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Research article

Aftermarket performance of green IPOs and portfolio allocation

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Abstract: This study examines the aftermarket performance of high-green and low-green IPO and how green IPOs can optimize portfolio allocation. We assume the higher level of greenness increases investors' participation in IPOs. To this end, we develop the utility function and determine that investors prefer to participate in new issues when firms account for greenness measures. This study proposes the global aspects of green measure: the desired level of greenness a firm maintains. We find that IPOs in our sample are far below the global standards of greenness. This evidence suggests they must adopt the necessary actions to make the environment green. Another significant contribution of this study is to measure the performance of high and low-green IPOs in short- and long-run horizons. This study reveals that high-green IPOs are less underpriced. This study estimates the effect of greenness on initial returns and finds an inverse relationship suggesting that high-green IPOs are less underpriced due to lower risk associated with new issues. In terms of measuring longer-term performance, this study determines that high-green IPOs underperform less than low-green IPOs.

Keywords: greenness index; IPOs; emissions; global measures of greenness; short- and long-term performance

JEL Codes: G11, G12, G23

1. Introduction

Green finance is a novel concept under which firms can raise funds through different financing instruments with the condition that they will bring greenness into their production facilities (Mumtaz and Smith, 2019). Under the green finance program, green bonds and green IPOs are considered crucial financing instruments for raising funds. This study examines the greenness level of new issues and how it can be attractive if a firm accounts for greenness measures. Ritter (1984) documents that new issues are significantly underpriced. Ritter (1991) found IPO underperformance up to three to five years after listing in terms of longer-term performance. However, the level of underperformance depends on the benchmark index used to compare the IPO returns.

Earlier studies have widely examined how new issues perform in short and long horizons (e.g., Que and Zhang, 2019; Mumtaz and Smith, 2017; Mumtaz et al., 2016a). The performance of new issues varies across markets and time horizons. However, it remains an interesting research area for academics, researchers and policymakers to investigate how new issues behave in short- and longer-term horizons. Due to changes in business patterns, technological advancements, and industrial innovations, the pricing behavior of IPOs has changed over time. Previous studies have identified factors affecting short- and longer-term IPO performance (Que and Zhang, 2019; Mumtaz and Smith, 2017; Ritter, 1991). Anderloni and Tanda (2017) report that initial returns obtainedby green firms are lower than by non-green firms. They find a statistical difference in the behavior of green and non-green firms. In examining long-term performance, green energy firms show a lower performance while testing the determinants; they report that underperformance does not affect green firms. Belghitar et al. (2014) report that green firms do not underperform other firms and have similar or higher returns.

Green finance is crucial in providing funds to renewable and green energy projects to overcome carbon emissions and their adverse health impacts, develop climate-resilient infrastructure for cities and ensure environmental sustainability. In line with the new development of green finance, it is imperative to investigate how IPOs behave in short- and longer-term windows. This study proposes an index that identifies how much emissions a firm creates to examine the greenness of the new issue. We also estimate the global attributes of greenness measures followed by each firm.

This study proposes a theoretical foundation for portfolio allocation and a firm's greenness. This study assumes that the utility function depends on the firm's greenness and the risk-return association. The utility function identifies that the greenness factors of a firm are positively associated with the share of IPO investment. When we increase the layers of risk sensitivity in the utility function, the proportion of investment in new issues decreases. However, by increasing investors' weight, the greenness enhances the share of investment in new issues. Interestingly, we determine the utility function based on the global aspects of greenness factors and determine that the percentage of IPO investment is higher than the measures presently account for firms going public.

This study examines the short and long run performance using the sample of IPOs listed on the Pakistan Stock Exchange (PSX) from 1995 to 2018. To investigate the magnitude of greenness, we consider only those firms involved in industrial production. We use 66 combinations of IPOs divided into high and low green IPOs. We find that the underpricing of low-green IPOs is higher than that of high-green IPOs. Our regression result reports a negative association between a firm's greenness and initial day returns. This study also analyzes the longer-term IPO performance and reports that

high-green IPOs underperform less than low-green IPOs; however, we find no evidence of the statistical significance of the underperformance of low-green IPOs. The results of empirical testing show that high green IPOs underperform less than low-green IPOs. We can infer that the present greenness index does not optimize the portfolio as IPO firms are not considering long-term goals. In this paper, we obtained the desired greenness goals under COP2030 using theoretical and empirical models showing that the desired greenness level can be achieved. By attaining the desired level of greenness, IPO firms and investors may allocate their funds to maximize their earnings.

2. A review of the literature

This section theoretically and empirically reviews the performance of new issues. We split our literary review based on the greenness and portfolio allocation and short-run and longer-term performance based on the greenness of the unseasoned issues.

2.1. Greenness and portfolio allocation

Earlier studies (e.g., Yoshino et al., 2019) proposed a utility function between two assets to construct a portfolio. An investor may keep funds in a bank and participate in Hometown Investment Trust (HIT) funds. They report that risk-averse investors (households) prefer to deposit funds in a bank and restrict investing in HIT funds as they are reluctant to invest in less risky assets. Alternatively, risk-taking investors participate in HIT funds and the utility function becomes flattered. Taghizadeh-Hesary and Yoshino (2019) also investigate how developing Distributed Ledger Technologies (DTLs) based on HIT funds can reduce the probability of risk and increase the return on green projects. Subsequently, they develop a portfolio by supposing households deposit their funds in banks and invest in green funds.

The rationale behind implementing a carbon tax system is to promote and invest in green technologies, thereby making the industrial sector green. Yoshino et al. (2019) consider whether households are risk-averse or risk-taking. If they are risk-averse, households prefer to keep their funds in banks, but if they are risk-taking, the share of investment in green funds increases. Banks and investors are less reluctant to participate due to the higher risks associated with green energy projects. Recently, Taghizadeh-Hesary and Yoshino (2020) contrasted two firms' production functions and profit maximization behavior. They documented that the production facilities of these firms generate emissions and the concerned authorities are required to impose a carbon tax depending on the pollution they create which ultimately affects their profits. In short, this proposition will devise a spillover effect of the green industry in a particular region.

In this modern era, investors participating in new issues are concerned about the risk-return relationship. Green finance emphasizes that a firm intends to float new shares and must adopt measures to reduce carbon emissions. Thus, investors are now concerned about the greenness level of a firm. However, firms' greenness level varies depending on the appropriate measures firms take to make production facilities green. In this case, the utility function of investors of new issues depends on the returns, riskiness associated with new issues and greenness measures followed by firms. In this study, we develop a greenness index that classifies the level of greenness among IPO firms. Suppose the firm

accounts for greenness measures compared to other firms the proportion of its investment increases. Thus, this study proposes a theoretical model that identifies that the green factor positively influences a firm's performance. To extend our analysis, we incorporate different layers of risk sensitivity and investors' weight toward the greenness index.

2.2. Short- and long-run IPO performance

Researchers have identified various reasons that cause the underpricing of unseasoned issues. The "information asymmetry hypothesis" is one of the foremost determinants of positive abnormal returns where information is transmitted differently to two different investors (Rock, 1986). As such, informed investors earn positive abnormal returns by gathering information utilizing their resources. Benveniste and Spindt (1989) proposed the costly information hypothesis where underwriters understate the IPO prices in the wake of extracting private information from subscribers before going public. The "ex-ante uncertainty hypothesis" is another significant predictor of underpricing of new issues (Beatty and Ritter, 1986), which argues that higher uncertainty associated with new issues leads to higher underpricing. Researchers have used various proxies to test that underpricing exists in new issues. Among others, firm and market-related characteristics are essential predictors that influence initial returns. Firm size, financial leverage and listing delay can affect the information asymmetries, which influence the level of underpricing (Ji and Zhang, 2019). Similarly, Anderloni and Tanda (2017) propose that green IPOs and start-ups may affect IPO underpricing. Besides, the innovation level of firms and the underwriters' reputation may also influence the initial returns of new issues (Anderloni and Tanda, 2015).

Previous studies report that IPOs underperform in the long run (see Gompers & Lerner, 2003; Ibbotson and Ritter, 1995). Lyon et al. (1999) document that underperformance depends upon the benchmark used to compare the IPO returns. Earlier studies (Lyon et al., 1999) used various techniques (e.g., cumulative abnormal return, buy-and-hold abnormal return and Fama-French three and four factors models) to gauge the long-term performance. Different hypotheses explain the long-term behavior of IPOs. The fads hypothesis envisages that issuing IPOs does not immediately determine the value of new issues. When new issues are traded on the stock market, the overvaluation represents the abnormal returns investors yield (Aggarwal & Rivoli, 1990). Subsequently, the initial excess returns correct the overpricing, resulting in lower returns in the longer horizon. Miller (1977) reports that the flow of information associated with new issues enters the market, and the expectations will diverge to correct the prices. Another critical hypothesis is the window of opportunity, where new issues are floated during the boom phase to be overvalued over other IPOs. For example, young firms issue their shares without good growth prospects. This overestimation flops to defend the hike in stock prices, which will revert to their actual value in the long run (Loughran and Ritter, 1995). Researchers have used various proxies to examine the long-term IPO performance, including initial returns, momentum, listing delay, firm size, hot IPO activity period, etc. Anderloni and Tanda (2017) examine the effect of green IPOs on longer-term performance and document an insignificant relationship.

2.3. Greenness and IPO performance

The issuance of IPOs is considered one of the essential sources of green finance. Taghizadeh-Hesary and Yoshino (2019) argue that firms prefer to account for greenness factors in their production facilities; as a result, investors choose to participate in those investments. The evidence on analyzing the effect of green IPOs is limited. Anderloni and Tanda (2017) studied the performance of 144 green energy IPOs registered on 13 European stock exchanges from 2000 to 2014. They classify green energy firms operating under alternative energies, while non-green firms utilize oil, gas or traditional energy methods. Green and non-green IPOs are distinguished using a dummy variable. They found that green IPOs are less underpriced than non-green IPOs. Besides the greenness, they reported that size of the firm, waiting time and market returns are the vital factors that influence initial returns. Employing the buy-and-hold abnormal returns (BAHR), they determined mixed results. The underperformance of green firms is higher than non-green for the first two years; however, green IPOs outperform in the third year of analysis. Using the Fama-French model, they determine an insignificant relationship between the returns of portfolios and green IPOs.

When a firm is going public, it is important to examine its level of greenness and how it affects the short- and long-run. This study proposes a greenness index that helps measure the greenness among IPO firms. Based on this index, we examine the short- and long-term behavior between high and low green IPOs.

3. Theoretical model

3.1. Risk, return, and the greenness of IPOs

Previously, the utility function of investors was the combination of risk and return. However, over time, the dynamics of businesses have tremendously changed, ultimately affecting the overall environment. To cope with this problem, firms are following appropriate measures to prevent the emissions from making the environment green. However, the level of greenness varies across firms. We assume that higher emissions will lead to lower investment in green IPOs. To consider this hypothesis, the utility function is based on the return, riskiness attached to new issues, and the greenness factors followed by a firm (Yoshino et al., 2020). In this study, we measure the greenness of IPOs, which is a crucial component of raising funds under green finance. The utility function is, therefore, written as:

$$U = R_t - \beta\sigma_t^2 + \gamma Green_t \tag{1}$$

where R_t is the rate of return obtained from the purchase of IPOs, σ_t^2 is the risk associated with IPOs, and $Green_t$ gauges the degree of the greenness of IPOs. β indicates the sensitivity of risk, and γ shows the investor's weight towards greenness compared to the risk and return. To develop the portfolio of new issues, investors purchase IPOs and the rate of return of the portfolio (R_t) is computed as:

$$R_t = \alpha R_{A_t} + (1 - \alpha) R_{B_t} \tag{2}$$

In Equation (2), α refers to the investment proportion in the firm "A" and $(1-\alpha)$ shows the investment proportion in the firm "B". R_{A_t} and R_{B_t} determine the rate of returns of green IPOs A and B. The aggregate risk of the portfolio is described as:

$$\sigma_t^2 = \alpha^2\sigma_{A_t}^2 + (1-\alpha^2)\sigma_{B_t}^2 + 2\alpha(1-\alpha)\sigma_{AB_t} \tag{3}$$

where $\sigma_{A_t}^2$ and $\sigma_{B_t}^2$ indicate the proportion of sensitivity of green IPOs A and $(1-\alpha^2)$ shows the proportion of green IPOs B. $\sigma_{A_t}^2$ and $\sigma_{B_t}^2$ are the risk associated with green IPOs A and B, and σ_{AB_t} represents the covariance. The variance and covariance are calculated as follows:

$$\sigma_{A_t}^2 = E\left(R_{A_t} - \bar{R}_{A_t}\right)^2$$

$$\sigma_{B_t}^2 = E\left(R_{B_t} - \bar{R}_{B_t}\right)^2$$

$$\sigma_{AB_t} = E\left(R_{A_t} - \bar{R}_{A_t}\right)\left(R_{B_t} - \bar{R}_{B_t}\right)$$

This study measures the greenness of unseasoned issues. At present, investors participate in firms emphasizing reducing carbon emissions. To do this, Equation (4) estimates the greenness factor relating to IPOs A and B. α and $(1-\alpha)$ are the share of the green factor relating to firms A and B (Mumtaz and Smith, 2022).

$$Green_t = \alpha IPO_{A_t} + (1-\alpha)IPO_{B_t} \tag{4}$$

This study proposes measuring the firm's greenness (GHG emissions divided by net sales). The emissions include CO_2, N_2O and CH_4 and this indicator is known as the proportion of emissions relative to the firm's net sales. A higher value (-x) indicates a higher proportion of emissions to sales, leading to higher emissions produced. We propose the following model to capture the greenness:

$$IPO_A = \frac{-a_1(CO_2) - a_2(N_2O) - a_3(CH_4)}{Y_A} \tag{5}$$

$$IPO_B = \frac{-b_1(CO_2) - b_2(N_2O) - b_3(CH_4)}{Y_B} \tag{6}$$

To maximize Equation (1) which is subject to Equations (2)–(4), we get:

$$\frac{\partial U}{\partial \alpha} = \left(R_{A_t} - R_{B_t}\right) - \beta\left(2\alpha\sigma_{A_t}^2 + 2\alpha\sigma_{B_t}^2 - 4\alpha\sigma_{AB_t} + 2\sigma_{AB_t} - 2\sigma_{B_t}^2\right) + \gamma(IPO_A - IPO_B) \tag{7}$$

To determine the proportion of investment in green IPOs, we assume that a firm accounts for or does not consider the greenness factors. If we suppose that a firm does not consider the greenness factor, the participation of investment is expressed as:

$$\alpha_t = \frac{\frac{1}{\beta}\left(R_{A_t} - R_{B_t}\right) - \left(2\sigma_{AB_t} - 2\sigma_{B_t}^2\right)}{\left(2\sigma_{A_t}^2 + 2\sigma_{B_t}^2 - 4\sigma_{AB_t}\right)} \tag{8}$$

where R_{A_t} and R_{B_t} indicate the returns of green IPOs A and B respectively. $\sigma_{A_t}^2$ and $\sigma_{B_t}^2$ show the riskiness associated with green IPOs A and B respectively, and σ_{AB_t} denotes the covariance. Equation (9) suggests the proportion of investment in IPOs considering the greenness factors by a firm.

$$\hat{\alpha}_t = \frac{\frac{1}{\beta}(R_{A_t} - R_{B_t}) - (2\sigma_{AB_t} - 2\sigma_{B_t}^2) + \frac{\gamma}{\beta}(IPO_A - IPO_B)}{(2\sigma_{A_t}^2 + 2\sigma_{B_t}^2 - 4\sigma_{AB_t})} \tag{9}$$

Equations (8) and (9) distinguish between the proportion of investment without and with greenness factors of IPOs. where β shows the risk sensitivity associated with green IPOs and γ refers to investors' weights for the greenness of new issues. We further presume that if a firm accounts for the reduction in emissions, the participation in respective IPOs would be higher.

3.2. The global aspect of the portfolio allocation

This study considers the portfolio allocation's global elements, which are consistent with COP2030. The magnitude of emissions varies across markets; therefore, every country has to set the desired reduction in emissions. The global aspect of the greenness factor by IPO firms can be estimated as:

$$IPO_t^* = \frac{-w_1(CO_2) - w_2(N_20) - w_3(CH_4)}{Y_t} \tag{10}$$

where w_1, w_2, and w_3 are the weights of emissions produced by CO_2, N_20 and CH_4 respectively. Y indicates the output level (i.e. GDP). IPO_t^* indicates the required level of decline in emissions of IPO firms. According to COP2030, every country is responsible for implementing measures to reduce greenhouse gas emissions.

$$\delta_A = \frac{IPO_{A_t}}{IPO_t^*} \tag{11A}$$

$$\delta_B = \frac{IPO_{B_t}}{IPO_t^*} \tag{11B}$$

where δ_A and δ_B show the gaps between the current level of greenness and the desired level of greenness.

$$\alpha^* = \frac{\frac{1}{\beta}(R_{A_t} - R_{B_t}) - (2\sigma_{AB_t} - 2\sigma_{B_t}^2) + \frac{\gamma}{\beta}(\delta_A - \delta_B)}{(2\sigma_{A_t}^2 + 2\sigma_{B_t}^2 - 4\sigma_{AB_t})} \tag{12}$$

Equation (12) demonstrates the investment share in new issues incorporating the portfolio allocation's global aspects. To discuss these scenarios, this study plots different combinations to identify the influence of greenness on the proportion of investment in IPOs. When $\gamma = 0$, then it is the same case as Equation (8).

3.3. Measuring the short-run IPO performance

We measure the short-run performance on the listing day, first week, and month. This study follows the methodology where the market-adjusted abnormal returns are obtained through initial returns after adjusting the market returns (Mumtaz et al., 2016a) and is computed as:

$$Return_{i,t} = \left[\frac{(1+R_{i,t})}{(1+R_{m,t})} - 1\right] x\ 100 \tag{13}$$

where $R_{i,t} = \left(\frac{P_{i,t}}{P_{i,0}} - 1\right)$, $R_{i,t}$ and $P_{i,t}$ are the return and price of stock i at time t and $P_{i,0}$ is the offer price of stock i. $R_{m,t} = \left(\frac{I_{i,t}}{I_{i,0}} - 1\right)$, $R_{m,t}$ is the market return at time t, $I_{i,t}$ is the market index (KSE-100) at time t of stock i, and $I_{i,0}$ is the market index on the offering date of stock i.

3.4. Examining the factors that influence the short-run IPO performance

This study empirically examines how the greenness level influences short-run IPO performance. To test this proposition, we develop the following expression:

$$Return_i = \alpha_0 + \alpha_1 Greenness_i + \alpha_2 Risk_i + \alpha_3 Size_i + \alpha_4 FinLev_i + \alpha_5 Startup_i + \alpha_6 OSize_i + \alpha_7 ListingDelay_i + \alpha_8 Price\ Discovery_i + \alpha_9 Hot_i + \alpha_{10} MarketReturn_i + \varepsilon_i \tag{14}$$

where $Return_i$ is the market-adjusted abnormal returns. $Greenness_i$ is estimated using the proposed index. A lower value of greenness $(-x)$ means that a respective sector creates lower emissions. $Risk_i$ shows the standard deviation of post-issue pricing of the first 30 trading days, $Size_i$ is the logarithm of total assets, $FinLev_i$ is the total debt by total assets, $Startup_i$ is a dummy variable (a firm that issues an IPO within five years of its establishment. = 1, 0 otherwise), $OSize_i$ is the logarithm of offer size, $ListingDelay_i$ is the difference between subscription and listing date, $Price\ Discovery_i$ is a dummy variable (book building mechanism = 1, and fixed offer price = 0), Hot_i is a dummy variable (issuance of IPO in a hot period = 1, 0 otherwise) and $MarketReturn_i$ represents the KSE-100 value-weighted index over 45 trading days before going public.

3.5. Measuring the longer-term IPO performance

We estimate the abnormal returns for 3-years starting from the closing price on the first day of trading (Lyon et al., 1999). The BHAR for firm i at time t adjusted by the benchmark index is measured as (Berk and Peterle, 2015):

$$BHAR_{i,t} = \left[\prod_{t=1}^{T}(1 + R_{i,t}) - \prod_{t=1}^{T}(1 + R_{mkt,t})\right] \tag{15}$$

where $R_{i,t}$ is the monthly return of firm i at time t and $R_{mkt,t}$ is the return of the benchmark index (KSE-100) over the corresponding period. The equal-weighted BHAR is measured as = $\frac{1}{n}\sum_{i=1}^{n} BHAR_{i,t}$.[1]

3.6. Determinants that affect the longer-term IPO performance

This study also determines the factors that affect longer-term IPO performance; thus, we propose the following model:

$$BHAR_i = \alpha_0 + \alpha_1 Greenness_i + \alpha_2 LT_i + \alpha_3 Initial\ returns_i + \alpha_4 Risk_i + \alpha_5 Size_i + \alpha_6 Startup_i + \alpha_7 ListingDelay_i + \alpha_8 Price\ Discovery_i + \alpha_9 Hot_i + \alpha_{10} MarketReturn_i + \varepsilon_i \quad (16)$$

where $BHAR_i$ represents the three-year equal-weighted buy-and-hold abnormal returns, LT_i is the long-term investment ratio measured through long-term investment divided by total assets, and $Initial\ returns_i$ is the market adjusted-abnormal returns on the first trading day.

4. Sample and data

To examine the magnitude of the greenness of IPO firms, we classify GHG emissions produced by different sectors (Mir et al., 2017). Table 1 presents sector-wise information on emission categories along with GHG emissions. Due to the paucity of information, it is difficult to determine the emissions produced by a firm going public; therefore, we employ the data produced by the respective sector in which a firm operates (Mir et al., 2017). We compare two IPO firms operating in different sectors to contrast different emissions levels produced for examining the utility function.

[1] The significance of buy-and-hold abnormal returns is tested using the skewness adjusted t-statistics (Lyon et al., 1999): $t = \sqrt{n}\, x\, (S + \frac{1}{3}\hat{\gamma}S^2 + \frac{1}{6}\hat{\gamma})$ where $S = \frac{\overline{BHAR_t}}{\sigma(BHAR_t)}$ and $\hat{\gamma} = \frac{\sum_{i=1}^{n}(BHAR_i - \overline{BHAR_t})^3}{n\sigma(BHAR_t)^3}$ where $\sigma(BHAR_t)$ is the cross-sectional sample standard deviation of abnormal returns, n is the number of IPO firms, and $\hat{\gamma}$ is an estimate of the coefficient of skewness.

Table 1. Sectoral classification for GHG emissions inventory in all sectors.

Sector	Emission category		GHG gases
Energy	Electricity generation		CO_2
	Manufacturing industries		CO_2, CH_4
	Transport	Road, Rail, Aviation, Navigation	CO_2, CH_4
	Other sectors	Residential, Commercial, Agri./fisheries	CO_2, CH_4, N_2O
	Fugitive	Coal and mining, Oil and natural gas	CH_4
Industrial processes	Minerals	Cement, limestone, dolomite, soda ash, ceramics	CO_2
	Chemicals	Ammonia, nitric acid, carbonates, others	
	Metals	Iron, aluminum, magnesium, lead, steel, zinc	
Agriculture		Electric fermentation, Manure management	CH_4
		Agricultural soils	N_2O
Land use and forestry		Changes in forest and other woody biomass stocks	CO_2
Waste		Solid waste disposal, waste water handling	CH_4, N_2O

Source: Mir et al. (2017).

This study estimates the behaviour of IPOs in short and long horizons using the greenness index from 1995 to 2018. Using the IPO prospectus and annual reports, we gather firm-related characteristics. Market-related data and stock prices are extracted from the Pakistan Stock Exchange (PSX) database. To analyze the effect of greenness on IPO returns, we exclude the financial and service industries from the sample to consider only those firms that are directly and indirectly involved in polluting the environment. This study compares firm A greenness level with firm B.

5. Results

5.1. Examining the level of the greenness of new issues

We measure the level of the greenness of new issues using $\frac{-a_1(CO_2)-a_2(N_2O)-a_3(CH_4)}{Y}$. where CO_2, N_2O, and CH_4 are the emissions produced in the relevant sector and Y refers to the revenues. The sample includes only those firms which are involved in industrial activities. Figure 1 exhibits the

greenness of IPO firms. We differentiate high and low-green IPOs based on the green and red colors respectively. The results suggest a higher level of green firms went public after 2008. This indicates that debuting firms are more concerned about adopting green measures to overcome the emissions level. However, other firms show a low level of greenness as they produce a higher emission.

5.2. Measuring the risk, return, and greenness of IPOs

This section empirically investigates the utility function of IPOs using the riskiness, return, and greenness index. To gauge the IPO abnormal returns, this study employs the cumulative abnormal return (CAR) technique (Mumtaz, et al., 2016b; Lyon et al., 1999) where the returns are cumulative for one month from the listing. To contrast the average return of firm A with firm B we formulate 33 combinations of IPOs to compare investment participation in firm A and firm B.

To determine the utility function, we develop the investment share in firm A without the greenness measures ($\alpha_t = \frac{\frac{1}{\beta}(R_{A_t} - R_{B_t}) - (2\sigma_{AB_t} - 2\sigma_{B_t}^2)}{(2\sigma_{A_t}^2 + 2\sigma_{B_t}^2 - 4\sigma_{AB_t})}$) where R_{A_t} and R_{B_t} are the average returns of firm A and B. β denotes the sensitivity of risk and $\sigma_{A_t}^2$ and $\sigma_{B_t}^2$ are the variances of the returns of the firm A and firm B. and σ_{AB_t} shows the covariance between firm A and firm B. The utility function is also formulated by incorporating greenness measures to account for the IPO firms ($\hat{\alpha}_t = \frac{\frac{1}{\beta}(R_{A_t} - R_{B_t}) - \left(2\sigma_{AB_t} - 2\sigma_{B_t}^2\right) + \frac{\gamma}{\beta}(IPO_A - IPO_B)}{\left(2\sigma_{A_t}^2 + 2\sigma_{B_t}^2 - 4\sigma_{AB_t}\right)}$) where γ shows investors weight for the greenness of new issues and IPO_A and IPO_B indicate the greenness level of firm A and B which are computed as $\frac{-a_1(CO_2) - a_2(N_2O) - a_3(CH_4)}{Y}$ where CO_2, N_2O and CH_4 represent the emissions produced by IPO firm and Y is the net sales of a firm going public. This study proposes the utility function by encompassing the global aspects of the greenness measures and proportion of investment is expressed as $\alpha^* = \frac{\frac{1}{\beta}(R_{A_t} - R_{B_t}) - (2\sigma_{AB_t} - 2\sigma_{B_t}^2) + \frac{\gamma}{\beta}(\delta_A - \delta_B)}{(2\sigma_{A_t}^2 + 2\sigma_{B_t}^2 - 4\sigma_{AB_t})}$ where $(\delta_A - \delta_B)$ shows the difference between δ_A and δ_B which are obtained by actual greenness to global greenness measures. The global aspect of greenness factors can be estimated as: $IPO_t^* = \frac{-w_1(CO_2) - w_2(N_20) - w_3(CH_4)}{Y}$ where w_1, w_2 and w_3 are the proportion of emissions produced by CO_2, N_2O and CH_4 in a country and Y is the total output.

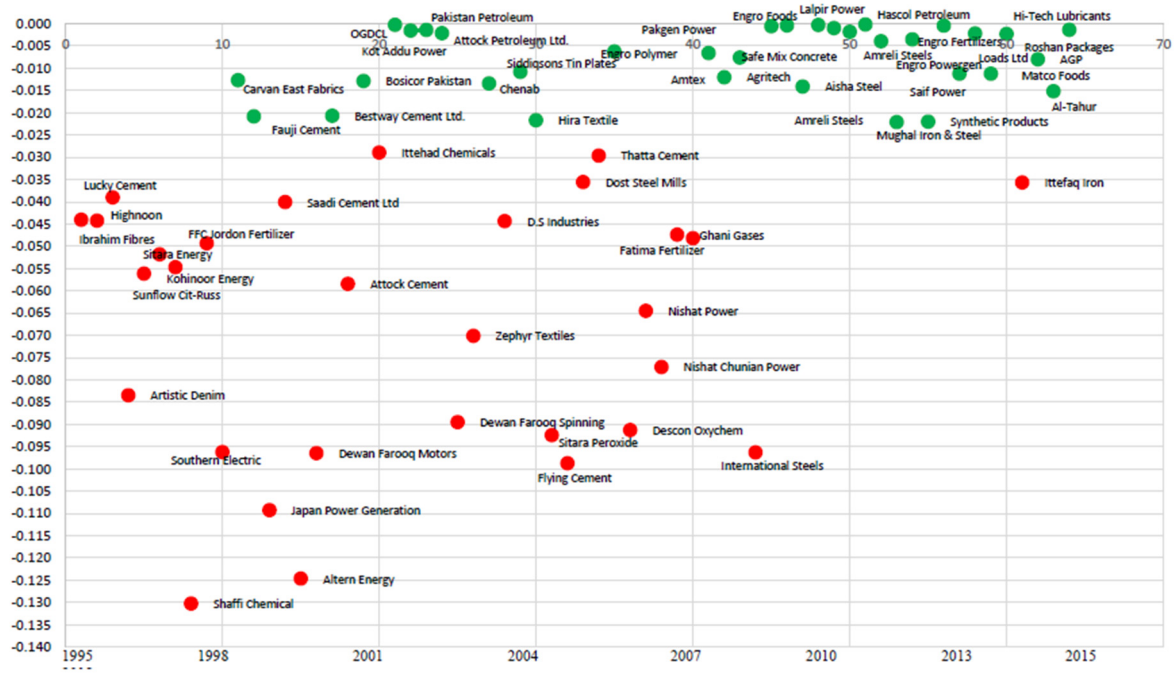

Figure 1. Greenness level of IPO firms.

We report that the average cumulative abnormal returns of 33 firms A and B combinations are 13.41% and 17.44% respectively. The variance of σ_A^2 is 7.22% and σ_B^2 is 12.31%. Table 2 presents the proportion of investment in IPOs using different levels of risk sensitivity. If $\beta = 0.5$, then $\alpha = 0.58$ (ignoring the greenness measures) explains that participation in investment in firm A is 58%, and firm B $(1 - \alpha)$ is 42%. Considering the greenness measures, the level of participation in firm A increases $(\acute{\alpha} = 0.68)$, which elaborates that the investor is concerned about the green standards a firm follows. In this study, we assume that the global greenness factor refers to the anticipated firm's greenness, which results from surging in the share of investment in the firm A i.e., $\alpha^* = 0.81$. This suggests that if a firm accounts for the desired greenness, the investment participation in firm A jumps to 81%. This evidence indicates that a firm is required to achieve the desired level of global measures of greenness, which seems favorable for investors; as a result, investment participation in new issues increases.

Table 2. Estimating the greenness level of IPOs using different layers of risk sensitivity.

β	α	$\acute{\alpha}$	α^*
0.5	0.58	0.68	0.81
1.0	0.48	0.54	0.59
1.5	0.44	0.47	0.51
2.0	0.41	0.45	0.48

Notes: This table presents the greenness of IPOs using different layers of risk sensitivity. α shows the proportion of investment in IPO_A without the greenness factors, $\hat{\alpha}$ accounts for the greenness factors and α^* captures the global aspect of greenness.

When we increase the level of risk sensitivity ($\beta = 1.0$), the share of investment in firm A is 0.48 in the non-existence of greenness factors. This implies that an increase in the sensitivity of risk level reduces the share of investment in IPOs. If a firm accounts for the greenness proposition, the share of firm A surges to 54%, and with the desired level of global greenness measures, the percentage of firm A becomes 59%. The results suggest that firm A increased risk sensitivity is still attractive as the share of firm A is higher than firm B. We further increase the risk sensitivity ($\beta = 1.5$), the percentage investment in firm A decreases to 44%, 47% and 51% in terms of non-greenness, greenness, and global measures of greenness respectively. With an increase in risk sensitivity, the evidence confirms that the share of firm B is higher than firm A. When $\beta = 2.0$, the share of investment in firm A decreases. Considering the greenness factor, firm A participation decreases to 41%. At this point, the percentage of investment in firm B is higher (59%). With the global measures of greenness, the share of investment in firm A is 45% which shows that it is less attractive when the risks associated with new issues increases.

Table 3. Estimating the level of the greenness of IPOs using investors' weights of greenness.

γ	$\hat{\alpha}$	α^*
0.5	0.19	0.42
1.0	0.25	0.44
1.5	0.30	0.45
2.0	0.34	0.46

Notes: This table presents the greenness level of IPOs using investors' weights of greenness. $\hat{\alpha}$ shows the proportion of investment in firm A covering the greenness factors, and α^* captures the global measure of greenness.

This study also captures the IPO greenness using different investors' weight of greenness to examine the share of investment in firm A. We control the sensitivity of risk ($\beta = 2.0$) in all the cases. When investors' greenness (γ) weight is 0.5, the share of investment in firm A is just 19%. This low level of participation of IPOs in firm A is attributed to a lesser proportion of greenness considered by a firm. If the level of greenness remains the same, we report that the global measure of greenness representing IPO_A is 42% higher than the current form of greenness that firms consider. When investors increase the weight of greenness to 1.0, the share of investment increases to 25%. Likewise, the participation of IPOs increases when the firm A considers the desired level of global measures of greenness. If the weight of greenness is 1.5, the share of IPOs investment in firm A is 30%; however, the percentage marginally increases to 45% when the firm considers the desired level of global aspects of greenness measures. If $\gamma = 2.0$, the share of investment in firm A gradually increases. When the proportion of greenness increases, it will enhance participation in IPO investment. However, with an increase in the weight of greenness, the proportion of investment slightly increases when a firm meets the desired level of global measures. This may happen as the desired level of global greenness based on the prevailing environment in the respective country is then adjusted with a magnitude of greenness considered by a firm. In short, we can infer from the results that investment participation in new issues increases if investors account for the weights of greenness. However, risk sensitivity is another important predictor in determining the participation of IPOs. If the sensitivity of risk increases, it reduces investment participation in IPOs.

5.3. Graphical representation of the risk, return, and greenness of IPOs

This study graphically presents the utility function covering the return, risk, and IPO greenness. To plot the utility function, the returns (R) of IPOs are shown on the y-axis. Standard deviation (σ) is indicated on the right side and the greenness factor ($Greenness$) is plotted on the left side.

To compare the IPO returns, this study constructs 33 combinations assuming that both firms are operating in different sectors. To estimate the returns of IPOs, this study employs the cumulative abnormal returns (CAR) approach. We measure the CAR for one month from the listing date and then take the average of 33 combinations. The CARs of R_{IPO_A} and R_{IPO_B} are 17.49% and 13.41% respectively. The variance of $\sigma^2_{IPO_A}$ and $\sigma^2_{IPO_B}$ is 12.31% and 7.22% respectively.

Figure 2 demonstrates the utility function under different scenarios using the risk sensitivity (β) of 0.5. First, we estimate the utility function $U = R_t - \beta\sigma_t^2$ using returns and risks associated with IPOs. This utility function is shown by a red line which demonstrates that investors purchase a 58% share of firm A and a 42% share of firm B. Second, we estimate the utility function, $U = R_t - \beta\sigma_t^2 + \gamma(Green_t)$ by incorporating the greenness measures taken by IPO firms. We identify that greenness factors positively influence the participation of IPOs and, as a result, the utility function shifts downward, which can be reflected by a blue line. In this case, investors prefer to participate in a 68% share in firm A and a 32% share of firm B. Furthermore, we find that firm A is more concerned about the greenness factors into their production facilities than firm B.

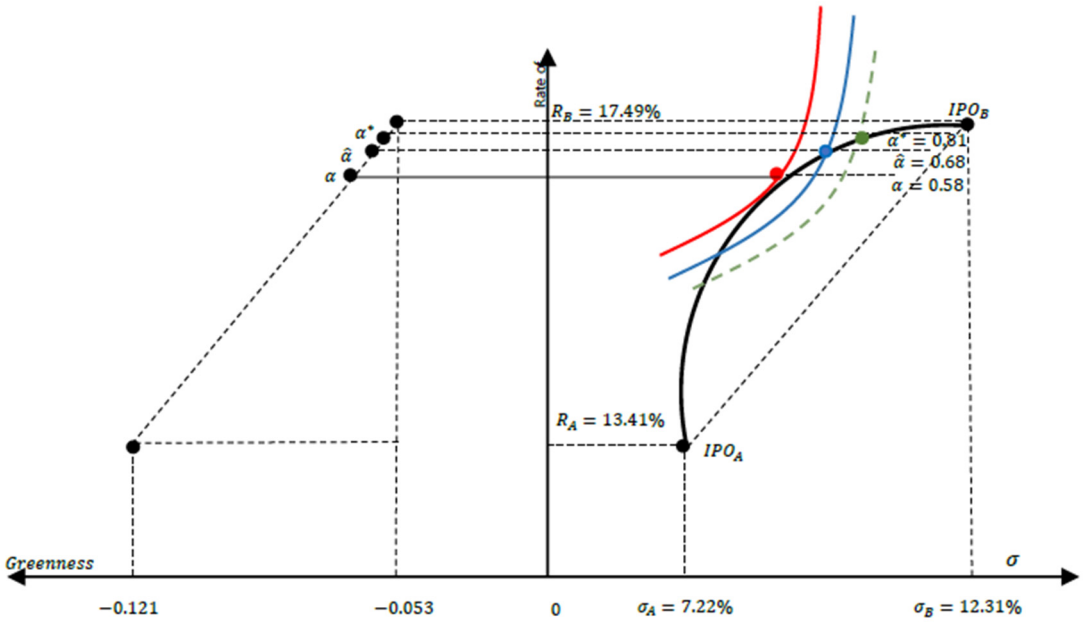

Figure 2. Risk, return, and greenness of IPOs $\{U = R_t - \beta\sigma_t^2 + \gamma(Green_t)\}$.

In this study, we formulate the global aspects of greenness which depends on reducing emissions. We estimate it as follows. $IPO^* = \frac{-w_1(CO_2)-w_2(N_20)-w_3(CH_4)}{Y}$. where IPO^* is the anticipated decrease in emission level and w_1, w_2 and w_3 are the weight of emissions produced by a country. Y refers to

the output of the country. Third, we examine the utility function by adding the global greenness measures and report that the utility function further moves downward (α^*). This refers to the desired level of greenness measure which is required to be followed by firm A. By achieving the desired greenness level, firm A investment share increases to 81%. However, the difference between α^* and $\hat{\alpha}$ is 13% which illustrates that firm A needs to be emphasized to achieve α^*. The particular illustration is structured based on the sensitivity of risk equaling 0.5. Suppose we increase the risk sensitivity, and the investment in firm A decreases. Likewise, if investors' weight for the greenness measure (γ) increases, the respective IPOs become more favorable for investment.

We can conclude by incorporating greenness parameters by a firm, and the utility function moves downward which shows a good omen for investors and the participation in green IPO rises. IPO^* denotes the reduction in the desired emissions level fixed by every country. By comparing α^* and $\hat{\alpha}$, we determine the potential to decrease emissions levels. In a nutshell, if IPO firms follow green measures, they will contribute less emissions, thereby enhancing the value of green IPOs.

5.4. Short-run performance: high versus low green IPOs

This study estimates the short-run IPO performance over one month from the listing date (Table 4). On the first trading day, IPOs are underpriced by 19.92% on average. However, if investors hold IPOs for one week and one month, they can obtain a marginal increase in return of 20.97% and 22.82% respectively. We split new issues into high and low green IPOs based on the median value and examine how they behave in the short run.

The results report that, on average, investors of high-green IPOs earn 18.69% which is less than the returns of the entire sample. This illustrates that high-green IPOs are less risky, yielding lower returns than the entire sample. Returns of high green IPOs increase to 19.81% and 21.73% for one week and one month respectively. This suggests that share prices of high green IPOs increase after the listing illustrating that investors observe the firm's greenness positively and tend to invest in new issues. On average, low-green IPOs obtain 21.15% on the first trading day, which is higher than the returns of high-green IPOs. This attributes to a higher level of riskiness associated with low green IPOs. When investors hold those issues over a month, their returns increase; however, the returns of low green IPOs are higher than those of high green IPOs in all event windows.

Table 4. Short-run performance: high versus low green IPOs.

Trading	Sample	(*t*-stat)	High Green	(*t*-stat)	Low Green	(*t*-stat)
one-day	19.92%	(3.03)***	18.69%	(2.36)**	21.15%	(2.00)*
one-week	20.97%	(3.23) ***	19.81%	(2.94)**	22.13%	(2.05)*
one-month	22.82%	(3.41) ***	21.73%	(3.09)***	23.89%	(1.81)*

Notes: This table displays the market-adjusted abnormal returns of 66 IPOs measured on the first trading day, first week, and month listed on the PSX during the period lasting from 1995 to 2018. ***, **, and * show significance at the 1, 5, and 10% levels.

5.5. Greenness and short-run IPO performance

We split our regressions based on (a) the greenness factor developed in Section 3.1, and (b) a dummy variable (classifying the sample into high and low-green IPOs based on the greenness index to examine the relationship. The proposed index of greenness reports negative values $(-x)$. A higher greenness index $(1/x)$ indicates lower emissions produced by a firm and vice versa. To create positive greenness values and examine the effect of short-run performance, we use the greenness index as $1/x$.

Table 5 exhibits the impact of IPO greenness on short-run performance. We employ the weighted least squares (WLS) method to resolve this issue to conduct our analysis. We estimate our results using the ordinary least square (OLS) technique and find the existence of heteroskedasticity in the data. The results of Model (1) – (4) are obtained using the greenness factor $(1/x)$. Model (1) suggests that the coefficient of greenness is negative and significant at 1%. This evidence argues that firms achieving higher greenness negatively affect the market, and investors obtain lower abnormal returns due to the lower risk associated with non-compliance with green standards. We include other explanatory variables to examine their effect and the greenness factor on initial returns. In Model (2), the greenness index seems a statistically significant contributor to initial returns. The risk variable positively influences the listing day returns, which explains that higher post-issue pricing fluctuations result in higher abnormal returns (Mumtaz and Smith, 2017). We also find that financial leverage positively affects initial returns, implying that higher leverage creates risk and investors demand higher returns (Wahid, Mumtaz, and Mantell, 2020). This evidence corroborates with an ex-ante uncertainty hypothesis. However, the firm size and start-up are insignificant variables in our analysis.

For model (3), we incorporate offer characteristics to analyze the effect on initial returns. We determine that the significance of the greenness factor deteriorates to 5%, indicating that the inclusion of offer characteristics diminishes the importance of greenness. The result identifies a direct association between listing delay and initial returns, demonstrating that a higher number of days in listing a firm on the stock market creates uncertainty and investors yield positive abnormal returns. The offer size and price discovery mechanism are insignificant determinants affecting initial returns. We add economic conditions factors in Model (4) and report that market returns positively affect IPO initial returns. This evidence suggests that market sentiments before issuing IPOs increase the market price of new issues, thereby obtaining higher initial returns (Lowry et al., 2010). In this model, the significance of the greenness factor decreases to a 10% level; however, it is still a vital parameter of initial returns.

Models 5–8 show the results of the greenness index used as a dummy variable to examine the influence of IPO greenness on listing day returns. We find that the greenness factor is an essential determinant of initial returns (Model 5), suggesting that firms adopt greenness measures to make the environment green and investors participate in new issues to earn lower abnormal returns owing to lower risks. We include firm-related characteristics in Model (6) and determine that the coefficient of the firm's size negatively influences initial returns, indicating that large firms are less risky; thus, initial returns of IPOs would be lower. The coefficient of the start-up variable inversely affects listing day returns, meaning that firms issuing their shares during the first five years of their operations obtain lower returns. Model (7) reports that offer size negatively affects initial returns. This evidence confirms that a firm offers a higher proportion of shares to investors; they attract higher offer prices, eventually

lowering the initial returns. The listing delay and price discovery mechanism are insignificant factors. Model (8) determines that market return is a statistically significant determinant of initial returns.

Table 5. Effect of greenness on short-run IPO performance.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Constant	0.465*	0.311	–0.511*	–0.453	0.232	–0.410***	–0.312***	–0.336***
	(0.261)	(0.356)	(0.292)	(0.329)	(0.376)	(0.052)	(0.047)	(0.051)
Greenness	–0.112***	–0.089***	–0.042**	–0.039*	–0.310***	–0.210**	–0.211**	–0.166*
	(0.006)	(0.016)	(0.019)	(0.021)	(0.025)	(0.086)	(0.096)	(0.084)
Risk		0.311***	0.316***	0.281***		0.356***	0.339***	0.299***
		(0.039)	(0.038)	(0.041)		(0.038)	(0.040)	(0.041)
Size		–0.149	–0.191	–0.211		–0.310***	–0.063	–0.050
		(0.115)	(0.172)	(0.189)		(0.049)	(0.040)	(0.037)
Financial leverage		0.164*	0.242**	0.218***		0.453***	0.395***	0.338***
		(0.093)	(0.090)	(0.089)		(0.079)	(0.071)	(0.075)
Start-up		0.069	–0.127	–0.192*		–0.184*	–0.121	–0.172
		(0.066)	(0.095)	(0.118)		(0.107)	(0.103)	(0.108)
Offer size			–0.375	–0.310			–0.116**	–0.079
			(0.252)	(0.246)			(0.058)	(0.058)
Listing delay			0.092***	0.079***			0.073	0.036
			(0.032)	(0.031)			(0.118)	(0.115)
Price discovery			–0.469	–0.125			–0.387	–0.231
			(0.429)	(0.421)			(0.294)	(0.419)
Hot IPO activity				0.132				0.212
period				(0.364)				(0.319)
Market returns				0.135*				0.139*
				(0.069)				(0.071)
Adj-R^2	0.798	0.895	0.884	0.921	0.756	0.903	0.924	0.926
F-value	265.67***	134.79***	119.21***	89.45 ***	176.21***	131.94***	121.32***	89.11***

Notes: Model (1)–(4) show the results of the greenness index and Model (5)–(8) present the findings of greenness index used as a dummy variable. Standard errors are reported in parentheses. ***, **, and * show significance at 1, 5, and 10%, respectively.

5.6. Longer-term performance: high-versus low-green IPOs

This study compares the IPO's returns with the benchmark (KSE-100) index and determines whether IPOs under or overperform (Mumtaz et al., 2016b). We employ BHAR to investigate long-term IPO performance. The findings of the equal-weighted BHARs of 66 IPOs using the benchmark index are presented in Table 6. We report that IPOs underperform in all event windows compared to the benchmark index. Over the three years, IPOs underperform by 29.28% which is significant at 1%. We classify high- and low-green IPOs based on the median value. The results suggest that high-green IPOs, on average, underperform by 27.34% at the end of three years. However, no underperformance is found over one- and two-year periods. On the other hand, low-green IPOs underperform more than high-green IPOs but have no statistical significance in all cases.

Table 6. Longer-term performance: high-versus low-green IPOs.

Year	Overall sample	$t(BHAR_T)$	High Green	$t(BHAR_T)$	Low Green	$t(BHAR_T)$
1	–6.76%	(–0.70)	–4.14%	(–0.15)	–10.01%	(–0.29)
2	–12.08%	(–1.32)	–3.53%	(–0.87)	–26.63%	(–0.97)
3	–29.28%	(–14.27)***	–27.34%	(–7.31)***	–31.60%	(–0.15)

Notes: This table reports the equal-weighted BHAR of 66 IPOs from 1995 to 2018. $t(BHAR_T)$ shows the skewness-adjusted t-statistics. *** shows the significance at the 1% level.

5.7. Greenness and longer-term IPO performance

Table 7 reports the results of greenness index and long-term IPO performance. We use the greenness index as $1/x$. Model (1) suggests that greenness negatively influences longer-term IPO underperformance. This implies that firms looking for greenness factors perform better in the long run.

Table 7. Effect of greenness on longer-term IPO performance.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Constant	–0.500***	0.170	0.331	0.262	–0.316*	–0.124	–0.135	–0.197
	(0.114)	(0.149)	(0.221)	(0.223)	(0.175)	(0.151)	(0.255)	(0.290)
Greenness	–0.060***	–0.059***	–0.062***	–0.062***	–0.046	–0.497*	–0.498*	–0.463*
	(0.012)	(0.013)	(0.013)	(0.013)	(0.247)	(0.268)	(0.271)	(0.256)
Long-term		–0.394**	–0.320	–0.369		–0.797**	–0.791**	–0.823**
investment		(0.196)	(0.263)	(0.263)		(0.347)	(0.352)	(0.382)
Initial returns		–0.254*	–0.209	–0.256*		–0.385*	–0.379*	–0.417*
		(0.146)	(0.244)	(0.150)		(0.223)	(0.215)	(0.244)
Risk		0.087***	0.080***	0.081***		0.117***	0.117***	0.119***
		(0.029)	(0.029)	(0.028)		(0.041)	(0.040)	(0.040)
Size		–0.105	–0.140*	–0.108		–0.041	–0.041	–0.069
		(0.071)	(0.079)	(0.082)		(0.072)	(0.076)	(0.081)
Start-up		–0.339	–0.347*	–0.418*		–0.251	–0.249	–0.319
		(0.212)	(0.204)	(0.232)		(0.222)	(0.221)	(0.256)
Listing delay			0.233	0.298***			0.026	–0.032
			(0.264)	(0.261)			(0.389)	(0.417)
Price			0.097	0.064			0.034	–0.005
discovery			(0.262)	(0.266)			(0.306)	(0.308)
Hot IPO				–0.443*				–0.397
activity				(0.234)				(0.298)
period								
Market				0.120				0.128
returns				(0.180)				(0.163)
Adj-R^2	0.260	0.356	0.347	0.372	0.000	0.171	0.142	0.152
F-value	23.78***	7.00***	5.31***	4.85***	0.04	3.23***	2.35**	2.17***

Notes: Model (1)–(4) show the results of greenness index and Model (5)–(8) present the findings of the greenness index used as a dummy variable. ***, **, and * show significance at 1, 5, and 10% levels respectively. Standard errors are reported in parentheses.

In Model (2), we add the firm characteristics and find that a firm's greenness is an essential factor of IPO underperformance. The long-term investment ratio negatively affects the IPO underperformance, which explains that higher investments of a firm positively affect its performance and the deterioration in share prices would be lower in the long run (Cai et al., 2008). The coefficient of initial returns is negative, meaning that initial and long-term returns move in opposite directions. This reversion to initial returns suggests that investors overact to the hype created by new issues that might generate unwarranted public interest, which diminishes as the excitement over the IPO fades. The risk variable is directly associated with longer-term underperformance which illustrates that post-issuing pricing behavior directly affects the IPO prices in the long run. We report that size of the firm and start-up are insignificant factors in our analysis. We include offer characteristics in Model (3) and determine that listing delay and price discovery mechanism are statistically insignificant parameters. Interestingly, we find that size of the firm and start-up become significant in Model (3), which shows that large-sized firms are more stable; thus, the underperformance would be lower. Model (4) suggests that investors earn higher initial returns on the listing day if IPOs are issued during the hot IPO activity period, reducing the probability of IPO underperformance. This relationship holds as underpricing and underperformance have an inverse relationship.

We use the greenness factor as a dummy variable (Model 5–8). In Model (5), this study reports that the greenness factor does not influence longer-term IPO underperformance. Interestingly, when we add firm characteristics in Model (6), the greenness factor becomes significant at a 10% level, demonstrating that underperformance is lower in the case of high-green IPOs. Models (7) and (8) determine that the greenness index, long-term investment ratio, initial returns, and aftermarket risk are robust predictors of longer-term IPO performance.

6. Conclusion

Previous studies account for the risk-return relationship to examine the utility function, as investors are more concerned about how much risk they take while participating in new issues. Over time, business dynamics and patterns have adversely changed, increasing the production facilities' manifolds. As a result, firms emit greenhouse gases, polluting the environment. To resolve this problem, green finance was introduced to raise funds under the green finance instruments with the condition that firms would follow all the necessary measures to bring greenness into their production facilities. Considering this new development, it is imperative to measure the greenness level of the latest issues and how crucial it is for investors. A higher level of greenness of a firm leads to a lower emission produced by manufacturing capabilities. This study develops a greenness index employing the emissions relative to the firm's sales.

At present, investors are more concerned about the greenness measures followed by a firm. Thus, the utility function depends on the return, riskiness associated with new issues, and greenness measures. We develop the utility function considering two firms and determine the proportion of their investment is based on the greenness index besides the sensitivity of risk and level of greenness. This study reports that a higher greenness measure leads to higher participation in new issues. When we increase the risk sensitivity into the utility function, the share of investment in new issues decreases. However, investors' weight for greenness enhances investment participation in new issues. This study also constructs the

global measures of greenness which is the desired level of greenness maintained by each firm. The results of the utility function identify that participation in investment is higher when global measures of greenness are considered compared to the greenness measures presently followed by the firm. We further report that the current greenness index does not achieve the optimal portfolio allocation without attaining the long-term goals. This study proposes the global aspects of greenness which stipulates that the desired greenness goals under the COP2030 can be achieved. IPO firms can optimize their portfolio allocation by achieving the desired level of greenness.

The results of empirical testing show that high-green IPOs underperform less than low-green IPOs. We use 66 combinations of IPOs splitting into high and low-green IPOs. High-green IPOs are less underpriced than low-green IPOs on a listing day. We further report that high green IPOs underperform the benchmark index; however, we find no evidence of the statistical significance of the underperformance of low green IPOs.

This study is helpful for policymakers, investors, and borrowers to determine the level of greenness for optimizing portfolios and how it affects the increase of the firm's wealth. Moreover, how the greenness of the firms can be assured and make the environment green. Future research proposes testing a theoretical model in other markets to examine their greenness effect on IPO performance.

Use of AI tools declaration

The authors declare that they have not used Artificial Intelligence (AI) tools in the creation of this article.

Conflict of interest

The authors declare no conflict of interest.

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