From Venture to Market: Financial performance of Sustainable VC-Backed Firms in the U.S.

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Abstract English

Sustainable investment has seen a sharp increase in popularity in recent years, prompting concerns about its true financial viability. The performance of portfolios made up of sustainable (green) vs non-sustainable (non-green) firms is examined in this thesis, with an emphasis on young and innovative firms that are backed by VC. The study estimates alpha, or risk-adjusted performance, for both synthetic green and non-green portfolio built from publicly traded, former VC-backed companies using both unconditional and conditional versions of the Carhart (1997) four-factor model and the Fama-French (2015) five-factor model. According to the results, greens portfolios do not beat non-green portfolios statistically significantly, however they do somewhat exceed them in more complete models with simpler simplifications. Overall, sustainability does not appear to be either penalized or rewarded by financial markets over the observed period (2020–2024). However, it does affect the profile and characteristics of the target firms—an aspect that may be relevant to investors who consider not only financial returns but also the environmental and social impact of their investment decisions.

Main contributions:

- Focus on how VC-backed green and non-green companies performed after their IPO.
- Application of both unconditional and conditional asset pricing models (Carhart, Fama-French) to estimate risk-adjusted performance.
- Evidence of no significant green premium, which adds to the discussion of sustainable investing's financial performance.

Key words: Venture capital, financial performance, Asset pricing models, Sustainable finance.

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Português abstrato

O investimento sustentável tem registado um forte aumento de popularidade nos últimos anos, suscitando preocupações quanto à sua verdadeira viabilidade financeira. O desempenho de carteiras compostas por empresas sustentáveis (verdes) e não sustentáveis (não verdes) é examinado nesta tese, com ênfase em empresas jovens e inovadoras que são apoiadas por capital de risco. O estudo estima o alfa, ou desempenho ajustado ao risco, para carteiras sintéticas verdes e não verdes construídas a partir de empresas de capital aberto, anteriormente apoiadas por capital de risco, usando versões incondicionais e condicionais do modelo de quatro factores de Carhart (1997) e do modelo de cinco factores de Fama-French (2015). De acordo com os resultados, as carteiras verdes não superam as carteiras não verdes de forma estatisticamente significativa, mas superam-nas um pouco em modelos mais completos com simplificações mais simples. Em geral, a sustentabilidade não parece ser penalizada ou recompensada pelos mercados financeiros durante o período observado (2020-2024). No entanto, afecta o perfil e as caraterísticas das empresas-alvo - um aspeto que pode ser relevante para os investidores que consideram não só os retornos financeiros, mas também o impacto ambiental e social das suas decisões de investimento.

Principais contribuições:

- Foco no desempenho das empresas verdes e não verdes apoiadas por capital de risco após o IPO.
- Aplicação de modelos incondicionais e condicionais de avaliação de activos (Carhart, Fama-French) para estimar o desempenho ajustado ao risco.
- Prova da inexistência de um prémio verde significativo, o que contribui para o debate sobre o desempenho financeiro do investimento sustentável

Palavras-chave: Capital de risco, Desempenho financeiro, Modelos de precificação de ativos, Finanças sustentáveis.

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1.Introduction

With the goal of producing significant returns, venture capital (VC) typically entails raising money from limited partners, or investors who contribute money to a VC fund without taking part in its day-to-day management and distributing that money to private startups with strong growth potential (Gompers & Lerner, 2001; Salhamn 1990). Pre-seed (nascent startups), early stage (Series A or B), late stage (Series C, D, or beyond), and venture growth stage (Series E or beyond) are the categories into which investments are divided based on the stage of development of portfolio firms. Despite the difficulties encountered recently, VC is still a commonly used financing method today. Its primary target audience includes not just early-stage startups but also highly innovative companies, usually in the tech sector, and those whose ideas or business strategies involve substantial operational and financial risks. The late 1970s and early 1980s marked a watershed in the history of the VC industry when the US changed pension fund laws (most notably the Employee Retirement Income Security Act, or ERISA) to permit institutional investors to invest in alternative assets, such as VC. The industry grew quickly because of this regulation reform, which also made enormous sums of money available. During this time, Silicon Valley emerged as a global center for innovation and VC activity, with startups like Apple, Genentech, and Microsoft receiving significant VC assistance (Lerner, J., 1994).VC creates a win-win partnership where investors want to make large sums of money through profitable exits, such initial public offerings (IPOs) or acquisitions- while startups seek to get access to resources, knowledge, and key networks. According to Gompers (1995), the most popular type of VC funding usually has an investment horizon of seven to ten years, following which an exit event is anticipated.

The absence of substantial exit events that generate returns has been a major constraint on the VC industry during the last three years. High value exits, including those worth more than $500 million, have decreased significantly, although the number of departures in the US (around 1,300 per year) has stayed constant when compared to pre-2021 levels. Only 114 firms made this kind of leave between 2022 and 2024, down from 220 in 2021—the fewest since 2017. Because of this, a sizable portion of capital is kept in illiquid securities, which restricts investor distributions. Most of the recent departure activity, on the other hand, has been smaller-scale deals, frequently from. Series A or B firms. Although these departures aid in lowering portfolio inventory, limited partners' (LPs') expectations for return are not met, particularly considering the almost $1 trillion spent in VC over the previous ten years. Although improved extrapolation techniques have made it possible to properly include their worth, many of these exits remain unreported, resulting in underrepresentation in venture data.

The conventional VC model, which has traditionally concentrated on high-growth, high-risk technology projects, has come into greater contact with sustainability-focused investment strategies in recent years. Combining these two topics, however, reveals that deal value in the climate-tech industry has decreased since 2021 (Pitchbook, 2024). The overall value of VC agreements in this industry peaked in 2021 at $870 billion, then fell to $568 billion in 2024, according to the PitchBook-NVCA Venture Monitor. Alongside this reduction, there has been a change in the distribution of investments, with a greater emphasis on late-stage VC rounds and pre-seed/seed stages. The future of VC is being shaped by the growing interest in green finance and sustainable investing. Investors are reevaluating prospects in the climate-tech and green startup sectors because of the difficulties presented by climate change, the energy transition, and the growing need for sustainable technological solutions. Considering this, VC has broadened its scope to include sustainability-driven projects in addition to high-growth industries like technology and healthcare. (PitchBook, 2023; PwC, 2022; Boocken, 2015).
Despite the growing interest in sustainable investment, there is still little, if any, real data on the financial performance of green firms that were funded by VC and went public. Most existing research focuses on the environmental impact of startups or on IPO performance in general, without distinguishing between green and non-green VC-backed firms. There is a lack of long-term data, partly because many of the relevant companies included in the study only went public after 2020.

This thesis attempts to bridge that gap by specifically comparing the post-IPO performance of green and non-green firms that have previously received VC investment. This study addresses a basic question: how do green investments affect VC portfolios' financial performance? It is situated within this changing environment. The research specifically focuses on publicly traded firms that have previously received VC funding and operate in both green and non-green industries. To shed more light on the long-term worth of sustainable VC investments, this thesis compares the success of these two types of firms. The following research issue is the focus of this thesis: Does a green strategy improve risk-adjusted returns for publicly listed VC-backed firms?
This study aims to increase the body of knowledge on VC by contributing to the existing research on post-IPO performance. Its primary contribution is to combine the rising relevance

of sustainability with the analysis of one of the most turbulent and unique periods in recent history—the post-COVID-19 era, which has drastically altered the VC scene. The study uses information from CRSP, Crunchbase, and PitchBook to create a unique sample of publicly traded companies. Companies that have received VC funding are identified, categorized according on their green orientation, and their success after becoming public is assessed using portfolio analysis methods. A systematic financial comparison that has rarely been used for this company group is made possible by this method.

The study was based on a sample of 100 publicly traded companies in the United States that received VC funding before going public. The data sources include CRSP (for historical stock return data from January 2020 to December 2024), PitchBook (for fundraising history), and Crunchbase (for sustainability category). The sample consists of companies that went public between 2020 and 2024. This thesis follows a linear format and is organized into six main chapters. The next chapter presents the literature evaluation, which incorporates significant scholarly publications on sustainability, the financial success of green firms, and recent VC studies. It also provides an overview of the research that served as the basis for this study and describes how some of its models have been adjusted to fit the current research environment. The third chapter discusses the methodology, which includes the asset pricing models that were employed and the comparison of VC-backed companies that are green and those that are not using a synthetic portfolio strategy. In Chapter 4, the data collection process and the descriptive statistics of the constructed portfolios—which are divided into long-short, non-green, and greens portfolios—are explained.
The empirical findings are presented in the fifth chapter together with statistical analyses and regression outputs derived from the four- and five-factor models' conditional and unconditional specifications.
The final chapters offer closing thoughts and addresses the primary research limitations. To close the current gap in the literature on the long-term financial success of VC-backed sustainable firms, it also provides guidance for future study.

2.Literature Review

In recent years, a central debate in the field of sustainable finance has focused on whether the increasing trend toward green investments is primarily driven by ethical-social considerations or by the superior financial performance of environmentally responsible firms.

2.1 Factors Influencing Green Investments

Theoretical perspectives lead to differing findings. Some firms may be more likely to attract green investors due to the enhanced social image associated with advancing non-profit-maximizing goals (Benabou & Tirole, 2010; Fombrun & Shanley, 1990; Hong & Liskovich, 2015). Nevertheless, green investments can come with additional costs, which might reduce company profitability and discourage companies from partnering with eco-friendly investors (Heinkel, Kraus & Zechner, 2001; Zhang, 2021). Financial performance and environmental performance have been proven to positively correlate in several empirical research (Molina-Azorín et al., 2009; Albertini, 2013; Dixon-Fowler et al., 2013; Endrikat, Guenther & Hoppe, 2014; Guenther & Hoppe, 2014; Galama & Scholtens, 2021). But according to other studies, firms typically respond to external constraints like investor expectations, public scrutiny, and legal requirements by implementing sustainability measures reactively rather than proactively. Furthermore, the financial benefits of these initiatives may not always be seen until the medium to long term (Li, Ngniatedema & Chen, 2017).

Recent research has also looked at the ways in which venture capitalists' investing practices support the green transition. Li, D., Liu, Y., Sun, M., Wang, X. and Xu, W. (2024) report a notable increase in the quantity and monetary amount of VC investments in clean technology, based on PitchBook data on more than 65,000 deals in 110 countries between 2011 and 2022. According to their research, green industries—in particular, energy management, electric cars, and lithium-ion batteries—attract more money per transaction than non-greens firms. China, India, and the United States are the top markets, and American and European venture capitalists are essential to the cross-border financing of sustainable technology. The study offers preliminary empirical proof that venture capitalists are actively promoting carbon neutrality by funding clean technology innovation.Building on similar empirical efforts, recent research employing a worldwide panel of 131 nations from 2011 to 2021 examined the correlation between venture capital activity and environmental intensity (measured as CO_2 emissions over GDP).The analysis demonstrates a substantial negative association between VC investments and environmental effect, implying that venture capital might be used as a financial tool for environmental advancement. However, the findings show significant regional heterogeneity: the benefit is most in the Asia-Pacific area and emerging and developing economies, where green technology are less established and environmental restrictions are less rigorous. These findings support the notion that the efficiency of green VC investments is determined not just by investor preferences, but also by institutional and regional preparedness to absorb and grow clean technology (Cappelari et al., 2024).

H1: Green VC-backed firms do not underperform non-green VC-backed firms in terms of long-term financial performance after IPO, despite potentially higher operational costs.

2.2 Green Classification, IPO and VC Investments

According to research, a company's classification a green does not always translate into a considerably greater or worse long-term stock return in terms of market valuation. However, short-term market behavior may be somewhat impacted by green categorization, especially in the vicinity of the initial public offering (IPO) date (Wang, Wang & Chang, 2022).
The function of ESG disclosure in the context of initial public offerings has also been examined in recent research. According to one study, more ESG disclosure might lessen the knowledge asymmetry that exists between investors and companies, which can result in more effective listing price. ESG transparency in particular helps to lower IPO underpricing by revealing a company's environmental and social risks (Ambrois, Butticè, Croce, Grilli & Ughetto, 2025). These findings highlight the signaling importance of ESG criteria during public offerings and suggest that non-financial information may influence initial market value.
With an emphasis on VC investors specifically, recent studies have looked at the differences in financial performance between dual-objective impact funds and traditional VC funds. According to Barber et al. (2021), impact funds generally perform worse than conventional funds, although this is largely mitigated by impact investors' willingness to accept lower returns in exchange for the positive externalities generated by their investments.
Further research on VC investor preferences by Z (2023) shown that investors are frequently less likely to support firms with a stated impact objective. It's interesting to note that these firms often outperformed in terms of long-term financial success and total funding. According to a research of 631 enterprises conducted between 2009 and 2019, Corporate Venture Capital (CVC) investments improve the financial success of startups mostly during the pre-IPO period, with higher advantages when R&D intensity and geographic closeness are high. After

the IPO, however, strong R&D intensity reduces CVC's favorable influence, probably because enterprises become more autonomous and corporate investors become more wary about sharing technology. These findings show CVC's strategic role in promoting long-term success for creative companies (Dai et al., 2023).

H2: VC-backed greens firms outperform non-green ones in the long run. VC-backed companies, even in the face of possible financial bias against firms with a clear objective.

2.3 Empirical Research on Methodological Foundations and Post-IPO Performance

Recent research has increasingly focused on the financial success of organizations that have gone public following venture capital investments. This section contains key empirical research that have investigated the financial consequences of such organizations, with special focus to green firms and the energy industry, offering a methodological foundation valuable for our work. Lange et al., 2024 examine how venture capitalists incorporate ESG criteria into their investment decisions, based on interviews with 11 investors. Results show that ESG is increasingly important in the long term, especially for improving startup performance and commercialization. Limited partners (LPs) drive this change, but lack of standardized frameworks and resources are major barriers. Currently, ESG is mainly assessed during due diligence, with only some VCs integrating it throughout the entire investment process. Growing attention to ESG and pressure from startups make its systematic adoption essential to remain competitive.
The purpose of this study is to evaluate the financial success of publicly traded firms that were once supported by venture capitalists. Interestingly, many of the greens firms in the sample are in the energy industry and are somewhat new. The 60 months following the first public offering are covered by the analysis. In this context, Anderloni and Tanda (2017) examined the post-IPO performance of green and non-green companies between 2000 and 2014 and found no appreciable difference in the financial outcomes of the two groups. The technique used in this study was modeled after Cortez, Andrade, and Silva's (2022) investigation of the economic and ecological consequences of green energy investments in Europe. Three portfolios of green and non-green energy firms were built as part of their study, and their performance from 2008 to 2020 was examined. Their work looked at public firms more generally, which allowed them to benefit from a larger dataset and longer time horizon than the current study, which focused especially on companies with past VC financing.

Furthermore, Cortez et al. (2022) divided the energy firms among companies that invest in sustainability and those that do not, whereas the current research focuses on green firms that predominantly operate in the energy sector. According to their results, there may not always be a financial trade-off when investing in green energy companies. Green investments frequently beat market benchmarks, especially when the economy was struggling. These results support the idea that investor preferences are shifting in favor of sustainable assets and highlight the significance of green finance from the standpoints of long-term financial sustainability and the environment. According to the study, the transition to a low-carbon economy could be consistent with financial performance objectives, which has important implications for governments, investors, and portfolio managers.

H3: Greens portfolios are more exposed to small-cap and growth risk factors, as captured by multifactor models (Fama-French 5 factors + momentum).

2.4 Impact of Systemic Crises Effects on VC Dynamics

Bellucci et al. (2023) who examine how the COVID-19 pandemic affected the reallocation of VC investments, make a pertinent contribution to our knowledge of how VC investors behave during emergencies. The authors demonstrate that VCs greatly increased investment toward firms involved in pandemic-related activities by using a difference-in-differences strategy and taking advantage of the pandemic's uneven distribution across nations. This effect holds up well in a variety of sensitivity tests and seems to be impacted by the size and organizational structure of the fund, the investing stage, and the expertise of the fund managers. The results provide useful information for examining ESG orientation in VC, even though the study focuses on a particular external shock rather than sustainability directly. They highlight the investors' ability to quickly adapt their strategies in response to systemic risks and emerging themes—such as those posed by the climate transition.

The COVID-19 pandemic resulted in a large drop in venture capital investments worldwide, with a particularly dramatic impact on seed-stage firms, industries worst hit by the crisis, and non-syndicated investments. In contrast, more renowned investors demonstrated better resilience, resulting in a rise in syndication as a risk reduction measure. As a result, many entrepreneurs in susceptible areas elected to postpone fundraising and instead use internal finance techniques to get through the period of uncertainty. These findings highlight the importance for policymakers to specifically support the most at-risk companies, particularly

those in the seed stage, and to ensure that economic stimulus packages are available even to firms with no established revenue track record, so that innovation and economic growth do not suffer in the post-pandemic period (Bellativitis et al., 2022).
In parallel, recent research has shown how the increase in sustainable investment, notably following the COVID-19 epidemic, may be promoted not only via reactive behavior, but also through long-term structural measures. A dualist strategy has been advocated, combining contractarian procedures with government backing to boost the long-term VC ecosystem. This involves enhanced contracting across all VC phases, increased financing sources from public institutions, and the development of specialist sustainability boards and reliable rating agencies to support quick exits and retain investor confidence. Such approaches highlight the importance of institutionalizing sustainability in venture capital beyond short-term market reactions, particularly in the post-COVID scenario, which emphasizes the urgency of concerted solutions to systemic global threats (Lin, 2022).

H4: During periods of economic uncertainty or crises, VC funds tend to shift investments toward sustainable (ESG) firms, expecting greater resilience, although this shift does not necessarily lead to better risk-adjusted financial performance

3.Methods

To carry out this analysis, the synthetic portfolio approach was followed, with reference made only to the U.S. market. In this case, the synthetic portfolio approach refers to the artificial (ex-post) creation of investment portfolios constructed from historical data, which do not correspond to portfolios held or managed by an investor or a fund. The research spans January 2020–December 2024, which corresponds with the time frame during which many the sample's initial public offerings (IPOs) took place and reflects the most current market conditions in the wake of the COVID-19 epidemic.
Initially, three value-weighted portfolios were created: one green, one non-green, and a third based on the difference between the two previous ones, reflecting a long position strategy for the green portfolio and a short strategy for the non-green portfolio.
Additionally, assuming the perspective of an investor, it assessed financial performance by considering risk-adjusted returns. To this end, it used the models of Carhart (1997) and Fama and French (2015), which include factors known in financial literature to explain the variation in stock returns across different portfolios. Specifically, Carhart's four-factor model (1997) extends Fama and French's (1993) model by including, in addition to the market, size, and value factors, the momentum factor. Carhart's four-factor model was found to be adequate in

explaining the portfolio performance. However, the results suggest that, while the model captures much of the variation linked to risk factors, the green portfolio did not show a significant positive alpha, while the non-green portfolio exhibited a weak alpha that diminished with the inclusion of additional factors. Furthermore, the long-green/short-non-green strategy did not generate significant abnormal performance, indicating that the market prices the two investment approaches correctly.
The four-factor model is represented as follows:

$$r_{p,t} = \alpha_p + \beta_1 r_{m,t} + \beta_2 SMB_t + \beta_3 HML_t + \beta_4 MOM_t + \varepsilon_{p,t} \quad (1)$$

Where: $r_{p,t}$ is the portfolio excess return in period t, calculated as the return of the portfolio minus the risk-free rate (1-month T-bill), α_p is the portfolio's abnormal return and $r_{m,t}$ is the market excess return. SMB_t, HML_t, and MOM are the size, value, and momentum factors, respectively while $\varepsilon_{p,t}$ is the error term.
Each factor is defined as follows: Size (SMB)**:** the return differential between a portfolio of small-cap stocks and a portfolio of large-cap stocks, Value (HML): the return differential between stocks with high book-to-market ratios and those with low book-to-market ratios. Momentum (MOM)**:** the return differential between stocks with high past returns and those with low past returns.

In addition to the four-factor model, it also employs the Fama and French (2015) five-factor model**,** which is specified as:

$$r_{p,t} = \alpha_p + \beta_1 r_{m,t} + \beta_2 SMB_t + \beta_3 HML_t + \beta_4 RMW_t + \beta_5 CMA_t + \varepsilon_{p,t} \quad (2)$$

Profitability and investment are two further elements of systematic risk that are added to the basic three-factor model in this approach. The addition of these extra components has been helpful in correcting the performance bias associated with the low-volatility anomaly, even though the five-factor model is not as frequently used as the four-factor model (Jordan & Riley, 2015). The additional factors are defined as follows: Profitability (RMW): the return spread between firms with high operating profitability and those with low profitability. Investment (CMA)**:** the return spread between firms with low investment activity (including those divesting assets) and firms with high investment levels.
For many purposes, the use of Fama-French's (2015) five-factor model and Carhart's (1997) four-factor model is especially suitable for examining green firms supported by VC. First, compared to regular corporations, green and VC-backed firms typically operate in capital-intensive areas with strong growth rates and unusual risk profiles. The separation of

"abnormal" performance is made possible by multifactor asset pricing models, which account for common risk characteristics including size, value, momentum, profitability, and investment. This is necessary to ascertain if sustainability is only linked to well-known risk characteristics or produces a true return premium (Fama & French, 2015; Carhart, 1997; Barber et al., 2021). Second, research on post-IPO companies shows that these models work especially well for assessing risk-adjusted performance in the years after a company goes public. During this time, venture-backed companies typically show distinctive return dynamics (Ritter, 1991; Cao & Lerner, 2009). Lastly, the Fama-French and Carhart models have been used in a few recent studies to evaluate the performance of sustainable portfolios and ESG funds, and they have been found to be effective in capturing the structural distinctions between green and non-green investments (Albuquerque et al., 2020; Cortez et al., 2022).

As shown in Table 1, after calculating the correlation matrix between the factors of Carhart's (1997) four-factor model and Fama-French's (2015) five-factor model, it allows to evaluate the efficacy and usefulness of both models for performance analysis. In all situations, the variables are highly independent of one another, indicating that each component reflects a unique risk characteristic. The four-factor model clearly distinguishes between momentum and the other elements, with negative correlations demonstrating that momentum is a distinct risk component. In the five-factor model, all components are moderately or weakly connected, except for the CMA and HML factors, which have significant positive correlation coefficient of 0,65. This high correlation indicated a potential redundancy between these two parameters, which might be a restriction when apply the model together and necessitats caution in interpreting the findings.

Nonetheless, the models are generally reliable and useful for assesing risk-adjusted performance in investing strategies.

These models were applied to both the green and non-green portfolio, as well as to the difference portfolio. The evaluation of this differential portfolio allows for a direct comparison of the performance and risk characteristics of sustainable versus non-sustainable investment strategies and enables the statistical significance of these differences to be tested

.

[Insert Table 1 here]

4.Data

The building of two separate portfolios—one categorized as "green" and the other as "non-green"—is the focus of the analysis that was done. About 50 publicly traded companies that were previously supported by VC before their first public offering (IPO) make up each portfolio. The private nature of VC data severely restricts the viability of such studies in this context, even though a sample size of at least 100 firms is often chosen for a more rigorous assessment of portfolio performance.

Former VC-backed companies that primarily work to create a more sustainable future are included in the "green" portfolio; around 87.5% of these companies are involved in the energy industry. In contrast, the “non-green” portfolio consists of companies operating in diverse industries such as healthcare, technology, and e-commerce, which do not explicitly pursue sustainability-oriented objectives.

An initial screening was carried out using CrunchBase, filtering for companies located in the United States and currently publicly listed to find the 100 firms that were included in the research. Keyword filters including "sustainability," "renewable energy," "solar," "wind," "clean energy," "greentech," and "pollution control" were used for the green portfolio. These factors were not taken into consideration while choosing non-greens firms.

PitchBook, which offers comprehensive details on the kind of funding obtained before going public, was then used to cross-reference each identified firm. Only companies that were clearly marked as "Formerly VC-backed" made it onto the final list. Both databases are known for gathering thorough information on firms funded by VC and private equity, including those that are still privately held or have just completed an IPO, merger, or acquisition.

Data was gathered using the CRSP database on the WRDS platform after an initial list of more than 100 firms was created. For the analysis, the period chosen is January 2020–December 2024. Firms lacking observations during this period were excluded, while others that became public after 2020 but did not have a full set of data were incorporated with a rebalancing approach. Specifically, monthly portfolio weights were adjusted based on the number of firms entering or exiting the dataset, including those subsequently delisted, resulting in value-weighted portfolios. From CRSP, monthly average prices were used to compute returns, and shares outstanding were used to calculate monthly market capitalizations. On average, the green portfolio displayed a market capitalization 74.40% higher than its non-green counterpart.

Based on the compiled dataset, two value-weighted portfolios were constructed. Excess returns were computed using the one-month Treasury bill rate as the risk-free benchmark. **Table 2** reports the statistical properties of the monthly excess returns, along with key characteristics of the green and non-green portfolio, as well as of the differential portfolio formed by investing in a long position for the green portfolio and in a short position for the non-green one.

The green portfolio exhibits a lower mean return, and a higher standard deviation compared to the non-green portfolio. Meanwhile, the difference portfolio—constructed as the return spread between the green and non-green portfolio—displays a negative mean, significantly lower than those of the individuals' portfolios

In comparison to the non-green portfolio, the green portfolio shows a larger standard deviation and a lower mean return. Constructed as the difference between the green and non-green portfolio, the difference portfolio has a negative mean that is far lower than the individual portfolios'. While the distribution of the difference portfolio approaches normality, the return distributions of the green and non-green portfolio both deviate from it, according to the p-values obtained from the Jarque-bera (JB) test[1].

In summary, green stocks show more symmetric and less extreme return behavior (i.e., narrower tails) while being more volatile. Non-green stocks, on the other hand, tend to yield larger returns but are also distinguished by significant skewness and kurtosis, which indicate more volatile and speculative dynamics. A possible trade-off between sustainability and financial success may be indicated by the difference portfolio's cleaner (near-normal) distribution, despite its negative mean.

[Insert Table 2 here]

As shown in **Table 3**, the correlation matrix the correlation matrix reveals major differences in green and non-green investing methods. Although they share some market features, their returns vary significantly. The difference portfolio, which represents the spread between green and non-green returns, closely tracks the green portfolio's performance while having minimal relationship with the non-green portfolio. This suggests that the difference portfolio successfully separates the green strategy's distinctive return component, making it a useful

[1] The Jarque-Bera (JB) test is a statistical test used to assess whether the distribution of a dataset—typically the residuals or returns in financial studies—deviates from a normal distribution. Specifically, the test examines the skewness (asymmetry) and kurtosis (tailedness) of the data.

The test statistic is calculated as: $JB = \frac{n}{6}\left(S^2 + \frac{(K-3)^2}{4}\right)$

Where: n is the sample size, S is the sample skweness and K is the sample kurtosis.

tool for comparing performance disparities between sustainable and non-sustainable investments.

[Insert Table 3 here]

5.Empirical Results and Discussion

5.1 Performance of green vs. non-green portfolios

The financial performance of the three portfolios, using the Carhart (1997) four-factor model and the Fama and French (2015) five-factor model, has been analized, as described in the “Methods” section. In **Table 4** alphas are used to assess potential outperformance: green portfolios do not generate significant excess returns relative to systematic risk. Non-green portfolios show a weakly positive alpha, which disappears under the more comprehensive model, while the long green / short non-green strategy does not yield statistically significant excess returns, suggesting that the market efficiently prices both investment approaches. Both green and non-green portfolios show positive exposure to market factors, with green portfolios being slighlty more susceptible to changes in the market.
Maybe it should be here? check
The third portfolio (long-short) suggests an essentially market neutral approach. The four-factor model shows that both portfolios have a positive exposure to small-cap firms, which is significant. According to the five-factor model, exposure remains significant for the non-green portfolio while decreasing for the green portfolio. Small-cap exposure for the long-short portfolio is still considerable but never statistically significant. Regarding the “Value” factor, all portfolios show negative exposure, indicating a preference for growth stocks. This effect is more pronounced and significant for the non-green portfolio. The long-short portfolio shows negative exposure in the four-factor model and positive (though not significant) exposure in the five-factor model, suggesting that green stocks are less “growth-oriented” than non-green ones once other factors are controlled for. With respect to the momentum factor (present only in the first model), no significant exposure is detected. However, the strategy exhibits a tilt toward low-momentum stocks, i.e., those that have not recently outperformed.
Lastly, with the two additional factors from the five-factor model, all portfolios are short on high-profitability firms, especially the green portfolio. The long-short strategy bets against the most profitable companies, possibly in favor of early-stage or fast-growing firms. Green firms indeed appear to be much more aggressive in their investment policies compared to non-green firms. The long-short strategy is exposed to firms with more expansionary investment

policies, which aligns with the profile of green companies being innovative or rapidly developing.

Table 5 shows the correlation matrix between green and non-green portfolios, as well as their relationship to risk variables, reveals the existence of distinguishing characteristics between sustainable and non-sustainable investment strategies. As previously stated in Chapter 4, the green and non-green portfolios are somewhat linked, implying that they share certain market dynamics while retaining their own characteristics. The difference portfolio has a good correlation with the green portfolio but a low or negative correlation with the non-green portfolio, demonstrating that this long-short strategy efficiently separates the return component common to green assets. Both portfolios have positive exposure to market risk and small-cap firms, with a bias for growth over value stocks. The negative association between the RMW and CMA factors, particularly for the green portfolio, shows a preference for less profitable firms with more aggressive growth plans, which is consistent with the character of innovative and fast-growing enterprises typical of the green category. These findings demonstrate how sustainable and non-sustainable strategies have distinct risk and return profiles, with important implications for performance analysis and portfolio development.

In conclusion, the green portfolio is more sensitive to market risk, more oriented toward growth and small-cap stocks, less profitable (RMW), and more aggressive in investment behavior (CMA). The non-green portfolio shows anomalous returns that vanish once RMW and CMA are accounted for. It also displays strong market and small-cap exposure, an even more pronounced growth profile compared to green firms (with a more negative HML beta), slight positive exposure to profitability, and more conservative investment behavior (CMA > 0), albeit without strong statistical significance. Although the long-short portfolio does not generate significant returns, it demonstrates characteristics consistent with a "green" strategy: it is market-neutral, short on more cautious and profitable firms, and long on firms with more aggressive investment plans. These disparities in factor exposure show that, while green firms do not underperform in risk-adjusted terms, they are fundamentally distinct types of investments. Their lower profitability and more aggressive investment behavior are consistent with investor expectations for future growth, but they also imply more uncertainty. As a result, while green investments may not provide excess returns, they may nonetheless play important roles in long-term portfolios, particularly for investors with sustainability requirements or a high risk tolerance. This conclusion is consistent with prior research by Barber et al. (2021), who claim that while ESG investments may not outperform in risk-adjusted terms, they continue to draw investors owing to non-pecuniary preferences or longer-term expectations.

Futhermore, these findings are consistent with the risk and return profiles commonly observed in organizations that were formerly VC-backed, which generally prioritized growth and innovation over immediate profitability.

According to the findings, exposure to green ex-VC-backed shares does not produce statistically significant abnormal returns from a portfolio management standpoint; that is, there is no convincing evidence of either underperformance or outperformance in compared to market expectations. This suggests to investors that these investments offer alignment with long-term objectives pertaining to sustainability and innovation, as well as financial performance comparable to non-green options. This shows to policymakers that encouraging VC investment in environmentally aware firms does not punish investors in a systematic way and can aid the green transition without demanding large financial sacrifices. The empirical data provide support for hypothesis 1. According to the unconditional and conditional models, green firms do not regularly perform worse than non-green firms, and there were no statistically significant differences in alpha between green and non-green portfolios. This suggests that any additional costs connected with sustainability do not result in bad financial performance; whereas H2 expected that in the long run, green venture-backed firms will outperform non-green ones. This idea is validated in part by empirical studies, which suggest that green firms outperform non-green firms in equally weighted portfolios in terms of excess performance (alpha). This is not the case with value-weighted portfolios, which have lower or equivalent performance. This means that high-growth small caps are the primary source of green firms' outperformance, making the evidence supporting the theory weak and non-generalizable.

[Insert Table 4 here]

[Insert Table 5 here]

5.2 Conditional Model

Prior to this point, the study was based on an unconditional model, which is a "static" model that does not respond to unique events such as market booms or crises.

Therefore, it has been decided to proceed with the same analysis, continuing to use the four- and five-factor models, but this time applying a conditional approach, i.e., a model that adapts to available information or specific market conditions by incorporating financial variables that change depending on macroeconomic conditions. The two variables chosen for this analysis are the term spread and the dividend yield. The term spread was calculated as the difference between the 10-Year Treasury Constant Maturity Rate (GS10) and the 3-month Treasury Bill Rate. The dividend yield is based on the S&P 500 dividend yield. Both datasets were obtained from FRED (Federal Reserve Economic Data), and the time horizon remains January 2020 to December 2024.

Table 6 reports the regression estimates for intercepts and coefficients, still using both the four- and five-factor models.

As can be immediately observed, the results are significantly different from those in Table II, with only one significant coefficient: the dividend yield in the "difference" portfolio, significant at the 10% level.

The conditional four- and five-factor models follow this regression specification:

$$r_{p,t=}\alpha_{0p+}A'_{p}Z_{t-1} + B_{0p}r_{m,t} + \beta'_{0p}\left(z_{t-1}r_{m,t}\right) + \cdots + \beta_{np}(f_t) + \beta'_{np}(z_{t-1}f_t) \qquad (4)$$

where Z_{t-1} is a vector of predictive variables (term spread and dividend yield) and f_t rapresents each factor of the regression.These were detrended (removing a 12-month moving average) and standardized (subtracting the historical mean to obtain a mean of zero), following the approach of Ferson, Sarkissian, and Simin (2003), in order to avoid bias from interaction terms in the regression. The findings reveal that in the four-factor conditional model, there are no statistically significant differences between green and non-green portfolios. No significant alpha is discovered, implying equivalent performance.

In the five-factor model, the difference in dividend yield exposure between green and non-green portfolios is significant at the 10% level, showing limited evidence that this factor affects green portfolios differently. From an economic standpoint, this might indicate a shift in investor attitudes about dividends: green investors may prefer companies that reinvest earnings rather than distribute them, which is compatible with a long-term sustainable growth plan. Even though most coefficients are not statistically significant, their magnitude hints at potential economic differences in how the portfolios respond to macroeconomic variables. For example, variation in term spread coefficients may indicate a different sensitivity of green stocks to the economic cycle, although not confirmed statistically.

Overall, there is no compelling evidence of significant performance or exposure differences between portfolios using conditional models.

In conclusion, while unconditional models revealed that green portfolios had higher market risk exposure and slightly outperformed non-green portfolios, conditional models found no significant differences in performance or factor exposure.

Although conditional models are theoretically more comprehensive, the results indicate that including predictive variables such as the term spread and dividend yield did not improve explanatory power compared to the unconditional model. This may be due to limited variation in risk premia, the presence of noise in conditional data, or more critically, overfitting—adding too many interaction terms may cause the model to fit historical data too closely, thus failing to capture genuine economic relationships. Unlike these findings, Cortez, M. C., Andrade, N., and Silva, F. (2022) discovered more consistent and significant coefficients. This disparity is most likely explained by variations in sample characteristics: although they examine mature publicly traded energy firms, our sample includes younger companies previously sponsored by VC, which tend to have more volatility and less consistent returns. Another possible explanation is that green firms, particularly those formerly VC-backed, may not yet demonstrate consistent patterns in how they respond to macroeconomic situations due to their relative young and volatile nature. In contrast, established corporations generally respond more predictably to fluctuations in interest rates or dividend expectations. It also raises concerns regarding the applicability of conditional models to growing industries, where risk exposures might change quickly.

Furthermore, the limited time frame (2020-2024) may have increased data noise as a result of extraordinary occurrences like as the COVID-19 pandemic and recent macroeconomic shocks. According to H4, venture capitalists may gravitate toward ESG investments during periods of macroeconomic instability or crisis because they are seen to be more resilient, even if this does not necessarily translate into improved risk-adjusted performance. The results support the second half of the hypothesis, which states that if risk is taken into consideration, green firms do not perform noticeably better than non-green firms, even though the available data does not provide direct observation of VC investment decisions during crises. This suggests that even if end investors develop a preference for ESG investing during difficult times, their financial outcomes may not necessarily improve. Finally, disparities in sector composition between green and non-green portfolios may have hampered efforts to isolate the influence of sustainability on financial performance.

[Insert Table 6 here]

5.3 Robustness Tests

5.3.1 Performance under Equally Weighting Assumption

To complement the main analysis, an additional test was conducted on the constructed portfolios to assess the robustness of the results. In particular, the sensitivity of the findings was examined using an alternative portfolio structure, namely an equally weighted portfolio. This approach makes it possible to verify whether the initial conclusions depend on the weighting methodology applied. In the literature, Cortez, Andrade, and Silva (2022) find less evidence of green portfolio outperformance compared to the market or to non-green portfolios, suggesting that larger firms may outperform smaller ones. However, in the findings of this study, the financial performance evaluation was duplicated using an equally-weighted portfolio structure.

Unlike the value-weighted strategy, which favors companies with bigger market capitalizations, the equally weighted methodology gives each stock equal weight, making smaller firms more relevant. This is especially important in the context of sustainable investing, as many green firms are startups or SMEs that have yet to establish themselves in the market. Consequently, equally weighted portfolios tend to amplify exposure to small-cap and high-growth stocks, resulting in a more "dynamic" and risk-prone composition compared to value-weighted portfolios.

As reported in **Table 7**, green portfolio alphas are higher than those observed under the value-weighted approach and are statistically significant at the 10% level in both the Carhart four-factor and Fama-French five-factor models. However, the long green / short non-green strategy still does not yield a statistically significant abnormal return, confirming the hypothesis that the market already correctly prices the green characteristics of firms. Compared to value-weighted portfolios, the green portfolio's excess return thus appears to be inflated by its stronger exposure to small-cap risk factors, which is more pronounced under this specification.

Regarding factor exposures, the equally weighted green portfolio exhibits a very high and highly significant SMB beta, much stronger than in the value-weighted equivalent. This reinforces the idea that the apparent outperformance of green stocks in this setting is partially attributable to the structural nature of the portfolio. Market sensitivity (β Mkt) is generally higher for green portfolios in this case as well, although without strong significance, while the long-short portfolio remains near market-neutral.

Exposure to the Value factor (HML) remains negative across all portfolios, consistent with a growth-oriented style. However, in the equally weighted model, the difference between green and non-green portfolios is less marked, suggesting that green firms appear less "growth-oriented" than non-green firms when controlling for other risk factors—similar to what was observed in the value-weighted setting.

A notable distinction emerges with respect to the Momentum factor, which is only included in the four-factor model: while no significant exposure was found under the value-weighted approach, the green portfolio has a significant negative exposure, indicating a clear tilt toward stocks that have not recently outperformed—possibly consistent with a longer-term investment approach typical of emerging green sectors.

Finally, in the five-factor model, green firms also exhibit negative exposures, though not always statistically significant, to the RMW (profitability) and CMA (investment) factors. The long-short portfolio once again shows a short position in more profitable and conservative firms and a long position in more aggressively investing firms, consistent with the narrative of green companies in a phase of expansion and innovation. However, the significance of these exposures is weaker compared to the value-weighted case. In conclusion, equally weighted portfolios accentuate the risk-related characteristics of green stocks, generating higher alphas that are more strongly influenced by high exposure to factors such as SMB and MOM. The comparison with the value-weighted approach suggests that part of the green portfolio outperformance may stem from structural features (small size, growth bias, low momentum), rather than from an intrinsic ability to generate excess returns. In both weighting schemes, the long-short strategy does not produce significant alpha but consistently reflects a preference for young, less profitable but dynamic firms, consistent with a sustainable and innovation-driven investment profile. H3 has a lot of support. Stronger growth orientation (negative value factor exposure), increased SMB (small-cap) exposure, and increased susceptibility to market risk are all characteristics of green portfolios. Additionally, according to the momentum component, green stocks tend to have low momentum profiles, which is in line with a longer-term growth plan.

[Insert Table 7 here]

5.3.2 Volatility and Risk Analysis

To fully evaluate portfolio performance, it is not enough to study average returns; it is also necessary to investigate the features of the associated risk. Traditional metrics of variability, such as standard deviation, give a broad evaluation of variability without distinguishing between downside and upside risks, or market systemic risks and firm-specific risks. To improve the analysis's robustness, two complementary tests are performed: one on downside volatility using Downside Risk (Sortino, 1980) and the Sortino Ratio (Sortino et al., 1994) , and another on risk decomposition into systemic and idiosyncratic components (Merton, 1973). These studies provide a better understanding of the nature of risk exposure in green and non-green portfolios, allowing for more accurate risk-return profiles and guiding portfolio creation and management decisions.

Downside Risk assesses the possible loss in comparison to a reference criterion, which is often zero or the risk-free rate. Unlike standard deviation, it solely analyzes negative variances, making it more understandable to risk-averse investors. In this case, the reference threshold considered was zero because the monthly portfolio returns had already been adjusted for the risk-free rate.

The standard formula to compute the Downside Risk is:

$$Downside\ Risk = \sqrt{\frac{1}{T}\sum_{t=1}^{T} min(0, R_t - \tau)^2} \tag{5}$$

Where τ is the reference threshold and min(0,Rt−τ) caputeres only the negative deviations from the threshold.

While, the Sortino Ratio measures risk-adjusted performance by measuring the ratio of excess return to downside risk. A greater number suggests a better compensation for downside risk, implying a more efficient risk-return tradeoff.

It has been computed as follow below:

$$Sortino\ Ratio: \frac{R_p - R_f}{Downside\ Deviation} \tag{6}$$

Where the downside deviation is the standard deviation computed only on negative returns.

[Insert Table 8 here]

Table 8 reveals that the green portfolio has a higher Downside Risk than the non-green portfolio, indicating a greater vulnerability to bad occurrences. As a result, the green portfolio's Sortino Ratio is significantly lower, implying that sustainable assets provide a less efficient return per unit of negative risk than non-green investments. The long-short strategy (difference between green and non-green) has a negative Sortino Ratio, indicating that it is ineffective in mitigating downside risk throughout the observation period. These observations provide more nuance to Hypothesis 2. While green venture-backed enterprises may not exhibit statistically significant underperformance in average returns, their higher downside risk and lower Sortino Ratios indicate a less favorable risk-adjusted return on the downside. This reinforces the notion that green businesses pursue more aggressive, growth-oriented strategies, which is consistent with their inventive character, but it also exposes them to bigger losses during market downturns. Because this research was carried out using value-weighted portfolio returns, it validates the prior finding that green firms' outperformance is mostly driven by smaller, high-growth enterprises, making the evidence for Hypothesis 2 context-dependent and not universally applicable.

To better understand the nature of risk, total risk was divided into systemic (market-related) and idiosyncratic (firm-specific) components. Systemic risk demonstrates susceptibility to market-wide variables that influence all equities, whereas idiosyncratic risk stems from distinct traits that are unaffected by market fluctuations (Merton, 1973). This difference is critical for investors who want to understand the advantages of diversity as well as the causes of return volatility. A large systemic component suggests significant market exposure, but a high idiosyncratic component shows increased uncertainty about specific firms.

[Insert Table 9 here]

The systemic risk corresponds to the variance explained by the multi-factor model such as Carhart (1997) and it has been computed as follow:

$$Systemic\ Risk = Var(\widehat{R_p}) = Var(\beta_1 Mkt - R_f + \beta_2 SMB + \beta_3 HML + \beta_4 MOM) \quad (7)$$

While the idiosyncratic risk is the part not explained by the market, i.e., the variance of the regression residuals:

$$Idiosyncratic\ Risk = Var(\varepsilon) = \sigma_\varepsilon^2 \quad (8)$$

The analysis, showed in **Table 9,** reveals that the green portfolio has a somewhat larger systemic risk than the non-green portfolio, although the difference is minimal. However, the green portfolio's idiosyncratic risk is almost double that of the non-green portfolio, demonstrating that particular, non-market variables account for a significant portion of the volatility in sustainable investments. This is congruent with the nature of green enterprises, which are typically young and inventive, with distinct development routes and risks. The long-short strategy has the highest idiosyncratic risk, which is consistent with its goal of extracting return components unique to green investments while eliminating broad market impacts.

The combination of downside risk analysis with risk decomposition yields a full picture of the risk profiles of green and non-green portfolios. Although green investments do not have inferior average performance, they do have more downside risk and more idiosyncratic risk, reflecting their inventive and growth-oriented orientation. These traits have significant implications for diversification and risk management, implying that investors in green assets should be wary of higher volatility due to firm-specific variables rather than market fluctuations. The combined studies underline the importance of doing more comprehensive risk evaluations when evaluating sustainable investment methods.

6.Conclusion

The financial performance of VC-backed sustainable and non-sustainable firms was compared in this thesis. There was no discernible risk-adjusted overperformance for green portfolios in the investigation, which included both unconditional and conditional asset pricing models. Significant alphas were observed in equally weighted green portfolios; however, this is mostly due to increased exposure to low-momentum and small-cap factors, not a premium associated with ESG. The failure of a long-green/short-non-green strategy to produce extraordinary returns suggests that market pricing is efficient. Sustainable firms do not function poorly, but they also do not provide better financial returns, which is consistent with a large portion of the most current scholarly research.

Although it does not ensure extra returns, the results comfort investors from a management standpoint that selecting sustainable firms does not entail a performance cost. For corporate venture capitalists, who must strike a balance between financial aims and strategic and sustainability objectives, this is particularly pertinent. The study theoretically adds to the current discussion of the ESG premium by demonstrating that conventional risk considerations, not a sustainability advantage, account for the returns of green firms.

Some limitations in this investigation might jeopardize the validity and generalizability of the findings.

First, the relatively small sample size—50 green and 50 non-green firms—may reduce the analysis's statistical power. Additionally, because the focus was on U.S.-based, VC-backed companies that went public after 2020, the fin

This limitation, however, stems from the scarcity of VC data, which is frequently more centered on private settings, making it difficult to expand the study to a larger range of companies o regions.

Second, the timeframe is brief and filled with noteworthy occurrences like the COVID-19 pandemic and the global financial crisis. The validity of long-term evaluations may have been limited by these exceptional circumstances, which may have warped typical risk-return correlations.

Third, due to data constraints, unobserved elements such as capital structure, corporate governance, and ESG standards were excluded, which could distort the models' ability to explain performance and change how sustainability is perceived. Finally, VC-backed firms are particularly vulnerable to volatility and idiosyncratic risk due to their nature, which is often characterized by a short operating history, a high degree of innovation, and high growth expectations. Furthermore, the risk analysis undertaken in this study demonstrates that green portfolios have much larger downside and idiosyncratic risks than non-green portfolios. This conclusion is consistent with the fundamental features of VC-backed green enterprises, which frequently have shorter operational histories, increased innovation intensity, and high growth ambitions. Such characteristics lead to heightened firm-specific volatility, which can hide steady risk-return correlations and confound determining sustainability's genuine financial impact throughout the post-IPO era. As a result, our findings emphasize the need of using sophisticated risk measures and decomposition approaches for assessing the performance and resilience of sustainable investments.

This thesis contributes to the body of knowledge by conducting an empirical examination of the post-exit performance of VC-backed green firms, which is mostly unexplored. It challenges the assumption of a consistent ESG premium and prioritizes portfolio qualities above sustainability status. For practitioners, it underlines that investing in environmentally responsible firms is financially neutral, encouraging the inclusion of ESG aspects while maintaining profitability. This information is timely and relevant in a market that is increasingly affected by investor preferences and sustainability requirements. Longer time horizons may be studied in future research when more sustainable firms exit. Additional study might improve the classification of green firms by incorporating data on carbon footprints, regulatory alignment, and textual analysis. Examining pre-exit performance, the role of VC firms' sustainability orientation, and the link between green investment and industry-specific advances (such as energy, transportation, and artificial intelligence) may also be useful.

Finally, cross-regional comparisons can help clarify the consequences of regulatory changes between the United States and Europe.

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Appendix

Appendix I – Table 1 – Correlation matrix of Factors Loadings

Table 2

Correlation Matrix of Factors Loadings - Carhart (1997) four-factor and Fama and French (2015) five-factor models.

Four-factor model	Mkt-rf	SMB	HML	MOM
FF Market Factor				
Mkt-rf	1			
SMB	0,31	1		
HML	0,04	0,09	1	
MOM	-0,42	-0,42	-0,17	1

Five-factor model	Mkt-rf	SMB	HML	RMW	CMA
FF Market Factor					
Mkt-rf	1				
SMB	0,33	1			
HML	0,04	0,37	1		
RMW	0,05	-0,41	0,14	1	
CMA	-0,20	0,00	0,65	0,15	1

Appendix II – Table 2 – Descriptive Statistics of Portfolios

Table 2
Descriptive statistics of monthly excess returns and stock characteristics of the green and non-green portfolios.

Descriptive Statistics	Green	Non-Green	Difference
Mean	0,027	0,034	-0,008
Median	0,017	0,017	-0,010
Maximum	0,440	0,518	0,415
Minimum	-0,567	-0,201	-0,560
Standard Deviation	0,205	0,128	0,176
Skweness	-0,216	1,473	-0,537
Kurtosis	0,760	3,546	1,905
JB Test	12,792	22,064	5,784
P-value	0,002	0,000	0,055

Table 2 presents the descriptive analysis of the monthly excess returns of the green and non-green portfolios over the period from January 2020 to December 2024. Each portfolio consists of 50 companies, respectively. The p-value refers to the probability associated with the Jarque-bera (JB) test, which is used to assess the normality of the return distributions.

Appendix III – Table 3 – Correlation Matrix of Portfolios return

Table 3
Correlation Matrix of Portfolios Returns

	Green	Non-Green	Difference
Green	1		
Non-Green	0,519	1	
Difference	0,78538688	-0,122	1

Appendix IV – Table 4– Value-Weighted Portfolios' Performance Using Unconditional Model

Table 4

Performance of green and non-green portfolios – Carhart (1997) four-factor and Fama and French (2015) five-factor models.

Four-factor model	α_p	$\beta 1_{Mkt}$	$\beta 2_{SMB}$	$\beta 3_{HML}$	$\beta 4_{MOM}$	$Adj\ R^2$
FF Market Factor						
Green	0,012	1,559***	1,641**	-0,987**	-0,491	0,354
	(0,022)	(0,439)	(0,758)	(0,472)	(0,602)	
NonGreen	0,022*	1,305***	1,358***	-0,605**	0,174	0,503
	(0,012)	(0,240)	(0,415)	(0,258)	(0,329)	
Difference	-0,009	0,255	0,282	-0,382	-0,665	0,058
	(0,024)	(0,473)	(0,818)	(0,509)	(0,649)	

Five-factor model	α_p	$\beta 1_{Mkt}$	$\beta 2_{SMB}$	$\beta 3_{HML}$	$\beta 4_{RMW}$	$\beta 5_{CMA}$	$Adj\ R^2$
FF Market Factor							
Green	0,016	1,725***	1,039	-0,700	-0,857	-0,783	0,323
	(0,023)	(0,449)	(0,892)	(0,756)	(1,006)	(1,058)	
NonGreen	0,023	1,329***	1,299***	-1,204***	-0,247*	0,760	0,510
	(0,012)	(0,240)	(0,476)	(0,403)	(0,537)	(0,564)	
Difference	-0,008	0,395	-0,260	0,504	-0,609	-1,543	-0,017
	(0,024)	(0,477)	(0,947)	(0,802)	(1,068)	(1,122)	

*Table 4 presents estimates of monthly abnormal returns (aplha), expressed in percentage, factor loadings, and the adjusted R^2. obtained from regressing eq. (1) and (2). Mkt corresponds to the excess return of the market benchmark, proxied by the broad market returns of the US market available in the Professor Kenneth French's website. The 1-month Treasury Bill rate is used as risk-free rate, SMB, HML, MOM, RMW and CMA correspond to the risk factors for the US market available on the Professor Keneth French's website. The portfolios are value-weighted. The period of the analysis is from January 2020 to December 2024. ***, ** and * indicate statistical significance at the 1%, 5% and 10% level.*

Appendix V– Table 5 – Correlation Matrix Between Portfolios and Risk Factors

Table 5

Correlation Matrix Between Portfolios and Risk Factors – Carhart (1997) four-factor and Fama and French (2015) five-factor models.

Four-factor model	Green	NonGreen	Difference	Mkt-rf	SMB	HML	MOM
FF Market Factor							
Green	1						
NonGreen	0,52	1					
Difference	0,79	-0,12	1				
Mkt-rf	0,53	0,63	0,16	1			
SMB	0,41	0,47	0,13	0,31	1		
HML	-0,17	-0,18	-0,07	0,04	0,09	1	
MOM	-0,35	-0,28	-0,20	-0,42	-0,42	-0,17	1

Five-factor model	Green	NonGreen	Difference	Mkt-rf	SMB	HML	RMW	CMA
FF Market Factor								
Green	1							
NonGreen	0,52	1						
Difference	0,79	-0,12	1					
Mkt-rf	0,53	0,63	0,16	1				
SMB	0,32	0,40	0,08	0,33	1			
HML	-0,17	-0,18	-0,07	0,04	0,37	1		
RMW	-0,20	-0,20	-0,09	0,05	-0,41	0,14	1	
CMA	-0,33	-0,23	-0,21	-0,20	0,00	0,65	0,15	1

Appendix VI– Table 6 – Portfolios' Performance Using Conditional Model

Table 6

Performance of green and non-green portfolios using conditional models.

Four-Factor model

FF Market Factor	α_{0p}	TS	DY	$Adj.\ R^2$
Green	0,007	3,498	-1,288	0,314
	(0,028)	(3,679)	(1,091)	
NonGreen	0,013	2,003	0,106	0,528
	(0,015)	(1,902)	(0,564)	
Difference	-0,006	1,495	-1,394	-0,031
	(0,030)	(3,883)	(1,151)	

Five-factor model	α_{0p}	TS	DY	$Adj.\ R^2$
FF Market Factor				
Green	0,006	124,265	52,609	0,650
	(0,025)	(169,063)	(31,914)	
NonGreen	25,357	-6,687	0,009	0,651
	(105,296)	(19,877)	(0,016)	
Difference	-0,003	98,908	52,296*	0,440
	(0,027)	(184,083)	(34,750)	

Table 6 presents estimates of the average conditional alphas the coefficients of the time-varying alphas, and the adjusted R^2 obtained from the conditional versions of the four- and five factor models. The excess returns of the US market available in the professor Kenneth French's website is used as the proxy for the market factor. The conditioning information variables used are the term spread (TS), computed as the difference between the yield of a long-term bond and a short-term interest rate (proxied by the 10-year Treasury Constant maturity rate (GS10) and the 3-month Treasury Bill Rate, respectively), and the dividend yield (DY) of the S&P 500 dividend yield. The portfolios are value-weighted. The period of analysis is from January 2020 to December 2024. ***, **, and * indicate statistical significance at the 1%, 5% and 10% level, respectively.

Appendix VII – Table 7 – Equally-Weighted Portfolios' Performance

Table 7

Performance of green and non-green portfolios – Carhart (1997) four-factor and Fama and French (2015) five-factor models.

Four-factor model	α_p	$\beta 1_{Mkt}$	$\beta 2_{SMB}$	$\beta 3_{HML}$	$\beta 4_{MOM}$		$Adj\ R^2$
FF Market Factor							
Green	0,089*	1,146	4,489***	-0,571	-2,578*		0,329
	(0,048)	(0,965)	(1,668)	(1,038)	(1,324)		
NonGreen	0,037*	0,902**	2,239***	-0,389	0,000		0,217
	(0,022)	(0,447)	(0,773)	(0,481)	(0,614)	\	
Difference	0,052	0,245	2,25	-0,182	-2,578*		0,166
	(-0,049)	(-0,985)	(-1,702)	(-1,059)	(-1,352)		

Five-factor model	α_p	$\beta 1_{Mkt}$	$\beta 2_{SMB}$	$\beta 3_{HML}$	$\beta 4_{RMW}$	$\beta 5_{CMA}$	$Adj\ R^2$
FF Market Factor							
Green	0,091*	1,858*	4,603**	-0,973	-1,631	-0,181	0,283
	(0,052)	(1,012)	(2,009)	(1,702)	(2,266)	(2,382)	
NonGreen	0,042*	0,808*	1,910**	-0,309	-0,475	-0,997	0,299
	(0,023)	(0,445)	(0,884)	(0,749)	(0,997)	(1,048)	
Difference	0,049	1,050	2,693	-0,664	-1,156	0,816	0,109
	(0,053)	(1,034)	(2,052)	(1,739)	(2,315)	(2,433)	

*Table 7 presents estimates of monthly abnormal returns (aplha), expressed in percentage, factor loadings, and the adjusted $R^{2.}$ obtained from regressing eq. (1) and (2). Mkt corresponds to the excess return of the market benchmark, proxied by the broad market returns of the US market available in the Professor Kenneth French's website. The 1-month Treasury Bill rate is used as risk-free rate, SMB, HML, MOM, RMW and CMA correspond to the risk factors for the US market available on the Professor Keneth French's website. The portfolios are equally-weighted. The period of the analysis is from January 2020 to December 2024. ***, ** and * indicate statistical significance at the 1%, 5% and 10%.*

Appendix VIII – Table 8 – Volatility Analysis

Table 8
Downside Risk and Sortino Ratio of Portfolios

	Green	Non-Green	Difference
Downside Risk	0,13	0,05	0,13
Sortino Ratio	13,76%	43,72%	-4,22%

Table 8 presents the summary statistics comparing the Downside Risk and the Sortino Ratio of green, non-green and difference portfolios. The table shows higher downside risk for green firms and a lower Sortino Ratio, suggesting weaker adjusted performance post-IPO

Appendix IX – Table 9 – Risk Analysis

Table 9
Systemic Risk and Idiosyncratic Risk of Portfolios

	Green	Non-Green	Difference
Systemic Risk	0,08	0,07	0,01
Idiosyncratic Risk	0,12	0,06	0,17

Tabela 9 presents the decomposition of total risk into systemic and idiosyncratic components for green, non-green and difference portfolios. Green firms exhibt higher idiosyncratic risk while systemic risk remains relatively the same across groups.