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Insights for sustainable business practices: Comparative impact of independent and corporate venture capital funding on financial and environmental performance☆

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ABSTRACT

This study aims to analyze the effects of venture capital (VC) financing schemes on the financial and environmental performance of their VC-backed companies. This research leverages a dataset including 325 U.S. firms between 2002 and 2022 and examines two issues of interest: independent venture capital (IVC) and corporate venture capital (CVC) funding. The results show that IVC-backed companies have significantly better environmental, social, and governance (ESG) ratings and emit fewer greenhouse gases (GHG) emissions when compared to companies backed by CVC. This highlights that the function of IVC is to improve the environmental sustainability of businesses. Together this helps provide a valuable perspective about which VC models (CVC, IVC) does have an impact on how businesses pursue sustainability practices alongside financial performance. This paper contributes to the sustainable entrepreneurship literature by focusing on the importance of funding types with performing sustainable practices.

1. Introduction

Venture capital (VC) financing undoubtedly has considerably driven the high rate of growth of startups and businesses today (Shuwaikh and Dubocage, 2022). But there is little research on the distinctive effect of Independent Venture Capital (IVC) and Corporate Venture Capital (CVC) on the environmental and financial performance of their backed companies (Chemmanur et al., 2014). The business activities have largely been oriented towards profit maximization. However, in a shift of paradigm there is now an emerging line of thought which emphasizes on environmental factor (Shuwaikh et al., 2022; Kraus et al., 2020). This is even more important now, given the growing international focus on environmental problems and the urgent need to address climate change. Tasks presented in the Paris Agreement such as the transition to renewable energy, increasing resource efficiency, implementing the principles of a circular economy, protecting biodiversity, sustainable transportation have taken on particular importance for companies of various industries.

☆ We declare that this work has: not been submit elsewhere, no conflict of interest, and no ethical issues.

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Although many studies have analyzed the financial and environmental performance of firms (e.g., Mansouri and Momtaz, 2022, Lange and Banadaki, 2023; Velte, 2017; Chouaibi et al., 2022). Some research has been reported on the environmental performance, e.g, Benkraiem et al. (2023a), and Lewandowski (2017), other researchers have examined financial performance, Environmental, Social, and Governance (ESG) criteria and corporate social responsibility (CSR) e.g. Diekel and Vanessa (2023) and Battisti et al. (2022). environmental performance. The ongoing studies in the field of VC financing have not provided the effect of different types of funding i.e., VC and financial performance aspect of corporate sustainability to date. A gap remains in the literature about the differentiated effects of IVC and CVC financing models on companies' financial and environmental performance of their funded companies. The study approaches at probing into the effectiveness of different VC strategies in fostering sustainable business practices and environmental sustainability practices.

IVCs, or "traditional venture capital," is generally focused on generating strong financial returns and investments for both the investing firm and their funded companies. On the other hand, CVC is the effort of large companies to directly invest in startups and the development of young companies to innovate its own business. The organization, interests, and motivations of these two mechanisms of finance could not vary further (Shuwaikh et al., 2023a). Based on the unique characteristics of companies that influence the success of CVC or IVC, this research aims to fill the existing gap, understanding the benefits and limitations inherent to each type of financing (Mazza and Shuwaikh, 2022). The research objective of this paper is primarily to clarify the impact of IVC and CVC funding mechanisms on their backed companies performance.

The crucial contribution of this research is the entry on environmental performance which will assist in identifying the determinants of the impact of IVC and CVC funding on business sustainability. The financial consequences for sustainability-focused business have emerged as an interesting topic of analysis as how the financial performance of companies can shape the sustainability prospects will surely be influenced by investors' assessment on financial return (Yuniarti, Soewarno and Isnalita, 2022). Through such decisive criteria as the ESG scores for environmental performance (Bassen and Kovács, 2008) or the GHG emissions. The focus on sustainability in the investment decision process allows this analysis to go beyond traditional financial measures, effectively illustrating how financing decisions interact with environmental performance. This provides an important resource for investors adopting new sustainable development strategies.

The paper contribution also is a comparison of IVC and CVC on financial performance. Net Income is an important measure for investors to assess the success of the company financial measurement (Yuniarti et al., 2022). This report is essential reading for both VC stakeholders as well as the stakeholders interested in understanding the rationale behind it. By presenting a systematic evaluation of the IVC as well as CVC financing, the study permits stakeholders to select the source of funding according to their needs and preferences. This helps them to plan a strategy that is custom suited for their need.

Our study, then, sheds light on a debate that has been ongoing in policy circles about the potential role of VC to act as an investor to enhance environmental sustainability. With growing policy and regulatory attention on the inclusion of ESG factors in corporate strategies, this research contributes important insights about how different types of VC funding influence environmental performance. Previously a number of studies have examined the overall influence that venture capital has on financial and environmental performance, but little comparative research between IVC- and CVC- backed companies. We clarify this by directly comparing investments in these two types of VC and delving into their consequences for ESG and greenhouse gas (GHG) emissions.

This paper is structured as follows to address the research question on the impact of venture capital financing types (IVC vs CVC) on financial and environmental performance. In Section 2, a systematic literature review will be presented, highlighting existing research. Section 3 will outline the data selection and methodology employed in this study. Section 4 will present empirical results and the analysis of each model. Finally, Section 5 will discuss limitations and provide recommendations for future research.

2. Theoretical framework

2.1. Introduction to venture capital funding

VC firms have eye-popping power to fuel and flourish new startups and entrepreneurial ventures (Shuwaikh and Dias, 2023). There are two broad methods of VC financing: first, the traditional IVC path and a larger volume of activity deemed CVC. The intent of this section is to elucidate the distinctions between these two financing mechanisms and enable readers to comprehend their distinct utility and features. Depending on regional environments, market conditions and cultural attitude towards sustainability the effect of VC may vary in terms ESG performance and GHG emissions. For example, regions with tight environmental regulations or sustainability legacies might experience varied dynamics. While our findings may be specific to U.S. firms, the core idea that VC plays in sustainability are of potential broader applicability internationally as well. Nevertheless the manner in which IVC and CVC function may vary due to regional facilities. Therefore, comparative studies might be meaningful to further explore how geographical location determines the effect of IVC and CVC.

The paper examines U.S. firms over the 2002–22 period, which has seen rapid and far-reaching changes in both VC markets and environmental regulations. The U.S., home to one of the largest venture capital ecosystems globally, is a valuable dataset used by many researchers for studying corporate finance and innovation patterns around the world. The specific time period included was pivotal in the transition of venture capital strategies from post-dot-com excesses to today's focus on sustainability and ESG metrics. This range covers important moments such as the entering into force of Paris Agreement, which has been urging companies more to introduce green technology and enhance their ecological performance.

Caselli and Negri (2021) provide an extensive overview of how VC markets work differently from country to country in the E.U. The variation with respect to cultural, economic and regulatory factors specific by country influence investment strategies as well as sector

focus on the impact of VC in general innovative activities and overall growth. A number of challenges that are unique to the European market, such as granularity and regulatory differences, both more so than can differ dramatically from those encountered by U.S. or Asia-Pacific countries. By combining these perspectives, authors extend the discussion of VC in sustainability and grounds our insights into a global context that may facilitate comparisons with regions across the globe.

Groh et al. (2010) built composite indices that assess the attractiveness of 27 European countries for institutional investment in VC and Private Equity. Top countries in terms of quality and range of the products offered are significantly amplified by better investor protection, corporate governance and larger as well as more liquid capital market. The size and liquidity in the market also demonstrates to the broader financial community experience with professionalism, deal flow and exit opportunities. In general, their results indicate that although investor protection and capital markets are important aspects of attractiveness, many other characteristics also matter.

2.1.1. Independent Venture Capital

IVC is grounded in a core set of principles as a strategic approach to finance creative sector businesses. As noted by Fulghieri and Sevilir (2009), IVCs are formed by VC firm, one of the most prominent types of investment institutions that concentrate on the selection of companies for the allocation of their resources that demonstrate a high perspective for innovation. This technique aims to achieve high capital gains through the growth and valuation increase of selected companies. Colombo and Murtinu (2017) has shown that IVC can manage any types of funds from all kinds of sources i.e. banks, pension funds, hedge funds, insurance companies, university endowments, high-net-worth individuals, and family offices. As described by Chemmanur et al. (2014), each individual fund is structurally set up as a discrete limited partnership, with the management firm serving as the general partner, and the capital backers as limited partners.

This form of organization can ensure the transparency and openness of management and mobilize interest of invested parties by efficiency of IVCs credibility. They have a number of financial sources which allow them to research all sort of opportunities and take a bit of risk. This is why they are a critical driver of innovation and economic growth. IVCs also do not control the destiny of start-ups as they are mostly not linked to the start-ups beforehand. This method ensures an impartial and neutral way to choose the investments (Colombo and Murtinu, 2017).

As Chemmanur et al. (2014) in detail emphasized, the greatest capitalism constant in IVC finance is the focus on maximizing financial returns. IVCs differentiate themselves from most other investments as they also often place an emphasis on, or mandate, financial returns for shareholders, indicating their intention to do everything they can to generate as high a profit as possible for the individuals who have placed money in their fund. The central aim is gaining maximization on investments, but with the intention of aligning the interests of investors and the growth trajectory of innovation-based companies (Fulghieri and Sevilir, 2009). IVCs play a critical part, as these firms provide money and specialized knowledge and strategic advice to companies that are in their investment portfolio. Fulghieri and Sevilir (2009) suggest that IVCs is actively initiated by investors. They do more than just give money but work to make their portfolio businesses successful.

2.1.2. Corporate Venture Capital

Shuwaikh (2018) explain how CVC is a strategic investment technique of existing corporates into pioneering start-ups. This investment goes further than just the money and it implies an intimate physical relationship between the parent company and the startup (Shuwaikh and Dubocage, 2022). This close relationship, in the shape of either minority or virtual control ownership, goes beyond the traditional financial benefits. Therefore, the latter is of negligible importance in relation to the former, is often set up to capture strategic synergies. CVC is unique given its diverse set of objectives. Mazza and Shuwaikh (2022) argued that CVC enterprises are not only for profit but also for strategic purposes — such as entering new industries, gaining technological insights, and seeking strategic alliances (Fulghieri and Sevilir, 2009). As highlighted by Chemmanur et al. (2014), this strategic focus is intended to create a differential competitive advantage to the parent firms (Shuwaikh et al., 2022b).

Some special characteristics of companies backed by CVC indicate that CVC-backed firms exhibit greater innovation output despite being younger, riskier, and less profitable relative to IVC-backed firms (Chemmanur et al., 2014). Value creation is a crucial aspect of CVC and specifically for its capability to exponentially increase value by tapping into the specialized resources of the parent firm of the CVC investor (Shuwaikh et al., 2022c). Greatly from the CVC model, as they get access to significant resources and domain expertise. Several core competences may be highlighted, including a variety of distribution channels, sales force capabilities, brand reputation, production improvements, and complementary technology expertise (Colombo and Murtinu, 2017).

The comprehensive strategy that is adopted in research to study VC funding is to choose certain financial performance indicators (ROA, ROE and Tobin's Q) which are meticulous to highlight the financial performance (Benkraiem et al., 2023b). The choice of the initial set of predictors builds on both the relevance and recurrence/occurrence of indicators in the extant literature suggested in Naeem, and Çankaya (2022) and Benkraiem et al. (2023a), and Velte (2017).

The empirical literature studying the link between environmental performance and competitiveness essentially examines whether practices consistent with a more environmentally friendly behavior translate into financial gains (Benkraiem et al., 2022). In other previous studies different internal and external driving forces were pointed out as motivated factors of environmental performance (Hart, 1995). In addition to the firm level outcomes, many studies have also aimed at explaining why environmental performance should matter for financial and non-financial measures (Klassen and Mclaughlin, 1996). One way of dealing with environmental problems is through incentives which do not directly force to go green, but motivate firms into adopting environmentally friendly behavior. For instance, Qian et al. (2022) have shown that corporate environmental responsibility activities improve firms ROE by 2.62 % and enhance their firm value about 0.10 %. These are firms represented on units which were traded (and also showed an

upward trend with time) as green, whose economic value added revealed an increasing trajectory through the years and in different periods had varying ROE (Shuwaikh et al., 2023a).

Related to this is that environmental performance improvements have a timing effect on financial success (Hoang et al., 2020). Other studies have analyzed the degree to which environmental performance impacts profitability within different industries (Chen et al., 2023). The negative relationship seems to be sector focused as suggested by Bendig et al. (2022) that found relatively uniform broad-based economic sectors were more volatile than narrowly defined business-cycle sensitive industry groupings. Furthermore, (Gonenc and Scholtens, 2017) have also documented similar negative relationships within the fossil fuel industry demonstrating that a relaxed regulatory framework can create stronger linkages among these variables.

The considerable and increasing body of research on environmental performance and financial success suggests that a "win-win" situation is realistic and firms can improve their financial outcomes by improving their environmental (Adomako et al., 2021). Busch and Hoffmann, (2011) find empirical evidence that financial performance, as measured by Tobin's Q, is positively related to outcome-based environmental indicators but this relation seems less robust for the process management based measurements. These benefits of improved environmental performance more than offset possible drawbacks to the company (Ambec and Lanoie, 2008); additionally confirmed by Dixon-Fowler et al. (2013) found a positive and significant association between environmental performance and market-based financial metrics.

Hypothesis 1. IVC- backed companies exhibit better financial performance in comparison to CVC-backed companies.

2.2. VC and ESG performance

Investor's emphasis on ESG aspects emerged as a common theme and featured high on their agenda in the current discussions (Naeem and Çankaya, 2022). Regarding ESG ratings, Bassen and Kovács (2008) also point out that "the development of ESG ratings has an important macroeconomic impact in the sense of providing information about company risks and opportunities to investors and stakeholders", and that "ESG ratings have rather evolved notably". ESG basically has to do with putting ESG factors at the heart of business practice. They are these important elements that are applied to assess the business ethics, corporate social responsibly and corporate governance while being classified as the non-financial performance indicators (Kim and Li, 2021).

Naeem and Çankaya (2022) believed that ESG provides a comprehensive analysis through integration of company ESG activities, which will increase the resolution of examination. Also, due to the awareness in the business world, there is an increased amount of interest in ESG strategies and investments as well as a demand in transparency and sustainability of such systems (Naeem and Çankaya, 2022). Making ESG disclosure helps increase transparency, reduce information asymmetry, and enhance investor confidence (Yang et al., 2023). In addition, more transparent can also reduce the cost of firm can be attributed to misleading information issues and promote the company and investors to trust each other (Cheng, Ioannou, and Serafeim, 2014).

This is aligned with the current sustainability investment movement pushing for VCs to incorporate ESG factors to their decisions or investments as illustrated by Bocken, Rana, and Short (2015). In a study by Botsari and Lang (2020), 70 % of VCs claim ESG issues form part of their investment considerations in investment decision making, with most of its focus during due diligence. Nonetheless, despite ESG screening being extraordinarily widespread, translations into ESG incorporation are scant (Lange and Banadaki, 2023). This underscores the importance of fully and consistently integrating ESG considerations to maximize their impact on investment decision-making. This underscores the importance of embedding ESG factors deeply and consistently to maximize the impact on investment decisions. VCs acknowledged the paramount significance of ESG, in both future investment decisions and the necessity to implement ESG into their strategy in order to attract more funds (Lange and Banadaki, 2023).

VCs should think about integrating ESG criteria into their investment decisions. When sustainable long-term operations are the goal of a VC. VCs can provide guidance and resources to their portfolio companies in order for them to improve upon sustainability practices. This would include any ESG reporting, sustainability strategy and advancement in green technologies. Sustainability should be on the radar for startups, they will have to figure out how to incorporate it into their business model in order to receive IVC funding and increase ESG. This can include installation of green technologies, resource use efficiency and good environmental management practices. Focusing on sustainability eventually pays great dividends, for instance in the form of investor relations and market positioning. ESG performance of a business is likely to attract more investors and customers if it is good, even considering some startups.

While IVCs typically chase high growth opportunities, ESG factors have become a more important part of the consideration set as the market has demanded it. For example, VCs who are independent may help startups having innovative technologies and solutions that leads to reduce GHG emissions. Most CVCs require their investments to be aligned with the sustainability goals of the parent corporation, leading to a higher standard when it comes to ESG criteria for portfolio companies.

Hypothesis 2. IVC-backed companies exhibit higher environmental performance (ESG) in comparison to CVC-backed companies.

2.3. VC and GHG emissions

The present circumstances emphasize the critical significance of adopting environmentally friendly practices in the endeavor to achieve worldwide sustainable development. Human activities, which release substantial amounts of GHG (Adedoyin, Alola, and Bekun, 2020), are primarily responsible for climate change. This phenomenon is causing a significant disruption to the global ecosystem. Businesses are increasingly acknowledging the significance of environmentally friendly investments as a means to address and mitigate pollution. Nevertheless, addressing the worldwide issue of climate change resulting from GHG emissions remains a multifaceted endeavor (Sun et al., 2022; Al-Ismail et al., 2023; Goglio et al., 2020). Shuwaikh et al. (2022a) emphasize the imperative

of establishing ambitious goals in order to foster a sustainable future with reduced carbon emissions.

In the current context, in order to pursue global sustainable development, the global citizens have more reasons to accept environmentally safe practices. Climate change is largely due to the release of massive greenhouse gases by human activities (Adedoyin et al., 2020). This trend is disrupting entire ecosystem on global scale. More and more businesses are realizing the importance of eco-conscious investing in an age when pollution is so rampant. However, the solution of global problem of the climate change caused by GHG emissions is a complicated issue (Sun et al., 2022; Al-Ismail et al., 2023; Goglio et al., 2020). Shuwaikh et al. (2022a) warn that any sustainable future with decreased carbon emissions must have notably aspirational target setting.

However, there is a large gap in VC funding for green startups due to risks related to regulatory uncertainty and volatility in the regulation (Bianchini and Croce, 2022). Therefore, as Hegeam and Sørheim (2021) illuminated, while sustainable VCs seek companies that support environmental goals, the question is how visible are they? A a new methodology named “Climate Performance Potential” (CPP) has been proposed so as to facilitate the evaluation of the environmental sustainability of venture capital firms. The CPP can provide the more informed perspective that investors desire, as it evaluates whether a startup has the potential to reduce a minimum of 100 million tons of carbon dioxide equivalent (CO2e) (Leendertse et al., 2021).

The CPP stands for climate performance potential that pertains to the ability of a start-up to assess the GHG emissions. The assessment alleviates the information gap, for example, helps start-ups to reveal their attractiveness but also supports VCs in making better decisions (Trautwein, 2021). In the end, companies must reduce their GHG emissions to tackle and redress the danger of climate change. It is equally important these organizations also understand the impact these emissions have on a business-as-usual basis. A major challenge is still in identifying businesses and entrepreneurs consistent with the sustainability goals of VC (LinLin, 2022).

Hypothesis 3. IVC-backed companies exhibit higher environmental performance (GHG) emissions in comparison to CVC-backed companies.

3. Data and methodology

3.1. Data and variables

The sample selected for our work includes companies located in the USA, this choice reflecting the country position as the most dynamic VC market and its impact as a benchmark of success. In recent years, VC investment in the USA has grown significantly, reaching unprecedented levels. VC-backed companies account for 41 % of total US market capitalization and 62 % of US public companies’ R&D spending (Gornall and Strebulaev, 2021). Furthermore, the environmental dimension is becoming increasingly important within companies, through various initiatives such as the reduction of GHG emissions, the adoption of respectful technologies, and the implementation of strategies aimed at minimizing their ecological footprint. This cultural shift will continue to encourage change in corporations as society realizes the urgent need for ecological and social change.

Regarding the study sample, we select a target period of 2002–2022. The data is extracted from various platform. Firstly, information on US companies financed by IVCs or CVCs was obtained from the Thomson VentureXpert database (Shuwaikh et al., 2023b). Financial and accounting data were obtained from Standard and Poor’s Compustat database. ESG score and GHG emission data were retrieved from Datastream Refinitiv Eikon database.

A careful procedure was undertaken to consolidate multiple databases, specifically merging the Thomson VentureXpert database with the Compustat and Refinitiv Eikon databases. Initially, the Thomson VentureXpert database was integrated with the Compustat database, employing the "VLOOKUP" function through company names and tickers. Subsequently, a parallel process was executed for data obtained from Datastream Refinitiv Eikon. A meticulous manual verification process was then conducted to ensure the accuracy and alignment of the merged data. The final sample used for analysis consisted of 32 companies funded by CVC, 293 companies funded by IVC, and a total of 1311 observations.

3.1.1. Dependent variables

This study tests on the financial and environmental performance by using the dependent variables: ROE, ROA, Tobin’s Q, ESG score and GHG. ROE, as a measure of how profitable a company is compared to its equity holders. A greater ROE indicates that more profits are being generated relative to the capital employed. ROA as well serves as a profitability index, the measure of return produces on all company assets, demonstrating how efficiently the company turns assets into profits. Meanwhile, Tobin’s Q of the firm value, which is the ratio of the market value of assets to their replacement value.

The environmental performance is represented by ESG score. The ESG score is a global score based on companies’ self-reported information. These scores are recorded on an annual basis and are constructed from three different sub-indices (environmental, social, governance). The emission performance is illustrating by GHG emissions. GHG emission intensity is determined by calculating the ratio of Scope 1 (direct) and Scope 2 (indirect) emissions to revenue. This metric serves as an indicator of a firm’s tangible carbon performance, where a lower intensity score signifies a superior carbon performance for the company (Busch and Hoffmann, 2011). It is considered the optimal solution for in-depth analysis of our data. In addition, for a better interpretation of emissions performance, with lower GHG emissions corresponding to higher values for environmental performance, the input variables are multiplied by (- 1), in line with (Busch and Hoffmann, 2011).

3.1.2. Independent variable

In our work, we have 2 subsets of companies, i.e. distinguishing between companies that received IVC financing or CVC financing,

respectively. This classification is achieved by introducing a binary variable, called "investor_type", which distinguishes between the two types of financing, this will represent the one and only independent variable. This independent variable assigns a value of 1 to companies receiving IVC financing and 0 to those receiving CVC financing. The utilization of a binary variable is pivotal in modeling and comprehending the associations among various financing types.

3.1.3. Control variables

The control variables are retrieved from financial statements in Compustat platform. Financial leverage, represented by the "lev" variable, measures the degree to which a company uses debt to finance its operations and assets. It is calculated as total debt by total equity and reflects the proportion of a company's financial structure financed by debt. The "size" variable is measured using the natural logarithm of total assets. By controlling for size, researchers seek to discern whether the observed effects are attributable to factors beyond the scale of the company. Capital intensity, indicated by the "cap_intensity" variable, evaluates the level of capital investment required to generate income. It assesses the efficiency with which capital is used in the production process. The innovation capacity, represented by the "innov_cap" variable, quantifies a company's commitment to innovation and its ability to participate in R&D activities. This variable is calculated as the ratio of Research and Development Expense to total assets. The aim of this measure is to control the capacity to innovate on different performances.

The "ageoffinancing" variable represents the age at which the company was first financed. The inclusion of this variable is intended to explore the implications of the temporality associated with obtaining financing; this measure is reported in months. The "invest_-date" control variable focuses on the date of the first investment in the company, providing a precise timeline of when investors first injected funds. The "fund_stage" control variable represents the stage in the financing cycle that a company has reached when raising funds. This variable is decomposed into four distinct categories: Seed Stage, Early Stage, Later Stage and Balanced Stage. The inclusion of the "fund_stage" variable in our analysis enables us to explore the implications of the financing phase on aspects of financial, environmental and emissions performance. The "public_status" control variable provides information on the public or private status of companies.

3.2. Empirical modeling

Concerning the detail of the terms of the equation models, $_{it}$ represents the individual company $_{i}$ at time $_{t}$. On the other hand, the term α_i represents unsystematic or unobserved variations, which are specific to each individual or unit in the sample, while the term u_{it} captures residual errors or disturbances that are not explained by the independent variables or random effects. It captures idiosyncratic variations specific to each observation or unmodeled changes over time.

Firstly, to test the impact of investor type on the financial performance, three distinct equations are applied:

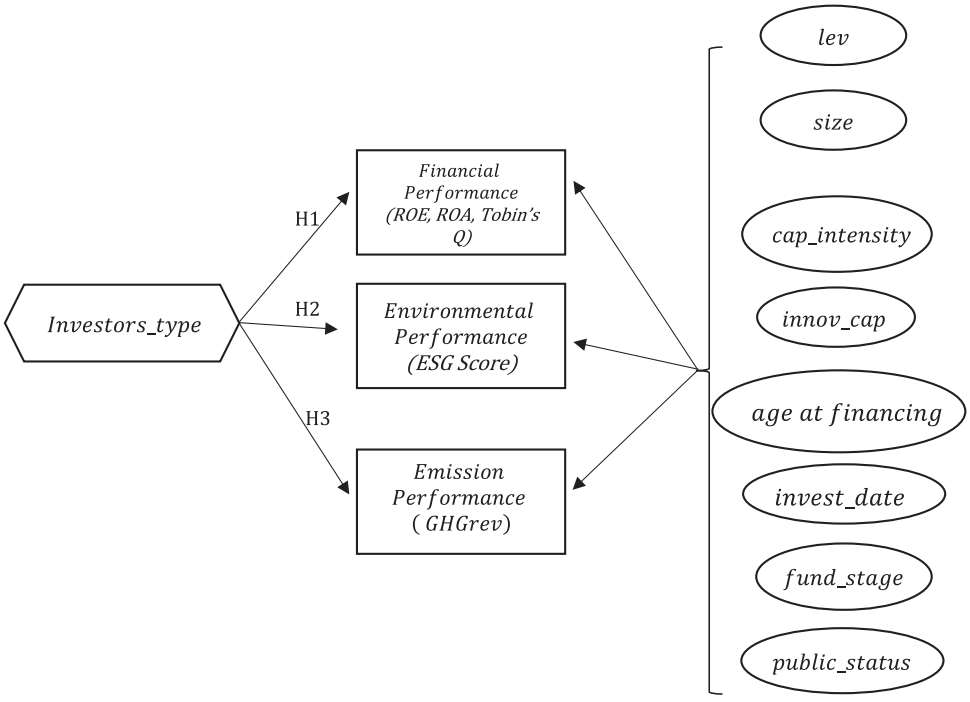

Fig. 1. Research Model. Representation of the research question. This one includes all dependent, independent and control variables. Hypothesis H1: Companies receiving IVC financing have a better financial performance compared to companies relying on CVC. H2: IVC-backed companies have better ESG performance than CVC-backed companies. H3: IVC-backed companies have better GHG emissions than IVC-backed companies.

$$ROEi_t = \alpha i + \beta 0 \quad + \beta 1\left(investors_{type}\right) + \beta 2(lev) + \beta 3(size) + \beta 4\left(cap_{intensity}\right) + \beta 5\left(innov_{cap}\right) + \beta 6(ageatfinancing) + \beta 7\left(invest_{date}\right) + \beta 8\left(fund_{stage}\right) + \beta 9\left(public_{status}\right) + ui_t$$

$$ROAi_t = \alpha i + \beta 0 \quad + \beta 1(investors\_type) \quad + \beta 2(lev) \quad + \beta 3(size) \quad + \beta 4(cap\_intensity) \quad + \beta 5(innov\_cap) + \beta 6(ageatfinancing) + \beta 7(invest\_date) + \beta 8(fund\_stage) + \beta 9(public\_status) + ui_t$$

$$Tobin'sQi_t = \alpha i + \beta 0 \quad + \beta 1(investors\_type) \quad + \beta 2(lev) \quad + \beta 3(size) \quad + \beta 4(cap\_intensity) + \beta 5(innov\_cap) + \beta 6(ageatfinancing) + \beta 7(invest\_date) + \beta 8(fund\_stage) + \beta 9(public\_status) + ui_t$$

Secondly, to evaluate the impact of investor type on environmental performance represented by the ESG score, the resulting regression equation is specified as follows:

$$ESGi_t = \alpha i + \beta 0 \quad + \beta 1(investors\_type) \quad + \beta 2(lev) \quad + \beta 3(size) \quad + \beta 4(cap\_intensity) \quad + \beta 5(innov\_cap) + \beta 6(ageatfinancing) + \beta 7(invest\_date) + \beta 8(fund\_stage) + \beta 9(public\_status) + ui_t$$

Thirdly, to examine the impact of investor type on emission performance, one distinct equation is employed:

$$GHGrevi_t = \alpha i + \beta 0 \quad + \beta 1(investors\_type) \quad + \beta 2(lev) \quad + \beta 3(size) \quad + \beta 4(cap\_intensity) \quad + \beta 5(innov\_cap) + \beta 6(ageatfinancing) + \beta 7(invest\_date) + \beta 8(fund\_stage) + \beta 9(public\_status) + ui_t$$

Fig. 1 provides an overview of the relationships between our key variables, making it easier to understand the underlying dynamics and reinforcing the clarity of our hypotheses and the coherence of our argument.

4. Empirical results and discussion

4.1. Descriptive statistics and correlation matrix

Table 1 shows the summary statistics for all dependent, independent, and control variables used in the different models. The statistical data for the variable assessing emissions performance, namely GHG, is presented before inversion. As a result, the values indicate higher GHG emissions and lower environmental performance. The analysis shows a varied set of financial and non-financial indicators, representing the underlying dynamics of the entities studied, the sample includes 325 companies.

The sample show a mean (median) Return on Assets (ROA) of −0.331 (-0.23), indicating that firms are underperforming in terms of generating profits in proportion to their total assets. By measuring other indicators, specifically Return on Equity (ROE) and Tobin's Q, are recorded at −0.236 (-0.076) and 4.172 (3.066) respectively, indicating different financial and market valuation levels. The high kurtosis value of 819.806 for ROA implies more pronounced extreme values compared to a normal distribution, a high kurtosis can be interpreted as a greater concentration of observations around the mean, but has very thick tails, indicating a significant presence of extreme values. Concerning the measure of the environmental performance, the mean (median) is 30.673 (28.62) respectively, offering insights into the green activities of the sampled companies. The dispersion of ESG scores is reflected by a standard deviation of 12.402, illustrating a certain variability in ESG performance within the sample. As for the distribution of scores, the positivity of skewness (1.147) indicates a slight asymmetry towards above-average ESG performance. However, kurtosis (5.123) suggests that the distribution is relatively moderate in terms of extremes, meaning that, while some scores may be high, there is no excessive concentration around extreme values.

Prior to inversing the emissions performance measures, including GHG emissions intensity, the average (median) is 226.101 (14.163). The last value is distinguished by a significant probability of extreme results, illustrated by a high kurtosis of 911.334 and a

Table 1
Summary statistics.

	Mean	SD	Min	Max	Median	Skewness	Kurtosis
ROE	−.236	.716	−11.713	2.563	−.076	−9.594	130.796
ROA	−.331	.965	−31.350	1.006	−.23	−25.953	819.806
Tobin's Q	4.172	3.593	0.303	33.853	3.066	2.599	13.167
ESG	30.673	12.402	1.560	85.74	28.62	1.147	5.123
GHG	226.101	3357.764	−1415.147	106289.99	14.163	29.168	911.334
investors type	.918	.274	0.000	1	1	−3.056	10.341
lev	.681	15.356	−206.323	459.884	.12	17.807	645.255
size	5.992	1.333	1.262	11.774	5.829	.913	5.287
cap intensity	.023	.032	0.000	.543	.012	5.231	64.231
innov cap	.249	.383	0.000	10.827	.185	17.605	457.464
ageatfinancing	22.795	29.695	−146.000	221	15	.672	11.008
invest date	18356.861	1587.372	15392.000	21843	18224.5	.173	2.207
fund stage	1.654	.762	1.000	4	2	1.368	5.105
public status	8.188	1.18	1.000	9	8	−2.93	14.892

positively high skewness of 29.168, underlining the exceptional and potentially risky nature of the data distribution. This skewness implies a considerable heavier tail risk in the distribution of GHG emissions intensity. This suggests the presence of outliers, perhaps represented by companies with exceptionally high GHG emissions. Additionally, the financial leverage provides an average (median) value of 0.681 (0.12), indicating a moderate level of financial leverage, the kurtosis is 645.255 suggesting an asymmetric distribution with the potential for extreme positive outcomes. Other variables like size, capital intensity and innovation capacity correspond to 5.992 (5.829), 0.023 (0.12) and 0.249 (0.185) respectively. Notably, for the innovation capacity, a remarkably high kurtosis of 457.464 and a positive skewness of 17.605 can be observed. We also note that the average (median) values of the variables age at financing, invest date, fund stage and public status associated to 22.795 (15), 1,8356.861 (18224.5), 1.654 (2) and 8.188 (8) respectively. Most companies in the sample exhibit an investor type of 1 (IVC), as indicated by the median value.

This detailed statistical summary provides a robust foundation for understanding the financial, environmental, and emissions-related dynamics within the research sample.

Table 2, correlation matrix, demonstrates that “ROE” has a highly significant positive correlation with “ROA”, “Tobin’s Q” and “ESG” of 0.318, 0.188 and 0.089 respectively, along with “size”. Conversely, “ROE” has a negative significant correlation the variables “cap_intensity”, “innov_cap” and “invest_date”. We can observe that the variable “public_status” has a positive correlation with "ROE" at a significance level of 5 %. The second financial performance, “ROA” has a highly significant positive correlation with “ESG” of 0.121 and “size”. However, “ROA” is negatively linked to “Tobin’s Q” at the 1 % significance level with values of −0.156, as well as “innov_cap”. The third financial performance, “Tobin’s Q” has a highly significant positive correlation with “size” and “innov_cap”, 0.109 and 0.108 respectively. Moreover, the variable “Tobin’s Q” has a negative correlation with “lev” and “invest_date” of −0.055 and −0.064, respectively, at a significance level of 5 % but also a positive relation with “ageatfinancing”. We note a positive relation with the variable “public_status” at 10 %.

Concerning the environmental performance variable, “ESG” has a significant negative relationship to “innov_cap” and “invest_date” of −0.144 and −0.110, respectively. The variable “ESG” has a highly significant positive correlation with “size” and “cap_intensity”. On the other hand, concerning the emissions performance variables, “GHG” has a highly significant positive correlation with “investor_type” of 0.110, that means investors have preference for companies with low emissions revenue performance. The variables have also a positive relation of 0.061 with “size” at the 5 % significance level. And a negative relationship with “fund_stage” at 10 %. The variable “investor_type” is positively linked to “cap_intensity” at the 5 % significance level with value of −0.064. And the variable has a significant negative correlation with “ageatfinancing” and “invest_date”.

About control variables, "lev" exhibits no statistically significant correlations. “size” reveals a high significant positive correlation of 0.197 with “cap_intensity” and a high negative correlation with “innov_cap”, “invest_date” and “public_status”. The variable “cap_-intensity” has a high positive relationship with “ageatfinancing” of 0.133, also has a negative correlation with “innov_cap” and “invest_date” of −0.061 and −0.064, repectively, at the 5 % significance level. The control variable “innov_cap” has a negative correlation with “ageatfinancing” and a positive with “invest_date” at the 10 % significance level. The variable “ageatfinancing” has significant correlation with “invest_date”, but a negative correlation with “fund_stage” and “public_status”. Finally, the variable “invest_date” has a high negative significant correlation with “public_status”

4.2. Relationship between VC funding and financial performance

Table 3 presents the impact of VC funding types (IVC vs CVC) on financial performance, ROE, and ROA as well Tobin’s Q. Standard errors (in parentheses) were estimated with random effects to control for unobserved heterogeneity across firms. The study results reveal that when compared to CVC backed companies, IVC-backed firms have a 22 % superior ROE, 37 % higher average in their ROA, and they also boasted of an average Tobin’s Q with about 48 %. highlighting the superior financial outcomes and market value achieved by IVC. This positive association indicates that, on average, companies with IVC backing perform better in terms of financial performance.

Further noteworthy relationships may be observed considering the control variables. There is a negative correlation between the "Tobin’s Q" variable and leverage of −0.125 at 5 % significance level, showing that high leverage and therefore high financial risk imply lower financial performance on average for the IVC sample. The "size" variable has a strong correlation with financial performance, positive for "ROE" and "Tobin’s Q" and negative for "ROA", which translates into larger companies in terms of revenue appearing to have lower ROA, but higher ROE and Tobin’s Q. Concerning "cap_intensity", we observe that more capital-intensive companies benefit from better short-term financial performance, as measured by ROA and ROE. The "innov_cap" variable affirms the same thing as the previous one, and also shows a positive "Tobin’s Q" as a measure of short- and long-term financial performance. The variable "ageatfinancing" has a strong positive correlation with "Tobin’s Q", the positive correlation may suggest that companies financed at a later age tend to have a better "Tobin’s Q". The "fund_stage" variable has no impact on financial performance. And finally, the "public_status" variable has a positive result with "ROE" and positive and significant for "ROA".

4.3. Relationship between VC funding and environmental performance

The Table 4 indicates the estimation result of the equation (4) and (5) through investor types and different control variables. The coefficient for investor type (0.460) suggests a positive association, indicating that companies benefiting from IVC financing have higher ESG scores than those dependent on CVC financing. The results explain that an IVC-backed company is likely to relate in higher GHG. The negative coefficient attributed to leverage, at −0.143, indicates that higher levels of debt are correlated with lower financial performance, reinforcing the idea of increased financial risk. The variable “size” has a highly significant positive coefficient of 0.612,

Table 2
Correlation Matrix.

Variables	(ROE)	(ROA)	(Tobin'sQ)	(ESG)	(GHG)	(investor,ype)	(lev)	(size)	(cap¡ntensity)	(innov,ap)	(ageatfinancing)	(invest date)	(fund stage)	(public,tatus)
ROE	1.000													
ROA	0.318***	1.000												
	(0.000)													
Tobin's Q	0.188***	−0.156***	1.000											
	(0.000)	(0.000)												
ESG	0.089***	0.121***	0.023	1.000										
	(0.001)	(0.000)	(0.398)											
GHG	−0.001	0.044	0.006	0.036	1.000									
	(0.984)	(0.147)	(0.844)	(0.228)										
investor_type	−0.027	−0.029	−0.004	0.041	0.110***	1.000								
	(0.337)	(0.291)	(0.896)	(0.140)	(0.000)									
lev	−0.022	0.006	−0.055**	−0.020	0.028	−0.011	1.000							
	(0.426)	(0.842)	(0.047)	(0.467)	(0.356)	(0.682)								
size	0.249***	0.289***	0.109***	0.454***	0.061**	0.029	0.014	1.000						
	(0.000)	(0.000)	(0.000)	(0.000)	(0.043)	(0.287)	(0.610)							
cap_intensity	−0.082***	0.015	0.022	0.089***	0.023	0.064**	0.005	0.197***	1.000					
	(0.003)	(0.600)	(0.416)	(0.001)	(0.439)	(0.021)	(0.860)	(0.000)						
innov_cap	−0.321***	−0.910***	0.108***	−0.144***	−0.035	0.032	−0.013	−0.364***	−0.061**	1.000				
	(0.000)	(0.000)	(0.000)	(0.000)	(0.242)	(0.244)	(0.631)	(0.000)	(0.027)					
ageatfinancing	0.023	0.033	0.070**	0.047*	−0.014	−0.195***	0.001	0.032	0.133***	−0.052*	1.000			
	(0.403)	(0.243)	(0.012)	(0.091)	(0.655)	(0.000)	(0.985)	(0.246)	(0.000)	(0.061)				
invest_date	−0.108***	−0.035	−0.064**	−0.110***	0.023	−0.194***	0.033	−0.099***	−0.064**	0.051*	0.197***	1.000		
	(0.000)	(0.213)	(0.021)	(0.000)	(0.444)	(0.000)	(0.239)	(0.000)	(0.023)	(0.069)	(0.000)			
fund_stage	0.017	0.012	−0.018	0.024	−0.053*	−0.018	0.025	0.087***	0.029	−0.001	−0.070**	−0.043	1.000	
	(0.536)	(0.671)	(0.519)	(0.393)	(0.081)	(0.504)	(0.375)	(0.002)	(0.290)	(0.962)	(0.012)	(0.123)		
public_status	0.060**	0.002	0.047*	0.010	−0.014	0.010	−0.027	−0.074***	−0.027	0.020	−0.119***	−0.477***	−0.035	1.000
	(0.030)	(0.953)	(0.086)	(0.708)	(0.637)	(0.728)	(0.330)	(0.007)	(0.324)	(0.460)	(0.000)	(0.000)	(0.199)	

*** p<0.01, ** p<0.05, * p<0.1
The correlations for the variable measuring emissions performance, "GHG", is shown after inversion.

Table 3
VC Funding and Financial Performance.

	(1)	(2)	(3)
VARIABLES	ROE	ROA	Tobin's Q
investor_type	0.223**	0.374**	0.484***
	(0.075)	(0.045)	(0.399)
lev	−0.109	−00398	−0.125**
	(0.131)	(0.722)	(0.637)
size	0.103***	0.315***	0.512***
	(0.162)	(0.974)	(0.862)
cap_intensity	0.331***	0.423**	0.543**
	(0.689)	(0.414)	(3.669)
innov_cap	0.469***	0.353***	0.758***
	(0.0520)	(0.0313)	(0.277)
ageatfinancing	0.105**	0.312**	0.342***
	(0.213)	(0.312)	(0.153)
fund_stage	0.00268	0.0208	0.0159
	(0.0254)	(0.0153)	(0.135)
public_status	0.0190	0.0228*	−0.0955
	(0.0199)	(0.0120)	(0.106)
Constant	132.284**	106.451**	4é3.284**
	(0.584)	(0.284)	(0.374)
Observations	1258	1258	1258
R-squared	0.456	0.836	0.543

This table explores the impact of venture capital funding types (IVC vs CVC) on the financial performance. Significance levels are denoted by *, **, and ***, representing statistical significance at the 10 %, 5 %, and 1 % thresholds, respectively.

Table 4
VC Funding and ESG and GHG Performance.

	(1)	(2)
VARIABLES	ESG	GHG
investor_type	0.460**	0397***
	(1.235)	(452.5)
lev	−0.143	5.496
	(0.0197)	(6.145)
size	0.612***	0.432*
	(0.267)	(0.534)
cap_intensity	0.241	0326
	(0.352)	(0464)
innov_cap	0.311**	0.224**
	(0.856)	(534.8)
ageatfinancing	0.315**	0.284*
	(0.131)	(0.401)
fund_stage_num	−0.704*	−0.381*
	(0.418)	(0.318)
public_status_num	0.312***	0.512**
	(0.328)	(0.154)
Constant	435.053	823,392**
	(6.719)	(2345)
Observations	1258	1258
R-squared	0.265	0.453

This table presents the impact of venture capital funding types (IVC vs CVC) on ESG and GHG emissions. Significance levels are denoted by *, **, and ***, representing statistical significance at the 10 %, 5 %, and 1 % thresholds, respectively.

this implies that larger companies may present stronger levels of ESG, due to the capacity and resources required to implement ESG initiatives and practices on a larger scale.

The « innov_cap" has a positive coefficient at 0.311. This result can be interpreted as, companies oriented towards sustainability and good ESG practices are likely to invest more in research and development, thus fostering a greater capacity for innovation, potentially suggesting a more thorough integration of sustainable practices by innovative companies. The "ageatfinancing" has a significant positive coefficient of 0.315 at 5 % of significance level. This indicates that there is a relationship between the age at which a company is first financed and its ESG score. Furthermore, the positive correlation may suggest that companies financed at a later age tend to have higher ESG scores.

The "fund_stage" show a negative coefficient of −0.704. The correlation is negative, indicating an inverse relationship between company financing stage and ESG score. This means that companies in the early stages of financing (Seed Stage and Early Stage) tend to

have higher ESG scores than companies in more advanced stages (Later Stage and Balanced Stage). The “public_status” has a high positive correlation with a value of 0.312, suggesting a robust relationship between these two variables. This means that companies with public status tend to have higher ESG scores than private companies. In general terms, companies receiving funding from IVC investors exhibit superior ESG scores in comparison to those supported by CVC investors.

In other words, IVC-backed companies tend to have on average 39.7 % higher GHG revenues compared to CVC backed companies (a beta coefficient of 0.397). This positive, important relationship suggests that companies backed by IVC have more opportunities to generate revenue from GHG reduction initiatives on average and this could be related with the financing backing from their investors. Moreover, we note that the coefficient is significant at 1 % of significance level. As for the other variables, the coefficient of leverage (5.496) is not statistically significant. Consequently, there is no strong evidence that leverage significantly affects greenhouse gas emissions intensity in this model. The coefficient of the variable “size” is positive at 0.432 and is statistically significant at 10 %. This means that, in this model, firm size has a little significant impact on greenhouse gas emissions intensity. This result remains fairly low. The positive coefficient “cap_intensity” of 0.326 is not statistically significant. Consequently, capital intensity does not appear to be a significant factor in explaining variations in greenhouse gas emissions intensity in this model. The variable “innov_cap” has a positive coefficient of 0.224, suggesting a positive association between innovation capacity and greenhouse gas emissions intensity. However, the lack of significance indicates that caution should be exercised before drawing strong conclusions.

The variable “ageatfinancing” has a coefficient of 0.284, the significance of the correlation suggests that there is sufficient statistical evidence to assert that age at financing has a significant relationship with the "GHG" variable. The "public_status" has a positive correlation of 0.512, and seems to be a significant factor in explaining variations in greenhouse gas emissions. The negative coefficient (fund_stage) of −0.381 is statistically significant at a level of 10. This suggests that, at more advanced stages of financing, companies may have lower greenhouse gas emissions relative to revenue. In our analysis, we have adopted one distinct measure to assess emissions performance “GHG". It is essential to note that emissions intensity (GHG) offers a more robust and significant perspective. Furthermore, the use of the ratio of greenhouse gas emissions to revenue is common practice in the academic literature, as demonstrated by researchers such as (Busch and Hoffmann, 2011).

IVCs are focused on financial gains and invest in startups that have a high probability of growth and innovation. Part of their growth strategy may involve an increased focus on assisting companies that are leading in sustainable technologies and practices. And this new alignment—for better or worse—will land on the side of best-practice sustainability and align with cutting edge ideals, potentially earning higher ESG ratings / lower GHG emissions. Earlier, CVC was more prevalent in a firm wanting access to new technologies or market opportunities without having it through its R&D powerhouse. Although aspects of sustainability have started to become a part of the mandate for some CVCs, core areas tend to represent key strategic directions or new business opportunities that may deviate towards enhancing four pillars. Because of this strategic focus, GHG emissions are higher and ESG ratings lower than for IVCs. Indeed, IVCs can do more than simply provide financial assistance; they often have the necessary know-how and resources to help startups integrate sustainable practices. The support can also provide ways to manage their environmental impact and sustainability initiatives, leading to improved ESG performance (and ultimately lower GHG emissions). CVCs could have a range of sustainability expertise and

Table 5
Total funding, VC Funding, Financial and Environmental Performance.

	(1)	(2)	(3)	(4)	(5)
VARIABLES	ROE	ROA	Tobin’s Q	ESG	GHG
totalfunding	0.124**	0.232**	0.423***	0.341**	0.343***
	(0.153)	(0.142)	(0.000)	(0.001)	(0.155)
investor_type	0.142**	0.212**	0.227***	0.245**	0.347***
	(0.761)	(0.043)	(0.399)	(0.243)	(0.331)
lev	−0.0108	−0.0403	−0.0124*	−0.0174	−0.323
	(0.0121)	(0.0718)	(0.0632)	(0.0197)	(0.2201)
size	0.113***	−0.0375***	0.633***	3.644***	173.7*
	(0.0178)	(0.0106)	(0.0931)	(0.290)	(103.2)
cap_intensity	−4.289***	−0.882**	0.922	−11.70	2164
	(0.714)	(0.425)	(3.739)	(11.65)	(4099)
innov_cap	−0.457***	−2.358***	1.794***	0.505	−197.3
	(0.0528)	(0.0314)	(0.276)	(0.862)	(546.4)
ageatfinancing	0.001	−0.002	0.128***	0.278**	−0.605
	(0.714)	(0.425)	(0.374)	(0.0117)	(3.896)
invest_date	−0.263**	0.523**	−0.036	−0.0344	0.137
	(0.332)	(0.223)	(0.225)	(0.004)	(0.031)
fund_stage	0.504	0.196	0.0363	−0.723*	−0.221*
	(0.257)	(0.153)	(0.135)	(0.420)	(0.714)
public_status	0.248	0.238*	0.134	0.908**	0.051
	(0.235)	(0.140)	(0.123)	(0.384)	(0.715)
Constant	101.177**	10.70634**	110.805**	110.653**	110.112**
	(0.443)	(0.264)	(0.321)	(0.232)	(0.567)
Observations	1258	1258	1258	1258	1258
R-squared	0.258	0.242	0.271	0.423	0.241

This table explores the impact of venture capital funding types (IVC vs CVC) with total funding. Significance levels are denoted by *, **, and ***, representing statistical significance at the 10 %, 5 %, and 1 % thresholds, respectively.

their funding thrust more to absorb the startups into with large-focus they may already be running as opposed to an independent drive in making initiatives sustainable. This can result in variances of sustainability prioritization and governance.

4.4. Additional analysis

This analysis aims to enrich our work by introducing a new variable to the regression model presented in Table 5. This represents a significant extension, aimed at capturing subtle nuances that could influence our results. This new variable, "total_funding", has been carefully selected to extend the scope of our analysis. It represents the cumulative total amount of financing a company has raised up to the specified date, measured in millions of US dollars (USD Mil). This data is often used to assess a company's ability to attract new investment. Model 1 shows that for every million increases in the total funding there is 12 % increase in ROE. Model 2 shows stronger effect for the total IVC funding on ROA than the one observed in ROE. IVC-backed companies show 23 % higher ROA than CVC-backed companies. Model 3 presents the Tobin's Q metrics of the financial performance. The total funding has substantial impact on Tobin's Q for IVC-backed companies of 42 % higher financial performance than CVC-backed companies. Model 4 Shows the results related with ESG scores. The total funding positively influences a company's ESG performance, underlining the importance of financial resources in achieving better ESG outcomes. IVC-backed companies have 34 % higher ESG performance impacted by the total funding. Model 5 explain the result of GHG revenues, indicating that companies with more financial resources are better positioned to generate revenue from greenhouse gas-related activities. Total funding improves the GHG rev by 34 % for IVC-backed companies.

The "investor_type" variable confirms the significant impact of "ESG" and "GHG" on "investor_type", with a slightly higher coefficient for "GHG" and significance at ($p<0.05$) for "ESG". This reinforces the initial conclusion of the importance of these two variables in influencing "investor_type". The variables "lev", "cap_intensity", "innov_cap", "ageatfinancing" and "fund_stage" have better coefficients and all maintain the same level of significance obtained in the original regression. We note that for the "size" variable, the results are positively and significantly related to the dependent variables.

The "public_status" variable obtains only positive results, and is correlated with the "ESG" variable. For our new variable, the results are close to zero. For every one-unit increase in "total_funding", the "ROE", "ROA" and "Tobin's Q" variables decrease by a minimal amount. Moreover, for "ROE" and "Tobin's Q" the relationship is only significant at the 0.1 level, suggesting a trend, but not a strong statistical certainty.

Table 6
Regression results for 2SLS (Lagged VC Funding, total funding).

	(1)	(2)	(3)	(4)	(5)
	ROE	ROA	Tobin's Q	ESG	GHG
totalfunding	0.162**	0.152**	0.324***	0.231**	0.312***
	(0.524)	(0.132)	(0.001)	(0.021)	(0.025)
investor_type	0.112**	0.153**	0.142***	0.152**	0.312***
	(0.635)	(0.423)	(0.231)	(0.113)	(0.118)
lev	−0.115	−0.142	−0.146*	−0.172	−0.231
	(0.142)	(0.152)	(0.172)	(0.413)	(0.213)
size	0.112***	−0.172***	0.142***	0.524***	0.277*
	(0.142)	(0.152)	(0.162)	(0.142)	(0.253)
cap_intensity	−4.132***	−0.765**	0.362	−1.797	1182
	(0.635)	(0.624)	(0.632)	(0.263)	(0352)
innov_cap	−0.243***	−0.524***	0.352***	0.413	−0261
	(0.142)	(0.148)	(0.231)	(0.654)	(0.254)
ageatfinancing	0.001	−0.001	0.014***	0.142**	−0.273
	(0.312)	(0.423)	(0.142)	(0.115)	(0.153)
invest_date	−0.142**	0.243**	−0.152	−0.354	0.243
	(0.142)	(0.112)	(0.231)	(0.112)	(0.241)
fund_stage	0.504	0.196	0.0363	−0.723*	−0.221*
	(0.023)	(0.312)	(0.635)	(0.312)	(0.651)
public_status	0.231	0.253*	0.132	0.263**	0.018
	(0.253)	(0.112)	(0.162)	(0.142)	(0.261)
Constant	−45.312***	−66.854***	10.147***	28.391***	18.391***
	(0.153)	(0.371)	(0.261)	(0.283)	(0.163)
R-squared	0.654	0.667	0.225	0.524	0.362
Observations	1258	1258	1258	1258	1258
First Stage (Prob > F)	0.0000	0.0000	0.0000	0.0000	0.0000
Durbin score chi2(p)	0.5243	0.2534	0.6543	0.3625	0.6534
Wu – Hausman(p)	0.3241	0.2134	0.2431	0.7863	0.7426

This table presents the results of the 2SLS regressions for the four different models. The independent variables are instrument variables calculated using the lagged values. The first-stage F-statistics indicate that the instruments are strong ($p = 0.0000$). The endogeneity tests (Durbin and Wu-Hausman) show no evidence of endogeneity.

5. Robustness tests

We test the robustness of our results and to alleviate concerns on reverse causality and endogeneity in our analysis we utilized Generalized Method of Moments (GMM) along with 2SLS. This is the approach we used to estimate our models. These models instead used lagged Investor type, and the lagged investment amounts as instrument for endogeneity variables, controlling for the same variables. Our results, presented in Tables 6 and 7 show the impact of investor funding, and investments amounts on the financial performance, ROA, ROE and Tobin's Q as previously established by our models. The first-stage F-statistics in the 2SLS models indicated that the instruments were quite strong, and they passed all of our validity checks in both GMM and 2SLS specifications. Such results of no more endogeneity from these two tests help with consistency and efficiency property of our OLS estimate. Therefore, the positive link from investor type and the investments funding to ESG and GHG revenues and ROE, ROA and Tobin's Q demonstrates a high degree of causality. The results from the Durbin and Wu-Hausman tests indicating no evidence of endogeneity suggest that our independent variable (type of investor and total funding) is not correlated with the error term in the regression models. This is a good outcome because it implies that the estimated relationship between the investor type and the investment amount with financial and environmental performance can be interpreted as causal, rather than spurious or biased due to omitted variable bias or reverse causality.

6. Conclusion

This study examines the impact of two distinct forms of VC financing, namely IVC and CVC, on the financial, environmental, and emissions performance of firms. This study provides unique insights into the dynamics by examining a comprehensive dataset of financial data, ESG scores, and GHG emissions from 293 companies supported by IVC, 32 companies sponsored by CVC, and a total of 1311 observations covering the period from 2002 to 2022. The analysis shows a nuanced association between the financial performance of companies funded by IVCs over those funded by CVCs. Companies financed by VCs sometimes have a lower ROE, which can be explained by the VCs' focus on emphasizing growth over immediate profitability. Conversely, there is a robust and positive association between ROA and firms that have received investment from IVC, suggesting effective financial management. However, firms supported by IVC exhibit higher Tobin's Q ratio, indicating the complex relationship between IVC funding and financial performance.

Companies supported by IVC exhibit much better environmental performance in comparison to companies funded by CVC, as indicated by their higher ESG scores. Larger organizations, those in advanced phases of financing, and those that are publicly listed tend to exhibit stronger ESG performance. The results suggest that organizations receiving support from IVC are more likely to achieve excellent performance in environmental indicators, indicating their commitment to sustainable practices. Companies backed by IVC

Table 7
Regression results for GMM (Lagged VC Funding, total funding).

	(1)	(2)	(3)	(4)	(5)
	ROE	ROA	Tobin's Q	ESG	GHG
totalfunding	0.173**	0.263**	0.423***	0.312**	0.321***
	(0.173)	(0.142)	(0.001)	(0.001)	(0.155)
investor_type	0.156**	0.211**	0.231***	0.241**	0.347***
	(0.264)	(0.002)	(0.003)	(0.014)	(0.212)
lev	−0.172	−0.132	−0.122*	−0.152	−0.241
	(0.231)	(0.241)	(0.142)	(0.152)	(0.231)
size	0.142***	−0.251***	0.423***	0.272***	0.257*
	(0.352)	(0.293)	(0.834)	(0.423)	(0.237)
cap_intensity	−0.452***	−0.274**	0.432	−0.782	0.224
	(0.142)	(0.241)	(0.131)	(0.625)	(0.153)
innov_cap	−0.435***	−0.231***	0.213***	0.321	−0.313
	(0.241)	(0.213)	(0.321)	(0.123)	(0.436)
ageatfinancing	0.132	−0.212	0.001***	0.123**	−0.391
	(0.142)	(0.261)	(0.211)	(0.132)	(0.212)
invest_date	−0.212**	0.112**	−0.212	−0.373	0.137
	(0.001)	(0.004)	(0.241)	(0.283)	(0.099)
fund_stage	0.243	0.351	0.232	−0.234*	−0.221*
	(0.101)	(0.121)	(0.273)	(0.413)	(0.352)
public_status	0.142	0.241*	0.121	0.172**	0.313
	(0.001)	(0.012)	(0.273)	(0.016)	(0.273)
Constant	−46.334***	−56.162***	23.311***	18.321***	38.382***
	(0.244)	(0.461)	(0.262)	(0.234)	(0.442)
R-squared	0.654	0.453	0.362	0.423	0.372
Observations	1258	1258	1258	1258	1258
First Stage (Prob > F)	0.0000	0.0000	0.0000	0.0000	0.0000
GMM C statistic chi2(p)	0.2432	0.2763	0.2631	0.6753	0.5634

This table presents the results of the GMM regressions for the four different models. The instrumental variable are calculated at the same way as 2SLS. The first-stage F-statistics indicate that the instruments are strong in all models. The endogeneity tests (Durbin and Wu-Hausman) show no evidence of endogeneity.

exhibit lower levels of GHG emissions as compared to companies backed by CVC. GHG emissions are greatly impacted by variables such as the company's scale, the extent of capital investment, and the level of innovation. Moreover, there is a distinct correlation between higher levels of finance and lower emissions, suggesting that IVCs effectively promote environmentally sustainable practices among the companies they invest in.

The significance of our findings holds considerable relevance for investors, entrepreneurs, and governments. They highlight the importance of considering the particular type of VC funding when evaluating the overall success of a company. The results can guide investment decisions by highlighting trends associated with ESG practices and GHG emissions within the framework of VC funding.

This study provides useful insights on the relationship between various types of VC funding and the performance of companies. While there may be some variances in the findings related to financial, environmental, and emissions measures, a clear trend emerges that companies who receive support from IVC demonstrate superior environmental performance and reduced GHG emissions. These observations emphasize the strategic importance of various forms of VC in fostering the development of sustainable and high-achieving firms.

VCs can help by aligning their investment strategies with global sustainability goals. By choosing investments which have a strong green signal, VCs can play their role in solving environmental issues at the global scale and comply with new market trends & regulations. This ensures investment not only realizes financial returns inclusive-profit, but more importantly is beneficial to complement sustainability. In a marketplace littered with competitors, sustainability can help startups rise above the competition. This could balance the two, as focusing on being green can make them more appealing to investors and their customers. Startups that adapt sustainable operating principles now will comply with new environmental regulations, which are bound to become more stringent over time.

Our results tend to point in the same direction of the other studies, but whether IVC or CVC will lead to better ESG ratings and GHG emissions remains an important issue that may vary across regions because regulations can be very different. Future research should replicate and extend this in other geographical settings to test generalizability. Such changes to investment strategies and support for ESG performance can point VCs in the productive direction of improving financial performance by way of ecosystem stewardship. Sustainability needs to be an imperative as startups include this in their business model and are also able to secure funding, tailored specifically for sustainability compliance. By providing incentives for sustainable investment, establishing regulatory frameworks to encourage a change in business norms and supporting innovation in various ways (for example through technical assistance or research partnerships), policymakers can catalyze the enormous potential of private sector engagement.

CRediT authorship contribution statement

Othman Alolah: Validation. **Emmanuelle Dubocage:** Formal analysis, Writing – original draft. **Fatima Shuwaikh:** Writing – original draft, Visualization, Validation, Supervision, Project administration, Methodology, Investigation, Conceptualization. **Agathe Tanguy:** Writing – original draft, Data curation.

Data Availability

Data will be made available on request.

References

Adedoyin, Festus Fatai, Alola, Andrew Adewale, Bekun, Festus Victor, 2020. An assessment of environmental sustainability corridor: the role of economic expansion and research and development in EU Countries. Sci. Total Environ. 713 (April)), 136726. https://doi.org/10.1016/j.scitotenv.2020.136726.

Adomako, S., Ning, E., Adu-Ameyaw, E., 2021. Proactive environmental strategy and firm performance at the bottom of the pyramid. Bus. Strategy Environ. 30, 422–431. https://doi.org/10.1002/bse.2629.

Al-Ismail, Fahad Saleh, Md Shafiul Alam, Md. Shafiullah, Md Ismail Hossain, Masiur Rahman, Syed, 2023. Impacts of renewable energy generation on greenhouse gas emissions in saudi arabia: a comprehensive review. Sustainability 15 (6), 5069. https://doi.org/10.3390/su15065069.

Ambec, S., Lanoie, P., 2008. Does it pay to be green? A systematic overview. Acad. Manag. Perspect. 22, 45–62.

Bassen, Alexander, and Ana Maria Kovács. 2008. "Environmental, Social and Governance Key Performance Indicators from a Capital Market Perspective."

Battisti, Enrico, Nirino, Niccolò, Leonidou, Erasmia, Thrassou, Alkis, 2022. Corporate Venture Capital and CSR performance: an extended resource based view's perspective. J. Bus. Res. 139 (February), 1058–1066. https://doi.org/10.1016/j.jbusres.2021.10.054.

Bendig, D., Kleine-Stegemann, L., Schulz, C., Eckardt, D., 2022. The effect of green startup investments on incumbents' green innovation output. J. Clean. Prod. 376, 134316. https://doi.org/10.1016/j.jclepro.2022.134316.

Benkraiem, R., Dubocage, E., Lelong, Y., Shuwaikh, F., 2023a. The effects of environmental performance and green innovation on corporate venture capital. Ecol. Econ. 210, 107860. https://doi.org/10.1016/j.ecolecon.2023.107860.

Benkraiem, R., Gonçalves, D., & Shuwaikh, F. (2023b). The role of corporate venture capitalists in supporting the growth of their backed start-ups. European Business Review, ahead-of-print(ahead-of-print). https://doi.org/10.1108/EBR-09-2022-0183.

Benkraiem, R., Shuwaikh, F., Lakhal, F., Guizani, A., 2022. Carbon performance and firm value of the World's most sustainable companies. Econ. Model. 116, 106002. https://doi.org/10.1016/j.econmod.2022.106002.

Bianchini, R., Croce, A., 2022. The role of environmental policies in promoting venture capital investments in cleantech companies. Rev. Corp. Financ. 2 (3), 587–616. https://doi.org/10.1561/114.00000024.

Bocken, N.M.P., Rana, P., Short, S.W., 2015. Value mapping for sustainable business thinking. J. Ind. Prod. Eng. 32 (1), 67–81. https://doi.org/10.1080/21681015.2014.1000399.

Botsari, Antonia, and Frank Lang. 2020. "ESG Considerations in Venture Capital and Business Angel Investment Decisions: Evidence from Two Pan-European Surveys."

Busch, Timo, Hoffmann, Volker H., 2011. How Hot Is Your Bottom Line? Linking carbon and financial performance. Bus. Soc. 50 (2), 233–265. https://doi.org/10.1177/0007650311398780.

Caselli, S., Negri, G., 2021. Private Equity and Venture Capital in Europe: Markets, Techniques, and Deals. Academic Press.

Chemmanur, Thomas J., Loutskina, Elena, Tian, Xuan, 2014. Corporate venture capital, value creation, and innovation. Rev. Financ. Stud. 27 (8), 2434–2473. https://doi.org/10.1093/rfs/hhu033.
Chen, S., Song, Y., Gao, P., 2023. Environmental, social, and governance (ESG) performance and financial outcomes: analyzing the impact of ESG on financial performance. J. Environ. Manag. 345, 118829. https://doi.org/10.1016/j.jenvman.2023.118829.
Cheng, Beiting, Ioannou, Ioannis, Serafeim, George, 2014. Corporate social responsibility and access to finance. Strateg. Manag. J. 35 (1), 1–23. https://doi.org/10.1002/smj.2131.
Chouaibi, Salim, Chouaibi, Jamel, Rossi, Matteo, 2022. ESG and corporate financial performance: the mediating role of green innovation: UK Common Law versus Germany Civil Law. Eur. J. Bus. 17 (1), 46–71. https://doi.org/10.1108/EMJB-09-2020-0101.
Colombo, Massimo G., and Samuele Murtinu. 2017. "Venture Capital Investments in Europe and Portfolio Firms' Economic Performance: Independent versus Corporate Investors."
Diekel, Felice, Vanessa Bach, 2023. Assessing the climate performance potential of start-ups: insights and guidance on environmental sustainability assessment of young ventures. Chair of Sustainable Engineering, Institute of Environmental Technology, Technische Universität Berlin, 10623 Berlin, Germany, Matthias Finkbeiner, and Chair of Sustainable Engineering, Institute of Environmental Technology, Technische Universität Berlin, 10623 Berlin, Germany Highlights Sustain. 2 (4), 207–223. https://doi.org/10.54175/hsustain2040015.
Dixon-Fowler, H.R., Slater, D.J., Johnson, J.L., Ellstrand, A.E., Romi, A.M., 2013. Beyond "Does it Pay to be Green?" A Meta-Analysis of Moderators of the CEP–CFP Relationship. J. Bus. Ethics 112, 353–366. https://doi.org/10.1007/s10551-012-1268-8.
Fulghieri, Paolo, Sevilir, Merih, 2009. Organization and financing of innovation, and the choice between corporate and independent venture capital. J. Financ. Quant. Anal. 44 (6), 1291–1321. https://doi.org/10.1017/S0022109009990391.
Goglio, P., Williams, A.G., Balta-Ozkan, N., Harris, N.R.P., Williamson, P., Huisingh, D., Zhang, Z., Tavoni, M., 2020. Advances and Challenges of Life Cycle Assessment (LCA) of greenhouse gas removal technologies to fight climate changes. J. Clean. Prod. 244 (January), 118896. https://doi.org/10.1016/j.jclepro.2019.118896.
Gonenc, H., Scholtens, B., 2017. Environmental and financial performance of fossil fuel firms: a closer inspection of their interaction. Ecol. Econ. 132, 307–328. https://doi.org/10.1016/j.ecolecon.2016.10.004.
Gornall, W., Strebulaev, I.A., 2021. The economic impact of venture capital: evidence from public companies. SSRN Electron. J. https://doi.org/10.2139/ssrn.2681841.
Groh, A.P., von Liechtenstein, H., Lieser, K., 2010. The European Venture Capital and Private Equity country attractiveness indices. J. Corp. Financ. 16, 205–224. https://doi.org/10.1016/j.jcorpfin.2009.09.003.
Hart, S.L., 1995. A natural-resource-based view of the firm. Acad. Manag. Rev. 20, 986–1014. https://doi.org/10.2307/258963.
Hegeman, Puck D., Sørheim, Roger, 2021. Why Do They Do It? Corporate venture capital investments in cleantech startups. J. Clean. Prod. 294 (April)), 126315. https://doi.org/10.1016/j.jclepro.2021.126315.
Hoang, T.-H.-V., Przychodzen, W., Przychodzen, J., Segbotangni, E.F., 2020. Does it pay to be green? A disaggregated analysis of U.S. firms with green patents. Bus. Strategy Environ. 29, 1331–1361. https://doi.org/10.1002/bse.2437.
Kim, Sang, Li, Zhichuan (Frank, 2021. Understanding the Impact of ESG Practices in Corporate Finance. Sustainability 13 (7), 3746. https://doi.org/10.3390/su13073746.
Klassen, R., Mclaughlin, C., 1996. The impact of environmental management on firm performance. Manag. Sci. 42, 1199–1214. https://doi.org/10.1287/mnsc.42.8.1199.
Kraus, Sascha, Rehman, Shafique Ur, García, F.Javier Sendra, 2020. Corporate social responsibility and environmental performance: the mediating role of environmental strategy and green innovation. Technol. Forecast. Soc. Change 160 (November), 120262. https://doi.org/10.1016/j.techfore.2020.120262.
Lange, Elfi M., Banadaki, Niloofar Ghotbedini, 2023. ESG Consideration in Venture Capital: Drivers, Strategies and Barriers. Stud. Econ. Financ. November. https://doi.org/10.1108/SEF-06-2023-0380.
Leendertse, Jip, Van Rijnsoever, Frank J., Eveleens, Chris P., 2021. The sustainable start-up paradox: predicting the business and climate performance of start-ups. Bus. Strategy Environ. 30 (2), 1019–1036. https://doi.org/10.1002/bse.2667.
Lewandowski, Stefan, 2017. Corporate carbon and financial performance: the role of emission reductions. Bus. Strategy Environ. 26 (8), 1196–1211. https://doi.org/10.1002/bse.1978.
LinLin, 2022. Venture capital in the rise of sustainable investment. Eur. Bus. Organ. Law Rev. 23 (1), 187–216. https://doi.org/10.1007/s40804-021-00238-8.
Mansouri, Sasan, Momtaz, Paul P., 2022. Financing sustainable entrepreneurship: ESG measurement, valuation, and performance. J. Bus. Ventur. 37 (6), 106258. https://doi.org/10.1016/j.jbusvent.2022.106258.
Mazza, Paolo, Shuwaikh, Fatima, 2022. Industry-relatedness, geographic proximity and strategic decisions of corporate and independent venture capital-backed companies. August, 1–38 J. Small Bus. Manag.. https://doi.org/10.1080/00472778.2022.2108432.
Naeem, Nasruzzaman, and Serkan Çankaya. 2022. "The Impact of ESG Performance over Financial Performance: A Study on Global Energy and Power Generation Companies."
Qian, L., Xu, X., Sun, Y., Zhou, Y., 2022. Carbon emission reduction effects of eco-industrial park policy in China. Energy 261, 125315. https://doi.org/10.1016/j.energy.2022.125315.
Yuniarti, R., Soewarno, N., Isnalita, I., 2022. Green Innovation on Firm Value with Financial Performance as Mediating Variable: Evidence of the Mining Industry. Asian Acad. Manag. J. 27 (2). https://doi.org/10.21315/aamj2022.27.2.3.
Shuwaikh F., (2018) " Key-Drivers of Innovation Success and Financial Performance in Corporate Venture Capital". Humanities and Social Sciences. Paris Saclay, 2018.
Shuwaikh, F., Benkraiem, R., Dubocage, E., 2022a. Investment in Green Innovation: How does It Contribute to Environmental and Financial Performance? J. Innov. Econ. Manag. Prépublication, I137-XLIII. https://doi.org/10.3917/jie.pr1.0137.
Shuwaikh, F., Brintte, S., Khemiri, S., 2022b. The impact of dynamic ambidexterity on the performance of organizations: evidence from corporate venture capital investing in North America. J. Econ. Behav. Organ 200, 991–1009. https://doi.org/10.1016/j.jebo.2022.07.012.
Shuwaikh, F., Brintte, S., Khemiri, S., Castro, R.G.D., 2022c. Venture capital activities under uncertainty: US and UK investors behavior. Ann. Oper. Res. https://doi.org/10.1007/s10479-022-04962-3.
Shuwaikh, F., Dias, J., 2023. The power of syndication: the innovation output of venture capital investments in the United States. Manag. Int. Int. Manag. GestiòN. Int. 27, 140–152. https://doi.org/10.59876/a-6r7m-ahrf.
Shuwaikh, F., Dubocage, E., Murer, D., 2023a. Underpricing of corporate and independent venture capital-backed IPOs: do they differ. Rev. Quant. Financ. Acc. 60, 1629–1650. https://doi.org/10.1007/s11156-023-01144-5.
Shuwaikh, F., Dubocage, E., 2022. Access to the Corporate Investors' Complementary Resources: A Leverage for Innovation in Biotech Venture Capital-Backed Companies, 175, 121374. https://doi.org/10.1016/j.techfore.2021.121374.
Shuwaikh, F., Hughes, M., Brinette, S., Khemiri, S. (2023b). Investment decisions under uncertainty: Corporate venture capital as a real option. Int. J. Finance Econ. n/a. ⟨https://doi.org/10.1002/ijfe.2794⟩.
Sun, Xiaohua, Yan Dong, Yun Wang, Junlin Ren, 2022. Sources of greenhouse gas emission reductions in OECD countries: composition or technique effects. Ecol. Econ. 193 (March), 107288. https://doi.org/10.1016/j.ecolecon.2021.107288.
Trautwein, Constanze, 2021. Sustainability impact assessment of start-ups – key insights on relevant assessment challenges and approaches based on an inclusive, systematic literature review. J. Clean. Prod. 281 (January)), 125330. https://doi.org/10.1016/j.jclepro.2020.125330.
Velte, Patrick, 2017. Does ESG Performance Have an Impact on Financial Performance? Evidence from Germany. J. Glob. Responsib. 8 (2), 169–178. https://doi.org/10.1108/JGR-11-2016-0029.
Yang, Tianle, Sun, Zhennan, Du, Min, Du, Qunyang, Li, Lei, Shuwaikh, Fatima, 2023. The impact of the degree of coupling coordination between green finance and environmental regulations on firms' innovation performance: evidence from China. Ann. Oper. Res. (December). https://doi.org/10.1007/s10479-023-05704-9.