is guided by practical experience with the arbitrage strategy detailed below, as well as a thorough review of relevant literature. Moreover, the work by Verdú et al. (2024) already demonstrates the effect that some of these factors can have on the occurrence of potential arbitrage. With respect to other factors, such as the method for interpreting the relationship between new and old actions, they allow us to approximate the effect of the regulation in each territory. Furthermore, factors related to sustainability were incorporated to assess whether the findings of previous studies are also applicable in these cases.

In addition to information on rights issues, data was also gathered on the primary stock market indices of each of the countries (where available), as well as on the shares and subscription rights themselves. For each of these three assets (indices, shares and rights), its *ticker* (identifier in the *Refinitiv* database), the currency in which it is listed, and its ISIN have been collected.

To conduct the analyses, it is necessary to obtain the price series of the shares and subscription rights when both assets are listed simultaneously. This study specifically uses the closing prices³ corresponding to the first ten days and the last day of trading of the rights have been obtained (although sometimes fewer data points are available).

Given the complexity of the analysis, particularly due to the diversity of countries, legislations, and procedures, additional processes required to obtain more robust data are explained in more detail below.

3.1. Currency adjustment

When downloading the data, rigorous checks were performed to ensure that the currency in which the share price series is consistent with used for the preferential subscription rights price series. In addition, it was confirmed that the currency in which the issue price of the new shares aligns the currency of both price series. The analyses and calculations conducted yields in the form of returns, thereby eliminating any potential impact of exchange rate fluctuations on the returns calculated for the arbitrage strategy.

3.2. Conversion ratio

A critical factor in rights issues is the number of old shares required to obtain the subscription rights necessary to subscribe to a specified number of new shares. In this paper, this factor is determined by the variables *old* and *new*. However, two possible interpretations of this ratio have been detected depending on the country's legislation, and the application of either may imply a significant change in the results of the arbitrage strategy from the perspective of an investor outside the company. Rewriting the variable *old* as *O*, and the variable *new* as *N*, these interpretations would be as follows:

1. One (1) old share entitles one (1) subscription right. A total number of (*O*) subscription rights entitles to receive a (*N*) number of new shares. An example would be the case of Spanish rights issues, in which an *old/new* ratio equals 19/5 (as in the case of the process of *Cellnex Telecom SA* in 2020) implies that 19 subscription rights are necessary to obtain 5 new shares, with one right being delivered beforehand for each old share.
2. One (1) subscription right is received for (*O*) number of old shares. One (1) subscription right enables a (*N*) number of new shares to be obtained. This happens, for example, in Canada, where an *old/new* ratio equal to 20/7 (as in the process of *Ivanhoe Mines Ltd.* in

² The bulk of the calculations have been carried out using the *Python* programming language. The code used is available to the reader upon request and subject to correct citation.

³ Calculations were also performed on opening, high and low prices for each session, but the results do not vary significantly.

Table 1
Codes by continent and country.

Continent		Country	
Code	Name	Code	Name
AFR	Africa and Middle East	EGY	Egypt
		SAU	Saudi Arabia
		TUN	Tunisia
AME	America	BRA	Brazil
		CAN	Canada
		USA	United States of America
ASI	Asia and Oceania	AUS	Australia
		HKG	Hong Kong
		IND	India
		MYS	Malaysia
		NZL	New Zealand
		PAK	Pakistan
		SGP	Singapore
		LKA	Sri Lanka
		AUT	Austria
		BEL	Belgium
EUR	Europe	DNK	Denmark
		FIN	Finland
		FRA	France
		DEU	Germany
		GRC	Greece
		ITA	Italy
		NOR	Norway
		POL	Poland
		ESP	Spain
		SWE	Sweden
		GBR	United Kingdom

2012) implies that one right allows to subscribe 7 new shares, although the shareholders received 1 right for each 20 old shares owned.

This can significantly affect the results of the arbitrage strategy. It has been identified which method is used in each of the territories, and subsequent calculations have been made considering this casuistry.

3.3. Sustainability

The sustainability level of an issuing company is assessed using the *ESG* index, which evaluates environmental, social and corporate governance factors, and is compiled by the *Thomson Reuters Eikon* database based on a set of factors. The value obtained by the company depends on its performance in a series of indicators, as well as its relative position with respect to other companies. Finally, a score between 0 and 1 is obtained, with 0 being the worst possible performance and 1 being the best. Following the methodology used by LSEG Group, this result is transformed into the quantitative variable ESG, whose values can be D (less than 0.25), C (between 0.25 and 0.50), B (between 0.50 and 0.75), and A (greater than 0.75).⁴

4. Methodology

This section outlines the calculations and procedures undertaken to analyze rights issues across various countries, and to assess whether this process generates arbitrage opportunities. Additionally, it examines the characteristics of these anomalies in the market and identifies the factors that may significantly influence their formation.

The primary step involves determining whether an arbitrage opportunity has occurred in a specific right issue. Such arbitrage will take the form of a significant difference between the market price of the issuing company's shares and the price at which a new share can be obtained through subscription rights. To exploit this, a strategy has been constructed to exploit it, and once applied, its net return is obtained (i.e., the strategy's own return reduced by the estimated costs and commissions that may be incurred).

Following this, two studies are then conducted. The first aims to analyze the anomalous returns obtained and assess their statistical significance, while the second seeks to identify which factors can cause the appearance of these anomalies, and whether it is possible to predict the probability of their occurrence.

⁴ For more information, see <https://www.lseg.com/en/data-analytics/sustainable-finance/esg-scores>

Table 2

Definition and identification of the main variables.

Name	Definition	Main Statistics	Models
Continent	Continent where the firm is located.	See Table 01	
Country	Country where the firm is located.	See Table 01	
Period	Time period when the equity offering happened.	PER1, PER2, PER3	
Dilution Ratio	Ratio between the number of new ^a and old ^b shares.		DIL
Dilutive	1 if the dilution ratio is higher than 0.5 ^c , 0 otherwise.	DIL (1), nDIL (0)	
Method	Specifies the appropriate application of the dilution ratio within the context of the arbitrage strategy.		
Issue Price	Price required to be paid for each new share subscribed through rights.		
Index	1 if the firm is listed in a stock index, 0 otherwise.	IDX (1), nIDX (0)	IDX
Price Ratio	Ratio between the Issue Price and the theoretical ex-right price ^d .		ISC
Equity Ratio	Ratio between the equity over the company's total capitalization after the issue ^e .		CAP
ESG	Qualitative ESG grade based on the score assigned to the firm at the time of the equity offering.	ESGA, ESGB, ESGC, ESGD	
Objective	The objective(s) for which the equity offering was carried out (multiple objectives may apply).		
General	1 if the objectives are related to general company functions, 0 otherwise.		GEN
Acquisition	1 if the objectives are related to the acquisition of other companies, 0 otherwise.		ACQ
Investment	1 if the objectives are investment-related, 0 otherwise.		INV
Refinance	1 if the objectives are related to refinancing, 0 otherwise.		REF
Economic Sector	Economic sector of the firm.		
Academic	1 if the sector is "Academic and Educational Services", 0 otherwise.		ACA
Materials	1 if the sector is "Basic Material", 0 otherwise.		BAS
Cyclical	1 if the sector is "Consumer Cyclical", 0 otherwise.		CYC
Non-Cyclical	1 if the sector is "Consumer Non-Cyclical", 0 otherwise.		NCY
Energy	1 if the sector is "Energy", 0 otherwise.		ENE
Financials	1 if the sector is "Financials", 0 otherwise.		FIN
Government	1 if the sector is "Government Activity", 0 otherwise.		GOV
Healthcare	1 if the sector is "Healthcare", 0 otherwise.		HEA
Industrials	1 if the sector is "Industrials", 0 otherwise.		IND
Real Estate	1 if the sector is "Real Estate", 0 otherwise.		EST
Technology	1 if the sector is "Technology", 0 otherwise.		TEC
Utilities	1 if the sector is "Utilities", 0 otherwise.		UTI

^a Number of new shares that can be obtained for each *old* old share. See the [conversion ratio](#) section^b Number of old shares required to obtain *new* new shares. See the [conversion ratio](#) section^c See the [conversion ratio](#) section^d Captures the effect of the listing of the rights on the share price of the issuing company's shares. The ex-right price is a theoretical price calculated by Eikon.^e This variable captures the company's financial structure after the issue, considering the new distribution between equity and debt.

4.1. Application of the arbitrage strategy and achievement of net return

4.1.1. Calculation of the average net return on the rights issues

The arbitrage strategy involves subscribing to new shares through preferential subscription rights while simultaneously establishing a short position in the existing shares. This strategy is predicated on the assumption that the price paid to obtain the new shares through subscription will align with the prevailing market price of the company's shares. Given the inherent characteristics of the subscription rights, the reverse strategy – taking a long position in the company's shares and short position in the subscription rights – is not viable. Consequently, only a positive and significant outcome of this strategy will be considered an arbitrage opportunity. Accordingly, under this strategy,⁵ the price of the company's shares incorporating the subscription rights can be defined as follows:

$$P_{i,t} = \frac{PSR_i * Right_{i,t} + N_i * I_i}{N_i} \quad (1)$$

where $P_{i,t}$ is the price of a new share from the company i on the day t , $Right_{i,t}$ is the price of the subscription right, PSR_i is the number of rights necessary to obtain N_i new shares, and I_i is the issue price of the new shares.

Regarding the formula, it should be noted that, if the rights issue is non-cash, the factor I_i will always be equal to zero and will make that part of the formula disappear. On the other hand, when **method 1** is given, the factor PSR_i will be equal to Old_i , while when **method 2** of subscription ratio calculation is given, the factor PSR_i will always be equal to 1.

The gross return⁶ of the arbitrage strategy is then defined as the percentage difference between the market price (short position) and the theoretical price (long position) of the shares, as follows:

⁵ It is important to note that we acknowledge the subscription rights valuation model proposed by Bae and Levy (1996). However, it is not the intention of this paper to define, in theoretical terms, a formula for valuing the right or the share, but to determine what price is effectively paid for the share acquired through subscription rights, and its relation to the price at which this asset is quoted on the market.

⁶ Throughout the work, the returns calculated and shown will be based on the cash value of the transaction. In no case are they annualized.

$$RB_{i,t} = \frac{S_{i,t} - P_{i,t}}{P_{i,t}} \quad (2)$$

where $RB_{i,t}$ is the gross return of the strategy, and $S_{i,t}$ is the market price of the issuing company's stock. Finally, the gross return is reduced by the estimated effect of the costs and commissions involved in the transactions necessary to carry out the strategy, as follows:

$$RN_{i,t} = RB_{i,t} - c \quad (3)$$

where $RN_{i,t}$ is the net return of the strategy, and c is the estimate of costs and fees. This is a constant factor that applies equally to all rights issues, and its derivation is explained in more detail in the section [Actual implementation of the strategy and estimation of fees](#).

As outlined in the data section, the available series include the closing prices of the subscription rights and of the issuing company's shares, for the first ten days and the last day of trading of the rights. This observation period is reduced if the process lasts less than 10 days or if data for all days is not available.

After applying the calculation for each of the days for which all the data is available, the variable of interest in this study is defined as the average of the net returns for each of the days. For each right issue, an average net return is computed, and it is classified as positive, negative, or indeterminable if insufficient data prevents calculation. From this point forward, "net return," will refer to the average daily net yield of the process. For the purposes of this paper, an "arbitrage opportunity" is defined as the scenario where the average net return of the strategy is positive, while "no arbitrage" encompasses all the other cases.

4.1.2. Withdrawal of atypical abnormal returns

In some instances, the calculation described in the previous section results in an anomalously high return. This is mainly due to significant discrepancies between the theoretical prices (share price paid with subscription rights) and the quoted prices of the issuing company's shares. These outliers artificially alter the results of some of the tests performed subsequently, so they have been removed from the sample for these tests. Specifically, it has been decided to consider as *outliers* those net returns equal to or greater than 1000 %.

Regarding the decision to establish as outliers those returns above 1000 %, we initially considered applying the "Median Absolute Deviation" (MAD) methodology proposed by [Leys et al. \(2013\)](#), both for the sample as a whole and for each country individually. However, the presence of excessively positive returns meant that this methodology was not able to remove from the sample all those returns considered too high. Because of this, it was decided to set the threshold discussed in the first paragraph.

Following all the calculations and adjustments, it was possible to obtain results for 2583 processes, with 1044 positive results and 1539 negative results. A total of 837 positive results were identified as outliers and subsequently excluded from the sample.

Depending on the characteristics of the subsequent tests to be performed, a sample including or not the atypical positive results will be used. In some of them, moreover, it has been possible to obtain results both for the complete sample and for the sample including only the outliers.

Finally, it should be noted that it is not possible to obtain negative outlier returns. This is due to the assumption that, when implementing the arbitrage strategy, no leverage is carried out on the short position, which implies that the lowest possible outlier return is equal to -100 % (the maximum possible loss is the total investment). An average net return equal to -100 % only occurs in a total of 18 issues.

The number and volume of outliers obtained are of great interest. Upon investigation, it was confirmed that the data are accurate and not the result of calculation errors. Possible causes for this behavior could be the low liquidity of the company's shares or rights. On the other hand, it has been found that in their last trading days, the price of subscription rights tends to plummet and approach zero, which could explode the returns of the proposed strategy. However, this analysis should be left for further study.

4.1.3. Real implementation of the strategy and estimation of commissions

Although the arbitrage strategy appears relatively straightforward (requiring only the purchase of subscription rights and short positions in the shares), its practical implementation can be a relatively more complex task. Specifically, it is important to recognize that it is not always possible to take short positions in a company's shares. During the period of interest (simultaneous listing of rights and shares), the option to take short positions in the shares of the particular company may be unavailable or restricted.

To circumvent this restriction, the short position in the shares will be replicated using *Contracts for Difference* (or CFDs). These derivatives make it possible to replicate a long or short position in the underlying stock, and their *payoff* will be equal to the difference between the opening and closing prices multiplied by the volume of contracts traded. Specifically, the payoff of a short position in a CFD is equal to the opening price minus the closing price, which replicates the payoff of a short position in the stock.

In the arbitrage strategy, simply taking the long position in the rights, subscribing and immediately selling the new shares could theoretically allow for profits from the price differential to be obtained. However, this process is not so fast in reality. From the moment the decision is made to subscribe the rights until the new shares are available for sale, there is a delay during which the share price may fluctuate, potentially reducing or even eliminating the arbitrage profits. By taking the short position in the shares (or using an equivalent instrument, as *Contracts for Differences*, CFDs), any subsequent price movements are offset, thereby ensuring that the final outcome is predetermined at the moment the positions are opened.

Contracts for Difference allow investors to leverage a position, allowing them to invest a smaller amount of capital than would be necessary in an equivalent position in shares, which can significantly increase the return obtained. However, this leverage introduces additional market risk, in the sense that a sharp increase in the price of the underlying could lead to a *margin call*, whereby the broker

requires the investor to deposit additional funds, or may even result in the early closure of the position. To mitigate this risk, it has been assumed that the investor allocates 100 % of the position's value to this derivative, i.e., trading without leverage.

Based on this information, an estimate can be made of the fees incurred during the development of the arbitrage strategy. For this purpose, we simulated an investment in a set of equity offerings carried out in Spain, for which the theoretical analysis pointed to the existence of arbitrage opportunities. It is also assumed that trading in rights and shares is carried out with the investment bank *Renta 4 Banco*, and that CFDs are contracted with the broker *IG*. Since we work in international markets, many of the operations have also been carried out with the broker *Interactive Brokers* (or *IB*). In the simulated strategy, a maximum of €10,000⁷ is used, divided equally between trading with rights and shares and contracting CFDs, and all the information provided by the two entities mentioned is used to calculate the costs incurred at each operation.

It is important to note that the complexity of the operations to be carried out leads to a highly conservative estimate of the effect of commissions. After performing the calculations and applying all these conditions, a maximum effect of costs and commissions equal to 2 %⁸ has been estimated. Although it is true that investments in countries other than Spain may imply a different expense, the actual transactions carried out in other countries have shown similar or lower costs, considering the 2 % a conservative estimate.

The theoretical strategy described in this paper has been applied to real equity offerings by companies located in Spain, France, and Germany, among other countries. These exercises act as an additional test to check whether the theoretical results obtained are real. With this practice, we also improve the robustness of the study by obtaining a set of results out-of-sample. The results of the most relevant investment of all those carried out are shown below.

4.2. Significance test of net returns

The first test involves testing the significance of the mean and median of the net returns calculated across all the rights issues. This test is performed for both the full sample and the restricted sample in terms of all the variables discussed in the data section. The objective is to determine whether they present significant results, which points to the fact that this factor plays a crucial role in the occurrence of arbitrage opportunities.

For robustness, the tests are repeated once for the full sample, once for the restricted sample for each of the territories (continent and country) studied, and once for each possible value of the relevant factors identified. In addition, a joint restriction of the sample is also applied, both by country and by factor, which allows estimating the effect of these variables in the context of each country and/or region. For each data set, we obtained its mean, median, standard deviation and number of data points used. No tests will be conducted on samples with fewer than 5 observations.

A total of three different tests have been applied, two on the mean and one on the median. Prior to performing these tests, the non-normality of the different samples was checked by means of the Jarque-Bera test. Then, the first test applied is the t-Student test, a parametric test on the mean of the results, was applied. This was followed by two non-parametric tests: the [Wilcoxon \(1992\)](#) signed-rank test for the median, and finally a *backtesting* procedure on the mean, as defined in [Wilcox \(2010\)](#).

4.3. Modelling the returns from the strategy

After obtaining and analyzing the results of the arbitrage strategy, the next step is to explain them through factors directly or indirectly related to the rights issues. To do so, we intend to model them using the Ordinary Least Squares (OLS), Feasible Generalized Least Squares (FGLS) and its version using a First-Order Moving Average (FMOGLS).⁹ Specifically, the model to be estimated is as follows:

$$RET_i = \beta_0 + \beta_1 DIL_i + \beta_2 IDX_i + \beta_3 ISC_i + \beta_4 CAP_i + \varepsilon_i \quad (4)$$

being *RET* the net return of the strategy, *DIL* the New/Old ratio, and *IDX* a binary variable that representing if the issuer is listed in a stock index. Additionally, control variables *ISC* and *CAP* are, respectively, the Issuer/ex-Right and Equity/Capital ratios. Every factor is also defined in the [Data](#) section. All models have been estimated with standard errors robust to heteroscedasticity, and the selection of factors has been made considering previous experience, other studies and the results of the tests explained above.

Regarding the model estimation, it is important to note that many countries do not have enough data to produce robust models.¹⁰ To address this limitation, the models have been estimated only for the total sample, and for the four groups resulting from classifying according to the continent in which the issuing company is located.

The statistical significance of the estimated coefficients was assessed using the Student's *t*-test. For factors that did not pass this test, their robustness was evaluated, determining whether they should remain in the model despite not being significant or not. To carry out

⁷ This amount is high enough to allow profitable investments in the equity offerings and, at the same time, operate Contracts for Difference without the need for leverage, but it is also not too large to distort the estimate of commissions.

⁸ On a cash transaction basis, not annualized.

⁹ The authors acknowledge the potential issues and biases associated with using the Ordinary Least Squares (OLS) estimator. Therefore, as an additional robustness check, more advanced estimation methods are employed.

¹⁰ This should not be confused with missing observations, as all variables in this database are fully reported, and no such issue exists. The challenge arises from the fact that, in some countries, at least one binary variable lacks a sufficient number of observations for one of its two possible values.

this test, the following steps are followed:

1. The original model is estimated with and without the factor in question, and the residuals of both the general and restricted models are saved.
2. A Kruskal-Wallis test is applied to test the null hypothesis that both sets of residuals are from the same sample. Rejecting the hypothesis implies that the model varies significantly when the factor is removed, so the model is robust and should hold. Rejecting the null hypothesis implies that the factor is not robust.

4.4. Predicting arbitrage opportunities

After analyzing and explaining the returns obtained by the arbitrage strategy, this paper aims to be even more ambitious, and to try to predict the occurrence or not of arbitrage opportunities, using the different factors related to equity offerings that are available. To achieve this, we intend to estimate probability models, following *logit* and *probit* methodologies.

In these models, the dependent variable is binary, taking the value 1 if an arbitrage (positive net return) occurs and 0 otherwise. To this extent, the model will estimate the estimated probability, with the available information, that an arbitrage opportunity will occur. The model is considered successful in predicting arbitrage when the binary variable equals 1 and the estimated probability is greater than or equal to 2/3. Conversely, it will be deemed successful in predicting the absence of arbitrage when the binary variable equals 0 and the estimated probability is less than or equal to 1/3.

As in the previous case, for this practice, data variability across countries must be considered. Since each country may exhibit characteristics, it would not be appropriate to aggregate different regions to estimate these models, so they will only be estimated for the samples of each of the countries. Secondly, the different distribution of data in each territory makes it impossible to apply the same model to all cases. To solve this problem, a general model has been developed, and for each country, the version that maximizes the number of correctly predicted arbitrages will be estimated.

Therefore, the general model is as follows:

$$\begin{aligned} ARB_i = & \beta_0 + \beta_1 MON_i + \beta_2 DIL_i + \beta_3 IDX_i + \beta_4 ISC_i + \beta_5 CAP_i + \beta_6 GEN_i + \beta_7 ACQ_i + \beta_8 INV_i + \beta_9 REF_i + \delta_1 DIL_i * ACA_i + \delta_2 DIL_i \\ & * BAS_i + \delta_3 DIL_i * CYC_i + \delta_4 DIL_i * NCY_i + \delta_5 DIL_i * ENE_i + \delta_6 DIL_i * FIN_i + \delta_7 DIL_i * GOV_i + \delta_8 DIL_i * HEA_i + \delta_9 DIL_i \\ & * IND_i + \delta_{10} DIL_i * EST_i + \delta_{11} DIL_i * TEC_i + \delta_{12} DIL_i * UTI_i + \varepsilon_i \end{aligned} \quad (5)$$

where ARB_i is a binary variable that will take the value 1 if arbitrage has taken place and 0 otherwise, MON_i will take the value 1 if the right issue is monetary, and 0 otherwise, and DIL_i , IDX_i , ISC_i and CAP_i are defined as for the OLS model (Equation [8]). GEN_i , ACQ_i , INV_i and REF_i are binary variables that will take value 1 if the objectives of the process include at least one of a general, acquisition, investment, or refinancing nature, respectively, and 0 otherwise. Finally, interactions between the DIL_i variable and binary variables indicating the sector to which the issuing firm belongs are also included. Those sectors are: Academic and Educational Services (ACA_i), Basic Materials (BAS_i), Consumer Cyclicals (CYC_i), Consumer Non-Cyclicals (NCY_i), Energy (ENE_i), Financials (FIN_i), Government Activity (GOV_i), Healthcare (HEA_i), Industrials (IND_i), Real Estate (EST_i), Technology (TEC_i) and Utilities (UTI_i).

4.5. Temporal robustness of results

The broad time span covered by this work encompasses periods during which the global economy experienced significant changes, with fluctuations in economic, financial, and broader environmental conditions. In general terms, we can speak of a first period of relative stability, which was broken by the global financial crisis of 2008, which lasted for a persisted for several years, before entering another stage of relative stability, albeit with smaller and more specific pockets of instability.

All these environmental conditions could be affecting the results obtained. For this reason, the aggregation of all the results could hide some relevant patterns or behaviors that occurred in certain periods. On the other hand, it is also interesting to know whether the aggregated results are replicated to a greater or lesser extent when analyzing specific periods. Therefore, it has been decided to replicate the analyses for three sub-periods.

The first period includes the relative stability corresponding to the period between 2000 and 2007, inclusive. The second period includes the toughest years of the 2008 financial crisis and the beginning of the recovery from the crisis, and it goes from 2008 to 2014 (inclusive). Finally, the third period includes the remaining years, corresponding to the period between 2015 and 2020, both of which are included, where the effects of the financial crisis are already more limited, although there are some localized pockets of instability.

5. Results

In this section, the results obtained from the application of the statistical and econometric tools outlined in the previous section will be presented, explained, and interpreted. We will begin by presenting the findings related to the proposed arbitrage strategy, followed

by a characterization of these results through the application of various statistical tests. Lastly, the outcomes from the econometric methodologies will be presented, aimed at explaining and predicting these anomalies.¹¹

5.1. General results of the arbitrage strategy

The results of the proposed arbitrage strategy will first be discussed at both the aggregate level and for each territory included in the sample, with distinctions made between the three sub-periods defined in this study. To begin characterizing the results, Table 3 presents, for each territory and period, the number of equity offerings analyzed as well as the number of arbitrage opportunities identified. Additionally, the table will show the number of outliers detected and excluded from the full sample. Tables 4 and 5 summarize the main statistics and test results for the entire period and each of the three sub-periods, respectively.

Table 3 demonstrates that arbitrage opportunities are present in nearly all the countries, with a relatively consistent distribution across the different time sub-periods. In countries with larger sample sizes, the proportion of detected arbitrage opportunities ranges between 20 % and 30 % of the total sample. In contrast, some groups exhibit significantly higher percentages, though these results should be interpreted with caution due to the small sample sizes.

Although the results in Table 4 exhibit greater variability, it is noteworthy that positive and statistically significant means and medians were observed. The result for the medians is particularly revealing, as the estimated effect of commissions would be expected to suppress this indicator, leading to more negative outcomes. However, this is not the case in all countries, suggesting resilience in the arbitrage opportunities despite the impact of transaction costs.

When analyzed by sub-periods, Table 5 presents results similar to the previous findings. However, in these cases, the positive and significant medians disappear, though the averages still indicate the presence of anomalies, albeit with reduced intensity. It is important to note that the sample sizes are smaller in these sub-periods, and in some instances, no results could be obtained. Despite these limitations, the findings continue to suggest the presence of arbitrage opportunities.

The information presented in the tables can be visually summarized through the two figures below. Fig. 1 illustrates, for each country, the relationship between the percentage of equity offerings with positive results (horizontal axis) and the percentage with negative results (vertical axis). The different territories are plotted along a 45° line, where it is theoretically expected that most points will be positioned toward the upper section. Fig. 2 compares the means (horizontal axis) and medians (vertical axis) for each country, with the expectation that most points will appear in the lower left quadrant.

Fig. 1 demonstrates that, while most countries align with expectations, a significant number are located in the lower half of the graph, indicating a higher percentage of arbitrage opportunities compared to non-arbitrage cases. Additionally, many of the countries in the upper half are situated near the center, which is equally noteworthy. Fig. 2 is more revealing, as it shows that most countries meet the expectation only with respect to the median, while the mean remains positive. Furthermore, a considerable number of countries are positioned in the upper right quadrant, indicating both significant means and medians.

A consistent observation in both the tables and figures is the discrepancy between the means and medians. These differences arise, in part, due to the presence of a few excessively high returns, which inflate the means without affecting the medians. Additionally, as previously mentioned, the conservative estimation of commissions significantly reduces the results, impacting the bulk of the data but not the positive outliers. This explains why the medians are considerably smaller compared to the means. A more detailed analysis, including statistical tests, is necessary to assess the robustness of these findings. This will be addressed in the following sections, along with the results from the estimated models.

To further illustrate the scope of the results obtained through the proposed strategy, Fig. 3 presents a histogram of the calculated net returns. In addition to offering a new perspective on the findings, this figure provides a clearer view of the distribution of results across sub-periods and includes the volume of outliers.

In this figure, one would expect the majority of observations to cluster on the left side. While a large volume of observations does align with this expectation, a notable number exceed the 0 % threshold. The graph provides a clearer view of those observations above 100 % as well as the outliers (represented by the penultimate and final columns, respectively). However, it is important to note that these two columns represent a very broad range (from 100 % to 1000 %, and beyond 1000 %¹²), and therefore, they aggregate both groups without revealing the true distribution of the observations within them.

Table 6 presents the results obtained from applying the tests to the subgroups based on whether the equity offerings were dilutive (DIL) or non-dilutive (nDIL), as well as whether the companies were listed on a stock index (IDX) or not (nIDX).

These results reinforce the trends observed in the broader sample groups, though some specific nuances can be noted. In particular, the volume of positive and significant averages is higher in equity offerings where the proportion of new shares relative to existing shares is substantial (i.e., in dilutive offerings), as well as in companies not listed on any stock market index. With respect to medians, none of the cases show significance or, if they do, they yield negative values. This outcome may also be influenced by the small sample sizes in many of the subgroups analyzed.

Finally, Fig. 4 illustrates the distribution of each equity offering by its Net Return (horizontal axis) and ESG score (vertical axis), with the points differentiated by ESG rating (A: green, B: blue, C: yellow, and D: red). We would expect most observations to cluster on

¹¹ It is important to emphasize that this paper focuses on the outcomes that the proposed arbitrage strategy would have yielded under the market conditions prevailing during the days of the equity offerings. Other factors, such as the market's reaction to significant events, including the announcement of these processes, are beyond the scope of this study and should be explored in future research.

¹² To better visualize the volume of outliers, they are included in this histogram but excluded from the sample used for analysis.

Table 3

Arbitrages in equity offerings by territory and period.

	PER1			PER2			PER3			FULL		
	N	ARB		N	ARB		N	ARB		N	ARB	OUT
AFR	0			20	10	50.00 %	54	35	64.81 %	74	45	60.81 %
EGY	0			13	4	30.77 %	26	14	53.85 %	39	18	46.15 %
SAU	0			2	2	100.00 %	22	18	81.82 %	24	20	83.33 %
TUN	0			5	4	80.00 %	6	3	50.00 %	11	7	63.64 %
AME	0			89	42	47.19 %	75	24	32.00 %	164	66	40.24 %
BRA	0			37	11	29.73 %	52	10	19.23 %	89	21	23.60 %
CAN	0			37	25	67.57 %	20	13	65.00 %	57	38	66.67 %
USA	0			15	6	40.00 %	3	1	33.33 %	18	7	38.89 %
ASI	242	95	39.26 %	511	206	40.31 %	398	158	39.70 %	1151	459	39.88 %
AUS	70	27	38.57 %	50	21	42.00 %	73	14	19.18 %	193	62	32.12 %
HKG	58	32	55.17 %	127	56	44.09 %	107	54	50.47 %	292	142	48.63 %
IND	1	0		5	2	40.00 %	17	15	88.24 %	23	17	73.91 %
MYS	57	12	21.05 %	147	43	29.25 %	44	20	45.45 %	248	75	30.24 %
NZL	11	3	27.27 %	12	5	41.67 %	0			23	8	34.78 %
PAK	0			9	0		46	9	19.57 %	55	9	16.36 %
SGP	45	21	46.67 %	124	70	56.45 %	68	33	48.53 %	237	124	52.32 %
LKA	0			37	9	24.32 %	43	13	30.23 %	80	22	27.50 %
EUR	65	21	32.31 %	481	195	40.54 %	648	258	39.81 %	1194	474	39.70 %
AUT	2	2	100.00 %	5	4	80.00 %	3	2	66.67 %	10	8	80.00 %
BEL	3			12	5	41.67 %	23	4	17.39 %	38	9	23.68 %
DNK	0			12	4	33.33 %	14	7	50.00 %	26	11	42.31 %
FIN	4	2	50.00 %	23	17	73.91 %	18	16	88.89 %	45	35	77.78 %
FRA	11	4	36.36 %	77	20	25.97 %	67	28	41.79 %	155	52	33.55 %
DEU	9	0		24	8	33.33 %	6	2	33.33 %	39	10	25.64 %
GRC	4	2	50.00 %	18	7	38.89 %	9	5	55.56 %	31	14	45.16 %
ITA	13	2	15.38 %	48	20	41.67 %	39	15	38.46 %	100	37	37.00 %
NOR	3	2	66.67 %	19	6	31.58 %	25	8	32.00 %	47	16	34.04 %
POL	0			10	8	80.00 %	6	3	50.00 %	16	11	68.75 %
ESP	2	1	50.00 %	19	5	26.32 %	28	6	21.43 %	49	12	24.49 %
SWE	10	3	30.00 %	193	73	37.82 %	390	152	38.97 %	593	228	38.45 %
GBR	4	3	75.00 %	21	18	85.71 %	20	10	50.00 %	45	31	68.89 %
TOT	307	116	37.79 %	1101	453	41.14 %	1175	475	40.43 %	2583	1044	40.42 %

NOTES: ARB refers to the number of strategies with a positive average result, while OUT indicates how many were removed from the sample because of a significantly high result (only shown for the full period).

the left-hand side of the graph, or at least observe a decreasing volume of observations on the right-hand side as the ESG score increases.

Although most observations are clustered on the left side of the figure, a notable number still exhibit positive results, as seen in previous figures. However, the figure aligns with expectations regarding the distribution on the right-hand side, where higher ESG scores correspond to fewer positive net returns. The figure suggests an inverse relationship between ESG ratings and market anomalies, though this observation warrants further investigation.¹³

5.2. Analysis by continent – returns and their modelling

The results of estimating the proposed general models for observations corresponding to companies located in Africa and the Middle East (Table 7), the Americas (Table 8), Asia and Oceania (Table 9), and Europe (Table 10) are the following:

In this group of countries, a higher proportion of new shares relative to existing ones appears to increase the likelihood of arbitrage opportunities, while inclusion in a stock index does not have a significant effect.

In these countries, the dilution ratio remains a relevant variable, though with a negative sign. Additionally, stock index membership appears to have a significant effect, also negative.

In this group of countries, both variables studied appear to have a significant effect on the occurrence of arbitrage opportunities. The dilution ratio seems to increase the likelihood of arbitrage, whereas stock index membership appears to reduce it.

European equity offerings exhibit the most variable and inconclusive results among the four groups. The models reveal significant differences, although the dilution ratio consistently shows a positive and significant effect.

Despite variations in the results across the four groups, some common conclusions can be drawn. The ratio of new shares issued to existing shares and the inclusion of the issuing company in a stock index both appear to influence the occurrence and intensity of arbitrage opportunities. The first variable seems to have a direct positive relationship with these anomalies, while the second appears to reduce them.

¹³ The limited number of observations with available ESG rating data has prevented the application of the proposed statistical tests.

Table 4

Main Statistics by Region and Country – Full Period.

	N	Average			Median		St. Dev.	Max.	Min.	Skew	Kurt
AFR	74	12.45 %	*	(+)	3.80 %		0.61	297.11 %	−100.00 %	1.76	6.20
EGY	39	−2.45 %			−2.39 %		0.60	222.14 %	−100.00 %	1.18	3.18
SAU	24	40.64 %	* **	(+)	21.07 %		0.64	297.11 %	−20.33 %	2.67	7.72
TUN	11	3.79 %			0.90 %		0.28	85.49 %	−25.75 %	2.05	3.72
AME	164	68.07 %	* **	(+)	−7.32 %	* *	2.40	910.93 %	−100.00 %	2.41	4.57
BRA	89	53.07 %	* *	(+)	−34.53 %	* **	2.40	900.42 %	−100.00 %	2.31	4.11
CAN	57	88.49 %	* **	(+)	4.50 %		2.32	910.93 %	−77.73 %	2.61	5.55
USA	18	77.54 %		(+)	−2.65 %		2.56	858.56 %	−85.83 %	2.46	4.23
ASI	1151	54.21 %	* **	(+)	−4.45 %	* **	2.01	974.03 %	−100.00 %	2.77	7.23
AUS	193	67.63 %	* **	(+)	−19.62 %	* *	2.30	948.94 %	−100.00 %	2.22	4.05
HKG	292	97.96 %	* **	(+)	−0.21 %		2.39	974.03 %	−100.00 %	2.15	3.62
IND	23	−4.28 %			3.64 %		0.36	58.97 %	−89.00 %	−0.97	0.56
MYS	248	8.18 %			−19.10 %	* **	1.26	732.81 %	−100.00 %	3.49	13.56
NZL	23	68.95 %		(+)	−10.67 %		2.27	940.90 %	−61.29 %	2.73	6.97
PAK	55	−26.83 %	* **		−32.90 %	* **	0.68	377.27 %	−91.68 %	4.18	21.21
SGP	237	82.67 %	* **	(+)	0.39 %		2.17	957.58 %	−97.21 %	2.57	5.76
LKA	80	−11.13 %			−23.30 %	* **	0.91	582.04 %	−95.48 %	4.32	22.73
EUR	1194	46.11 %	* **	(+)	−1.84 %	* **	1.83	979.54 %	−100.00 %	3.42	11.46
AUT	10	2.57 %			1.89 %		0.07	18.69 %	−9.07 %	0.90	1.45
BEL	38	15.34 %			−1.76 %	* *	0.91	483.20 %	−85.60 %	4.10	17.28
DNK	26	20.20 %			−0.98 %		0.89	340.57 %	−83.49 %	2.67	6.58
FIN	45	98.45 %	* **	(+)	21.93 %		2.14	963.31 %	−78.44 %	2.67	6.70
FRA	155	29.39 %	* *	(+)	−2.24 %	* **	1.50	879.16 %	−82.17 %	4.33	18.35
DEU	39	34.65 %		(+)	−1.42 %	* *	1.51	703.16 %	−76.83 %	3.79	13.06
GRC	31	59.37 %	*	(+)	−1.24 %		1.86	840.91 %	−100.00 %	2.91	8.30
ITA	100	35.57 %	* *	(+)	−1.88 %		1.64	873.08 %	−94.79 %	3.90	15.37
NOR	47	132.25 %	* **	(+)	−2.10 %		3.03	953.60 %	−91.36 %	1.86	1.96
POL	16	59.58 %	*	(+)	22.15 %		1.25	501.42 %	−26.23 %	2.79	6.82
ESP	49	1.43 %			−4.35 %	* *	0.65	295.91 %	−81.78 %	2.79	9.17
SWE	593	38.27 %	* **	(+)	−2.68 %	* **	1.84	979.54 %	−99.57 %	3.55	12.23
GBR	45	183.51 %	* **	(+)	111.26 %		2.52	917.51 %	−58.55 %	1.36	1.12
TOT	2583	50.15 %	* **	(+)	−2.32 %	* **	1.93	979.54 %	−100.00 %	3.06	8.99

NOTES: For averages and medians, it is shown whether they are significant at the 1 % (***), 5 % (**) or 10 % (*) level of significance, as well as whether Bootstrapping provided a positive (+) or negative (−) result.

5.3. Analysis by country – returns and prediction of arbitrage

Tables 11 and 12 present the success rates of the probability models estimated for each country, specifically in predicting the occurrence of arbitrage opportunities (ARB), their absence (nARB), and the overall outcome of the strategy (TOT). Table 11 reports the results for the full sample and the first time sub-period, while Table 12 covers the results for the second and third sub-periods.

Despite significant variations between countries, the estimated models—particularly those using the Logit methodology—demonstrate high success rates. Focusing on the success rate for predicting the occurrence of arbitrage opportunities, we observe values exceeding 50 % for the majority of equity offerings analyzed, with only a few exceptions. Similarly high success rates are found in the other two categories (absence of arbitrage and total observations), suggesting that these models, and the factors used in their estimation, are capable of predicting the presence or absence of arbitrage opportunities with an acceptable degree of accuracy. Tables 13 and 14 indicate the variables used in each of the models estimated by Logit and Probit.

Finally, the variables included in each model and their relative importance are summarized in Figs. 5 and 6.

Fig. 5 illustrates the frequency of each variable's inclusion in the Logit (red) and Probit (blue) models, indicating significance with dark colors and non-significance with light colors.

Fig. 6 summarizes the average explanatory power of each variable, calculated for each country using the following formula:

$$Exp_x = \frac{\overline{R^2} - \overline{R^2}_{\{-x\}}}{\overline{R^2}} \quad (2.6)$$

where $\overline{R^2}$ is the adjusted R-Squared of the original model, while $\overline{R^2}_{\{-x\}}$ is the adjusted R-Squared of the model without the variable of interest x .

Taken together, these figures demonstrate that the primary explanatory variables for the observed anomalies are DIL, IDX, and, to a lesser extent, ISC and CAP. Additionally, it is evident that the Logit models incorporate interactions with economic sector variables more frequently than the Probit models, with the explanatory power of DIL being distributed across these interactions in the former.

Beyond the models' predictive ability, which could only be tested in-sample, these results carry broader implications. The high success rates indicate that the factors employed have strong explanatory power in predicting the occurrence or absence of arbitrage opportunities in the context of equity offerings.

Table 5
Test Results by Region and Country – Subperiods.

	PER1					PER2					PER3			
	N	Average (%)		Median (%)		N	Average (%)		Median (%)		N	Average (%)		Median (%)
AFR	0					20	7.52		0.43		54	14.28	* *(+)	6.13
EGY	0					13	−14.15		−18.55		26	3.40		2.89
SAU	0					2					22	29.06	* ** (+)	18.17
TUN	0					5	−0.39		3.06		6	7.27		−4.01
AME	0					89	97.17	* ** (+)	−0.26		75	33.53	(+)	−15.59
BRA	0					37	100.06	* *(+)	−36.69		52	19.64		−26.60
CAN	0					37	95.67	* *(+)	3.74		20	75.21	(+)	4.78
USA	0					15	93.73	(+)	−3.18		3			
ASI	242	79.57	* ** (+)	−12.98		511	68.60	* ** (+)	−4.59		398	20.32	* ** (+)	−2.77
AUS	70	119.54	* ** (+)	−17.31		50	96.47	* *(+)	−12.22		73	−1.89		−22.15
HKG	58	185.42	* ** (+)	3.62		127	82.22	* ** (+)	−1.06		107	69.23	* ** (+)	0.01
IND	1					5	−23.28		−22.53		17	6.30		3.99
MYS	57	−34.98	* ** (-)	−44.71	* **	147	21.64	* (+)	−16.53	* **	44	19.09		−0.88
NZL	11	−3.45		−28.61		12	135.31	(+)	−6.50		0			
PAK	0					9	−34.76	* ** (-)	−32.10	* **	46	−25.28	* *	−37.36
SGP	45	50.09	* (+)	−3.74		124	129.22	* ** (+)	2.63		68	19.34	* (+)	−0.10
LKA	0					37	−16.44		−39.84	* **	43	−6.57		−11.60
EUR	65	63.74	* *(+)	−1.90		481	68.88	* ** (+)	−2.22		648	27.44	* ** (+)	−1.71
AUT	2					5	2.56		0.18		3			
BEL	3					12	33.26		−1.69		23	8.48		−1.69
DNK	0					12	−12.60		−1.20		14	48.32	(+)	0.13
FIN	4					23	151.20	* *(+)	31.51		18	38.92	* (+)	18.29
FRA	11	23.02		−1.50		77	55.05	* *(+)	−2.95	* **	67	0.94		−1.81
DEU	9	−4.03	* *(-)	−1.48	* **	24	28.75		−1.00	*	6	116.27		−1.29
GRC	4					18	56.07	(+)	−8.58		9	88.88	(+)	2.35
ITA	13	−19.59	* (-)	−17.94	* *	48	72.83	* *(+)	−1.38		39	8.10		−1.58
NOR	3					19	73.06	(+)	−2.93		25	136.25	* *(+)	−2.11
POL	0					10	42.08	* (+)	35.15		6	88.73		2.03
ESP	2					19	4.97		−13.09	*	28	−4.23	* (-)	−3.79
SWE	10	70.90		−32.52		193	67.93	* ** (+)	−6.35	*	390	22.76	* ** (+)	−1.80
GBR	4					21	235.57	* ** (+)	197.29		20	81.81	* *(+)	−2.67
TOT	307	76.22	* ** (+)	−9.71		1101	69.93	* ** (+)	−2.74		1175	24.81	* ** (+)	−1.91

NOTES: For averages and medians, it is shown whether they are significant at the 1 % (***), 5 % (**) or 10 % (*) level of significance, as well as whether Bootstrapping provided a positive (+) or negative (-) result. No test has been applied on samples of less than 5 observations.

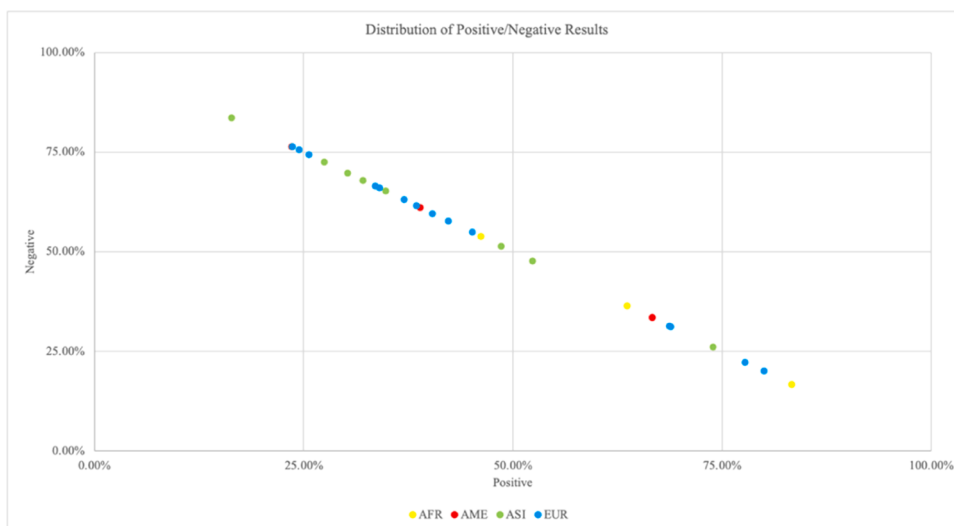


Fig. 1. Distribution and relationship between positive and negative results.

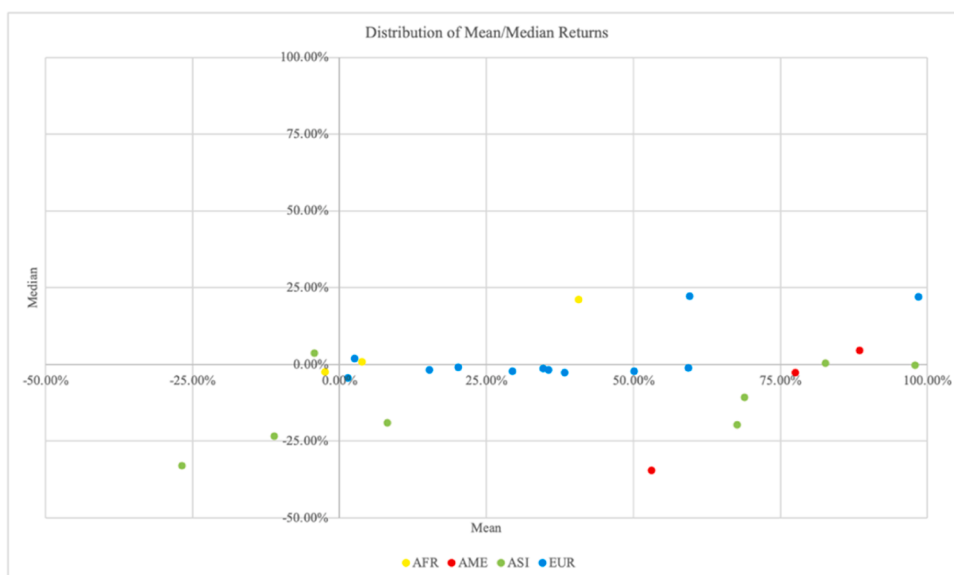


Fig. 2. Distribution and relationship between average and median results.

5.4. Real application of the strategy – case of Atari (France)

All methodologies and results presented thus far are based on simulations of arbitrage strategies applied to historical price series of both shares and subscription rights. However, within the framework of this research, the described arbitrage strategy has also been applied to real cases, testing whether the theoretical results hold once the strategies are implemented. These transactions were executed when theoretical calculations indicated a sufficiently high positive result to cover the associated costs. While multiple capital increases were involved, the most exemplary case is discussed below.

In early 2022 (out-of-sample), the French company Atari S.A. conducted a rights issue under the following conditions:

- New shares with a par value of 0.100€ and a share premium of 0.154€.
- Four subscription rights entitled the holder to one new share,
- The rights were traded on the market from 11/03/2022–24/03/2022.

Given the issue premium, the shares were to be paid upon subscription, classifying the equity offering as monetary. The dilution ratio was 1/4, indicating a non-dilutive issue, and the company was not listed on any major stock index. The strategy was executed

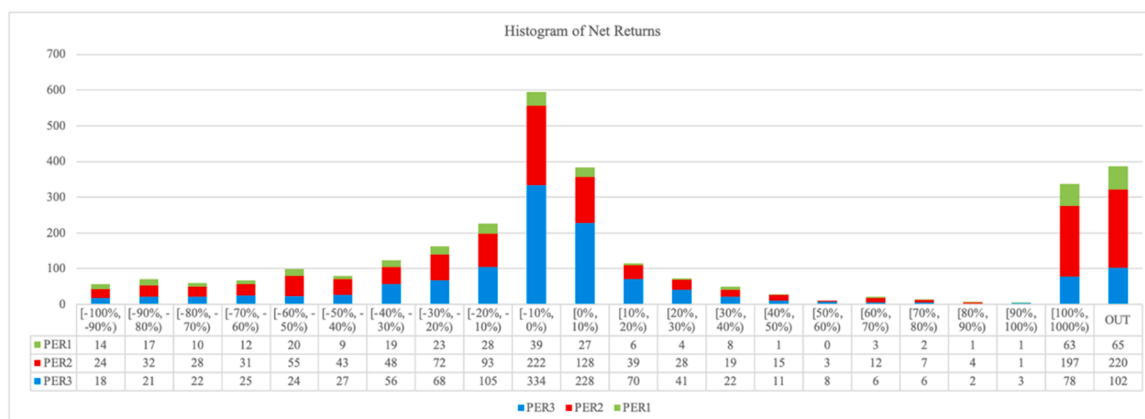


Fig. 3. Histogram of Net Returns.

using *Renta 4* Bank for purchasing and selling shares and rights, and *IG* broker for CFD trading. The steps were as follows:

1. On 03/23/2022, 40,000 PSRs were purchased at 0.0039€, amounting to 156.00€ plus 15.00€ in commissions.
2. A short CFD position was opened on Atari shares at 0.2072€, with a margin of 1000.00€ (50 % of the investment) incurring 5.00€ in commissions.
3. On 04/01/2022 10,000 new shares were obtained, after paying the subscription price of 0.1640 €, totaling 1640.00€. These shares were sold on the same day at 0.1865€ yielding 1865.00€, with an additional 15.00€ paid in commissions.
4. The short CFD position was closed on the same day at 0.1878€, generating a gross profit of 194.43€, with maintenance and closing commissions amounting to 19.34€.
5. The total investment for this strategy was 2796.00 €, and the gross result was 3059.43 €. After accounting for total commissions were 54.34€ (1.94 % of total cost), the net profit amounted to 209.09€, representing a 7.48 % return on investment).

Due to the nature of the operation and the use of CFDs, the outcome could be precisely calculated when the positions were opened. Table 15 provides a summary of this strategy.

As mentioned earlier, this strategy has been applied not only to this case but also to a series of capital increases, particularly in Spain, as well as in other countries such as France and Germany.¹⁴ In all instances, positive returns were achieved in line with the estimated theoretical outcomes, adding further robustness to the conclusions of this paper. These results also provide out-of-sample validation, reinforcing the theoretical findings obtained from the sample.

6. Conclusions

The objective of this study has been to conduct a comprehensive analysis of rights issues globally, identifying potential arbitrage opportunities, explaining their occurrence, and predicting them through factors related to the process and the issuing companies. To achieve this, an arbitrage strategy was designed and implemented. After obtaining returns from these strategies, they were analyzed using various statistical tests and econometrical estimations, and then we attempted to predict arbitrage occurrences through Logit and Probit probability models. This was done using a sample of several thousand rights offerings from 27 countries across all continents, spanning 20 years.

The results provide sufficient evidence to support the main hypothesis, showing that arbitrage opportunities have consistently occurred in these processes and are still present today. Positive returns were recorded in all countries, with the average returns for each country being positive and significant. However, this pattern is not consistent for all issues, as most medians were negative and significant. This suggests that while the anomaly occurs frequently, it does not happen systematically across all offerings. It is also noteworthy that, once arbitrage opportunities are detected, they tend to persist over time, contrary to what would typically be expected in such situations. This suggests that either investors have not identified these opportunities or have been unable to exploit them.

The occurrence of these opportunities does not seem to be random, as certain factors were found to significantly influence their likelihood. For instance, a higher ratio of new shares to existing shares tends to increase the potential performance of the arbitrage strategy, while companies listed on a stock index seem to reduce this result.¹⁵ Additionally, a negative relationship was established between arbitrage returns and the sustainability of the issuing company, as well as the economic development level of the country during the process.

¹⁴ Tables with the results of all other operations are available upon request.

¹⁵ Note that companies listed on stock indices may have a higher probability of enabling short positions.

Table 6

Test Results of Subgroups (Dilutive and Listed in a Stock Index) by Region and Country – Full Period.

	DIL				nDIL				IDX				nIDX							
	N	Average (%)		Median (%)	N	Average (%)		Median (%)	N	Average (%)		Median (%)	N	Average (%)		Median (%)				
AFR	56	21.62	* *(+)	9.55	18	−16.07	* (-)	−8.57	**	5	33.68		6.15	69	10.91	(+)	3.34			
EGY	31	7.80		4.26	8	−42.19	* ** (-)	−45.75	* **	2				37	−7.04		−2.39			
SAU	23	42.47	* ** (+)	23.66	1					3				21	46.28	* ** (+)	25.00			
TUN	2				9	5.53		0.90		0				11	3.79		0.90			
AME	92	88.93	* ** (+)	0.43	72	41.41	(+)	−26.60	* **	12	−45.13	* ** (-)	−41.48	* **	152	77.00	* ** (+)	−3.23		
BRA	36	91.14	* (+)	−16.16	53	27.21		−36.20	* **	12	−45.13	* ** (-)	−41.48	* **	77	68.37	* *(+)	−27.46	* *	
CAN	42	99.76	* ** (+)	4.12	15	56.92		4.92		0				57	88.49	* ** (+)	4.50			
USA	14	50.76		−4.59	4					0				18	77.54	(-)	−2.65			
ASI	642	83.24	* ** (+)	−0.45	509	17.60	* *(+)	−15.07	* **	116	−8.77		−18.39	* **	1035	61.27	* ** (+)	−3.61	* **	
AUS	73	158.22	* ** (+)	6.78	120	12.52		−33.84	* **	16	−40.80	* ** (-)	−43.05	* **	177	77.43	* ** (+)	−16.37		
HKG	198	112.67	* ** (+)	−0.02	94	66.97	* ** (+)	−0.94		2				290	96.60	* ** (+)	−0.31			
IND	6	−11.68		3.06	17	−1.66		3.64		7	12.52	* *(+)	5.84	16	−11.62		3.02			
MYS	171	26.12	* *(+)	−11.88	**	77	−31.68	* ** (-)	−33.91	* **	8	−7.68		−1.69	240	8.70		−19.63	* **	
NZL	9	100.24	(+)	25.90	14	48.83		−30.34	*	4				19	91.98	(+)	−9.82			
PAK	23	6.74		−8.96	*	32	−50.96	* ** (-)	−51.05	* **	17	−42.80	* ** (-)	−40.24	* **	38	−19.69		−32.14	* **
SGP	120	112.38	* ** (+)	1.98	117	52.20	* ** (+)	−0.04		4				233	84.11	* ** (+)	0.56			
LKA	42	15.25		−2.98	*	38	−40.29	* ** (-)	−39.39	* **	58	−1.47		−15.95	* **	22	−36.61	* ** (-)	−52.82	* **
EUR	598	80.89	* ** (+)	0.73	596	11.22	* *(+)	−3.48	* **	76	63.58	* ** (+)	−1.91	1118	44.93	* ** (+)	−1.84	* **		
AUT	4				6	−0.44		0.69		2				8	3.18		2.70			
BEL	13	48.53		−2.40	25	−1.92	* *(-)	−1.69	* **	0				38	15.34		−1.76	* *		
DNK	17	33.36		1.19	9	−4.66		−1.61		0				26	20.20		−0.98			
FIN	24	126.38	* *(+)	24.26	21	66.54	* *(+)	21.46		3				42	84.64	* ** (+)	21.70			
FRA	38	100.50	* *(+)	−0.95	117	6.29		−2.59	* **	10	−4.70	* ** (-)	−2.56	* **	145	31.74	* *(+)	−2.22	* **	
DEU	18	36.24		−0.94	21	33.29		−1.91	* *	9	−1.60		−1.91		30	45.53	(+)	−1.38	* *	
GRC	22	84.58	* (+)	−0.10	9	−2.25		−10.12		1				30	61.40	* (+)	−1.11			
ITA	54	72.40	* *(+)	1.73	46	−7.66		−10.33	* **	1				99	31.77	* (+)	−1.92	*		
NOR	36	147.08	* *(+)	−1.94	11	83.69		−7.89		1				46	135.16	* ** (+)	−2.11			
POL	8	20.29	* *(+)	10.94	8	98.86	(+)	35.15		9	36.09	(+)	8.62	7	89.78		34.67			
ESP	21	24.46		−2.38	28	−15.85	* *(-)	−8.74	* **	10	−7.88	* *	−6.67	* *	39	3.81		−4.32	*	
SWE	316	64.79	* ** (+)	0.69	277	8.02		−4.96	* **	9	1.22		−19.16		584	38.84	* ** (+)	−2.62	* **	
GBR	27	275.12	* ** (+)	218.62	18	46.11		−16.20		21	159.63	* ** (+)	96.67		24	204.41	* ** (+)	116.14		
TOT	1388	80.12	* ** (+)	0.42	1195	15.35	* ** (+)	−7.04	* **	209	16.47	* (+)	−8.65	* **	2374	53.12	* ** (+)	−2.14	* **	

NOTES: For averages and medians, it is shown whether they are significant at the 1 % (***), 5 % (**) or 10 % (*) level of significance, as well as whether Bootstrapping provided a positive (+) or negative (-) result. No test has been applied on samples of less than 5 observations.

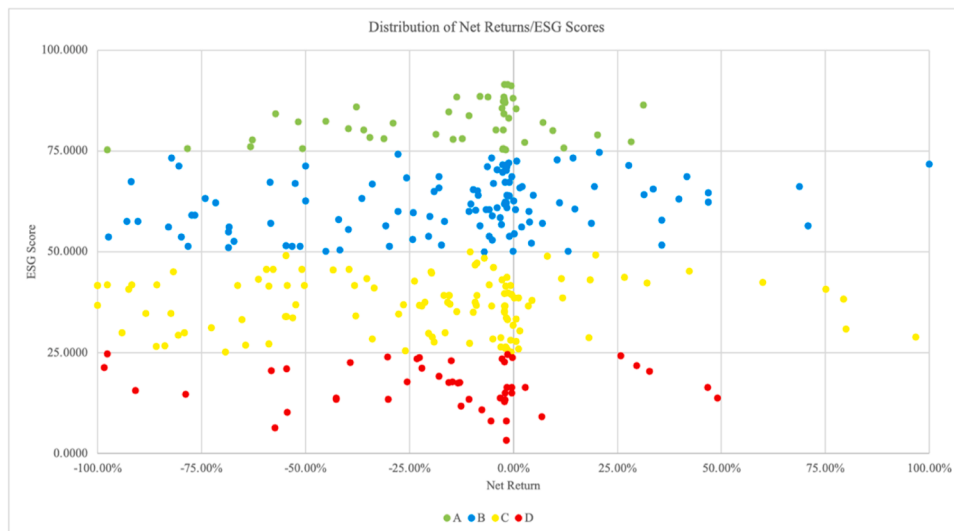


Fig. 4. Distribution of Net Returns and ESG scores.

Table 7

Model Estimation Results for Africa and Middle East.

	OLS		FGLS		FOGLS	
Intercept	-0.4432 (0.164)	** *	-0.3731 (0.134)	** *	0.1318 (0.013)	** *
DIL	0.2436 (0.081)	** *	0.1835 (0.088)	**	0.0399 (0.011)	** *
IDX	-0.0154 (0.190)		-0.0233 (0.202)		-0.0080 (0.021)	
Controls	Yes		Yes		Yes	
R-Squared	0.299		0.241		0.984	
Observations	74		74		72	

Table 8

Model Estimation Results for the Americas.

	OLS		FGLS		FOGLS	
Intercept	1.1319 (0.464)	**	0.8751 (0.438)	**	-0.2560 (0.012)	** *
DIL	-0.0070 (0.002)	** *	-0.0072 (0.002)	** *	0.0021 (0.002)	
IDX	-1.3396 (0.266)	** *	-1.4923 (0.263)	** *	0.0809 (0.036)	**
Controls	Yes		Yes		Yes	
R-Squared	0.025		0.029		0.998	
Observations	164		164		162	

Table 9

Model Estimation Results for Asia and Oceania.

	OLS		FGLS		FOGLS	
Intercept	0.2401 (0.165)		0.2877 (0.166)	*	0.0658 (0.001)	** *
DIL	0.1277 (0.041)	** *	0.1271 (0.041)	** *	0.0048 (0.005)	
IDX	-0.7044 (0.107)	** *	-0.6284 (0.108)	** *	-0.0098 (0.002)	** *
Controls	Yes		Yes		Yes	
R-Squared	0.040		0.036		0.997	
Observations	1151		1151		1149	

Table 10
Model Estimation Results for Europe.

	OLS		FGLS		FOGLS	
Intercept	0.1288 (0.127)		0.0758 (0.119)		−0.8049 (0.044)	**
DIL	0.0265 (0.013)	**	0.0246 (0.008)	**	0.0003 (0.002)	
IDX	0.1381 (0.203)		0.5931 (0.224)	**	0.0596 (0.041)	
Controls	Yes		Yes		Yes	
R-Squared	0.028		0.038		0.990	
Observations	1194		1194		1192	

Table 11
Success Rate (%) by Model and Country - Full and First Period.

	Full Period						PER1					
	LOGIT			PROBIT			LOGIT			PROBIT		
	ARB	nARB	TOT	ARB	nARB	TOT	ARB	nARB	TOT	ARB	nARB	TOT
AFR	81.22	80.16	85.18	74.37	81.75	81.01						
EGY	72.22	90.48	82.05	66.67	95.24	82.05						
SAU	100.00	50.00	91.67	85.00	50.00	79.17						
TUN	71.43	100.00	81.82	71.43	100.00	81.82						
AME	86.55	74.46	86.90	46.62	87.22	72.98						
BRA	61.90	97.06	88.76	57.14	97.06	87.64						
CAN	97.74	26.32	71.93	68.42	73.68	70.18						
USA	100.00	100.00	100.00	14.29	90.91	61.11						
ASI	61.19	90.41	80.26	37.41	86.85	70.84	74.16	94.25	85.41	62.50	90.39	75.00
AUS	35.48	97.71	77.72	9.68	97.71	69.43	51.85	93.02	77.14			
HKG	25.35	90.00	58.56	9.15	96.67	54.11	78.13	92.31	84.48	25.00	80.77	50.00
IND	94.12	66.67	86.96	82.35	33.33	69.57						
MYS	37.33	97.11	79.03	16.00	97.11	72.58						
NZL	100.00	100.00	100.00	75.00	93.33	86.96	100.00	100.00	100.00	100.00	100.00	100.00
PAK	100.00	100.00	100.00	66.67	97.83	92.73						
SGP	29.03	75.22	51.05	4.03	82.30	41.35	66.67	91.67	80.00			
LKA	68.18	96.55	88.75	36.36	96.55	80.00						
EUR	69.61	89.02	85.17	43.99	89.33	76.45	84.87	78.57	84.42	76.80	67.06	74.69
AUT	100.00	100.00	100.00	100.00	100.00	100.00						
BEL	77.78	100.00	94.74	44.44	96.55	84.21						
DNK	72.73	93.33	84.62	18.18	100.00	65.38						
FIN	100.00	20.00	82.22	100.00	0.00	77.78	94.12	50.00	82.61	94.12	16.67	73.91
FRA	36.54	94.17	74.84	7.69	96.12	66.45	100.00	100.00	100.00	100.00	85.71	90.91
DEU	90.00	96.55	94.87	30.00	100.00	82.05						
GRC	64.29	88.24	77.42	21.43	94.12	61.29	50.00	100.00	75.00	50.00	100.00	75.00
ITA	56.76	95.24	81.00	37.84	93.65	73.00						
NOR	62.50	90.32	80.85				50.00	0.00	33.33	50.00	0.00	33.33
POL	100.00	100.00	100.00	81.82	100.00	87.50						
ESP	41.67	97.30	83.67	8.33	100.00	77.55	100.00	100.00	100.00			
SWE	12.28	96.44	64.08	3.95	98.63	62.23	100.00	100.00	100.00	100.00	100.00	100.00
GBR	90.32	85.71	88.89	74.19	92.86	80.00	100.00	100.00	100.00	66.67	100.00	75.00
TOT	74.64	83.51	84.38	50.59	86.29	75.32	79.52	86.41	84.91	69.65	78.72	74.85

NOTES: In the sections corresponding to country groups, the results presented represent the averages of the countries included.

Having identified several factors that explain the occurrence of arbitrage, we attempted to predict it using probability models. Although the predictive success varied across the sample, high success rates were generally achieved, reinforcing the significance of the studied factors in the appearance of these anomalies.

While much of this study is theoretical, as the analysis was conducted on a specific sample of past equity offerings, it also demonstrates practical application. The proposed arbitrage strategy was tested in out-of-sample scenarios, yielding positive results. In each case, the strategy allowed not only for positive returns but also for a known final result at the time of opening the positions, even when the closing occurred weeks later. These out-of-sample results enhance the robustness and reliability of the conclusions.

The presence of arbitrage opportunities signals market inefficiency. In an efficient market, arbitrage should either not exist or persist for only a short time, which was not the case in many instances analyzed. Market incompleteness, such as the inability to short-sell the issuing company's shares, may contribute to the persistence of arbitrage opportunities. A notable finding of this study is that sustainability efforts by companies and higher levels of economic development have positive effects on market efficiency. This is observed through the reduced profitability of the strategy in more sustainable companies and developed markets.

The most significant contribution of this work is the comprehensive analysis of rights offerings across various countries and continents, yielding both common results and identifying factors and behaviors consistent across all regions. The results account for

Table 12

Success Rate (%) by Model and Country - Second and Third Period.

	PER2						PER3					
	LOGIT			PROBIT			LOGIT			PROBIT		
	ARB	nARB	TOT	ARB	nARB	TOT	ARB	nARB	TOT	ARB	nARB	TOT
AFR	100.00	100.00	100.00	62.50	100.00	82.31	81.75	69.44	83.49	72.22	66.67	77.08
EGY	100.00	100.00	100.00	50.00	100.00	84.62	78.57	83.33	80.77	50.00	75.00	61.54
SAU							100.00	25.00	86.36	100.00	25.00	86.36
TUN	100.00	100.00	100.00	75.00	100.00	80.00	66.67	100.00	83.33	66.67	100.00	83.33
AME	94.30	91.67	94.60	46.87	89.46	74.48	91.16	70.24	85.58	28.08	91.67	70.39
BRA	90.91	100.00	97.30	27.27	96.15	75.68	90.00	97.62	96.15	10.00	97.62	80.77
CAN	92.00	75.00	86.49	80.00	83.33	81.08	92.31	42.86	75.00	46.15	85.71	60.00
USA	100.00	100.00	100.00	33.33	88.89	66.67						
ASI	66.01	94.33	83.43	40.57	95.89	74.59	74.54	94.56	86.67	51.59	76.59	73.93
AUS	47.62	96.55	76.00				64.29	98.31	91.78			
HKG	35.71	91.55	66.93	10.71	98.59	59.84	38.89	83.02	60.75	18.52	88.68	53.27
IND	100.00	100.00	100.00	50.00	100.00	80.00	100.00	100.00	100.00	100.00	0.00	88.24
MYS	25.58	96.15	75.51	13.95	97.12	72.79	75.00	95.83	86.36	60.00	91.67	77.27
NZL	100.00	100.00	100.00	100.00	100.00	100.00						
PAK							100.00	100.00	100.00	66.67	97.30	91.30
SGP	64.29	79.63	70.97	24.29	79.63	48.39	66.67	91.43	79.41	18.18	88.57	54.41
LKA	88.89	96.43	94.59	44.44	100.00	86.49	76.92	93.33	88.37	46.15	93.33	79.07
EUR	81.27	92.98	90.64	55.40	68.99	76.60	76.21	97.80	89.93	61.94	95.99	83.32
AUT	100.00	100.00	100.00	75.00	0.00	60.00	100.00	100.00	100.00	100.00	100.00	100.00
BEL	80.00	85.71	83.33	60.00	100.00	83.33	50.00	94.74	86.96	50.00	100.00	91.30
DNK							100.00	100.00	100.00	42.86	100.00	71.43
FIN	94.12	50.00	82.61	94.12	16.67	73.91	93.75	100.00	94.44	100.00	100.00	100.00
FRA	35.00	96.49	80.52	5.00	98.25	74.03	67.86	94.87	83.58	28.57	92.31	65.67
DEU	87.50	93.75	91.67	37.50	100.00	79.17	100.00	100.00	100.00	100.00	100.00	100.00
GRC	85.71	100.00	94.44	14.29	100.00	66.67	100.00	100.00	100.00	80.00	75.00	77.78
ITA	80.00	96.43	89.58	50.00	96.43	77.08	100.00	100.00	100.00	60.00	95.83	82.05
NOR	100.00	100.00	100.00	66.67	100.00	89.47	25.00	88.24	68.00	12.50	100.00	72.00
POL	100.00	100.00	100.00	100.00	50.00	90.00	66.67	100.00	83.33	66.67	100.00	83.33
ESP	80.00	100.00	94.74									
SWE	32.88	93.33	70.74	6.85	97.50	63.21	11.18	95.80	62.82	2.63	98.74	61.28
GBR	100.00	100.00	100.00	100.00	0.00	85.71	100.00	100.00	100.00	100.00	90.00	95.00
TOT	85.40	94.74	92.17	51.33	88.58	76.99	80.91	83.01	86.41	53.46	82.73	76.18

NOTES: In the sections corresponding to country groups, the results presented represent the averages of the countries included.

regulatory differences between countries, enhancing the robustness of the conclusions.

In general, the findings of this study confirm that (1) price discrepancies exist, leading to arbitrage opportunities in the equity offering process, (2) these anomalies persist over time, (3) this casuistry is robust across different territories and regulatory environments, and (4) certain factors play a significant role in the occurrence of these anomalies. These conclusions offer valuable insights for all parties involved in such operations. For external investors, the study highlights key factors to monitor for identifying potential arbitrage opportunities, while also providing a strategy to exploit and eliminate these price discrepancies. Issuing companies are given insights into which factors to manage in order to align the pricing of new shares more closely with their fair market value. Finally, regulators are provided with relevant information on how to minimize market anomalies in these types of transactions.

The primary limitations of this study are directly tied to one of its strengths—its large sample size. The diversity of the sample, particularly across different countries, presented a significant challenge in applying uniform methodologies to all cases. Despite this, the results have successfully yielded conclusions that are broadly applicable across the sample, thereby overcoming this obstacle. Additionally, the lack of information has been a significant limitation, leading to the exclusion of a substantial portion of the initially collected sample. Furthermore, differences in regulations and the equity offering processes across countries have posed additional challenges in the analysis.

Future research could explore other market anomalies that occur in the context of equity offerings, such as abnormal returns linked to milestones or events within these processes. Additionally, a focused study on positive outliers and the factors driving these anomalous results would be of interest. These areas represent promising avenues for further investigation, as well as further research analyze in depth the reasons why the market appears unable to close these types of anomalies.

Table 13

Probability Models estimated for each country – Logit Model.

LOGIT Models																				
	DIL	IDX	ISC	CAP	GEN	ACQ	INV	REF	ACA	BAS	CYC	NCY	ENE	FIN	GOV	HEA	IND	EST	TEC	UTI
EGY	F23	F23	F23	F23	F23				3	F3	F2	F3	F	F23		F3		23		
SAU	F3	F		F	F							F		3						
TUN	F23		F	F23	F					3	F			F3			F			
BRA	F23	F23	F23	F23	F23					2	F3	F23	2	F3		F3	23	F23	F	F23
CAN	F23		2	2						3	F3		2					F23		
USA	F2		F2	F2	F2					2	F2		F2	F				2		
AUS	F123	F123	F123	F123	13					F23	F23	12	F23	F123		1	F13	F12	F12	F3
HKG	F123	F2	13	F123	F123	1				F123	F12	F23	F23	123		3	F12	F2	F123	F123
IND	F3	2	F23	2	2					F3	F	3	3	F						
MYS	F23	F23	F3	F	F3				F	F2	F3	F3	F2	23		F3	F23	F	23	F
NZL	F2	F1	F12	F	F					F		F	F2	F				F	F	2
PAK	F3	F3	F3	F3	F3					F	F3	F3	F	F3		F	F3			3
SGP	F123	F23	F123	F123						F123	123	F23	F3	F123		F1	123	F123	F23	2
LKA	F23	F23	F23	F2	F23					F	F23			F23			F23	2		F
AUT	F2	F2	F23	F										2						
BEL	F23		F3	F3	3					23		3		F		2	F2	F23		2
DNK	F3		F3	F						F	F3		F	F3		F3		3	F3	
FIN	F123		3	123	F13					23	3	F23		F2		F23	3		F2	
FRA	F123	F12	F123	2	F12	F			2	23	F23	F2	F2	F23		F2	F23	F23	F23	F1
DEU	F23	F23	F23	F2	F2					F2	F		F			F2	F	2	F2	
GRC	F23	F3	F123	F23							2	2	2	F2			F23	F	F2	
ITA	F23	2	F23	F23	F3					2	F23			F23		F23	F3	F3	F23	F2
NOR	F23	F	F123	F23	F23					F23		F2	F2	3		F2	F23	23	F23	
POL	F23	F23	F	3	F									F3			F	F		
ESP	F2	F2	F2	F12	F2						F	F2		F2		F	F2	F	F2	
SWE	F23	123	F23	13	F23	2	2			23	F23	F23	F2	3		F3	23	F23	23	F3
GBR	F123	F23	13	12						F3	23	F	F2	2		F2	F	F2	F	F2

NOTES: The presence of a variable in the model for the complete sample is indicated by the letter “F.” Numbers 1, 2, and 3 denote the presence of the variable in the models corresponding to the respective subperiods. The presence of a variable associated with an economic sector indicates the inclusion of its interaction with the DIL variable.

Table 14
Probability Models estimated for each country – Probit Model.

PROBIT Models																				
	DIL	IDX	ISC	CAP	GEN	ACQ	INV	REF	ACA	BAS	CYC	NCY	ENE	FIN	GOV	HEA	IND	EST	TEC	UTI
EGY	F23	2	F23	F23	F23	F	F		F		F	F	F	F		F	F	F	F	
SAU	F3		F	F	F3	F				F	F			F			F			
TUN	F3		F2	F3	F						F			F			F			
BRA	F23	F23	F23	F23	F23				F	F	F	F	F	F		F	F		F	F
CAN	F		F23	3	F23	F														
USA	F2		F2	2	F															
AUS	F1	F1	F1	F1	F1	F	F	F												
HKG	F123	F2	F123	F12	F12															
IND	F	3	F23	2																
MYS	F23	F23	F23	F23	F															
NZL	F2	F2	F1	F1	F															
PAK	F3	F3	F3	F3	F3															
SGP	F23	F23	F23	F23	F23															
LKA	F23	F23	F23	F23	F23															
AUT	F2	2	F3	F	3															
BEL	F23		F23	F3																
DNK	F3		F3	F3	F															
FIN	3	2	13	23	F1															
FRA	F123	F12	F123	F23	F12															
DEU	F23	F	F	F23	2															
GRC	F2	F3	F123	F3																
ITA	F23	F2	F23	F23	F3															
NOR	23		123	23	23															
POL	F3	23	F	F23	F2	2														
ESP	F	F	F	F	F															
SWE	F23	F123	123	12	F123	F														
GBR	F3	F12	F3	F3	F123															

NOTES: The presence of a variable in the model for the complete sample is indicated by the letter “F.” Numbers 1, 2, and 3 denote the presence of the variable in the models corresponding to the respective subperiods. The presence of a variable associated with an economic sector indicates the inclusion of its interaction with the DIL variable.

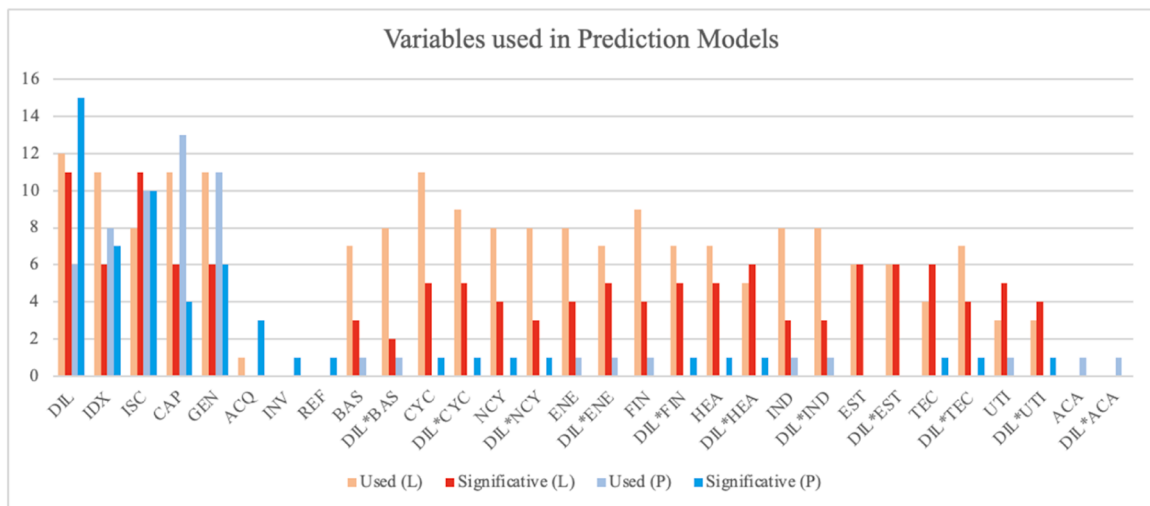


Fig. 5. Variables used in Prediction Models.

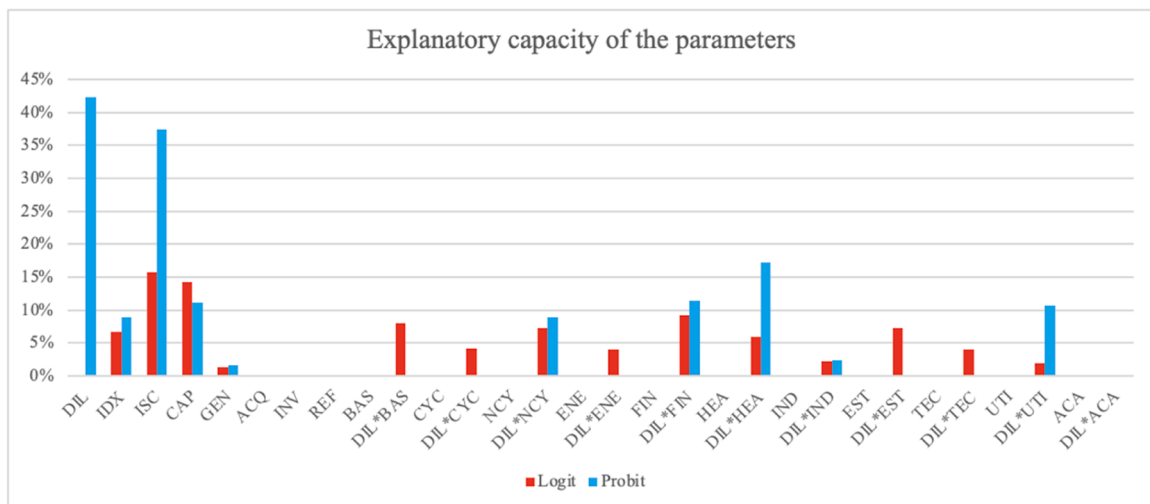


Fig. 6. Explanatory capacity of the parameters.

Table 15

Application of the Arbitrage Strategy on Atari S.A. (April 2022).

ATARI S.A.						Start	23/03/2022	End	04/04/2022
Rights	4	New	1	Notional	0.0100€	Premium	0.1540€	Price	0.1740€
Asset	Position	Volume	Opening			Close			Result
			Price	Fees	Total	Price	Fees	Total	
Rights	Long	40.000	0.0039€	15.00€	171.00€				-171.00€
Stock		10.000	0.01640€	-	1640.00€	0.1865€	15.00€	1850.00€	210.00€
CFD	Short	10.000	0.2072€	5.00€	2072.43€	0.1878€	19.34€	2266.86€	180.90€
	Margin				1000.00€	60.98 %			
Investment	2811.00€	Fees	54.34€	Result	3020.09€	Net Result	209.09€	i_e	12,015.15 %
			1.93 %				7.44 %	i_a	4891.18 %

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Data availability

Data will be made available on request.

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