

Exploring the Role of Venture Capital in Advancing Green Innovation: A Systematic Literature Review

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How to cite this article:

Mašek, J. and Plaček, J. (2024). Exploring the Role of Venture Capital in Advancing Green Innovation: A Systematic Literature Review, *Acta Montanistica Slovaca*, Volume 29 (4), 839-861

DOI:

<https://doi.org/10.46544/AMS.v29i4.05>

Abstract

Venture capital (VC) is instrumental in overcoming financial barriers for companies focused on green innovation (GI), enabling them to scale their solutions and strengthen their competitiveness. Despite growing interest in this domain, knowledge remains fragmented. This study employs an integrated methodological approach, combining bibliometric analysis and a systematic literature review of Web of Science and Scopus data to identify key trends in GI financing through VC and uncover research gaps for future exploration. Of the 147 identified studies, 49 publications from 2006 to 2025 were included in the final analysis. The findings emphasize the need for further research to reconcile VCs' short-term financial objectives with their investments' long-term environmental impacts. Future studies should also examine the distinct approaches of various VC types—-independent venture capital (IVC), corporate venture capital (CVC), and government venture capital (GVC)—toward GI, alongside geographical and cultural factors that influence investment outcomes. Additionally, the cleantech sector and potential synergies between public and private stakeholders warrant greater attention. This study contributes to the Resource-Based View (RBV) and Natural Resource-Based View (NRBV) theories by demonstrating how VC financing is a strategic tool for enhancing firms' competitive advantage and environmental sustainability. It offers valuable theoretical and practical insights for firms, investors, and policymakers. However, potential limitations include reliance on Web of Science and Scopus databases and a focus on English-language publications, which may have excluded relevant studies.

Keywords

Venture capital (VC), green innovation (GI), cleantech, Resource-Based View (RBV), Natural Resource-Based View (NRBV), sustainability



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Introduction

Investments in green innovations (GI) are essential for driving the transition to a sustainable economy (Perotti et al., 2024) and addressing urgent environmental challenges like the climate crisis, resource depletion, and pollution. Therefore, venture capital (VC), as a pivotal mechanism for addressing financial barriers faced by companies focused on green innovation (GI), is at the center of growing scholarly attention (B. Q. Lin & Y. J. Xie, 2024; Siefkes et al., 2025).

Moreover, venture capital (VC) not only enables firms to allocate more resources toward the development of green innovations (GI) (Liu & Tao, 2024) but as research highlights, green innovations (GI) serve as a magnet for attracting such investments (Bellucci et al., 2023; Prokop et al., 2024), enhance firms' competitiveness (Çetin & Erkisi, 2023; Y. Chen et al., 2024; Rehman et al., 2023; Riaz et al., 2023; Szczepanska-Woszczyzna et al., 2024) and increase their energy independence (Suhányiová et al., 2023).

The rise in venture capital (VC) investments targeting green innovation (GI) underscores the growing interest in sustainable investments, highlighting investors' increasing recognition of the importance of these types of innovations and their potential to deliver significant environmental and social benefits (Gajdzik et al., 2023; Pacana et al., 2023; Simková et al., 2023). Despite the trends, venture capital (VC) faces significant challenges, including high initial investment costs (Sun, 2024), significant risks and uncertainties associated with returns (Laachach & Ettahri, 2023; Xiong et al., 2023; Zhang et al., 2024), as well as a lack of consistent data to objectively assess the impacts of green innovations (GI) (Laachach & Ettahri, 2023). Moreover, the short-term return on these investments is often low, which may discourage potential investors (Li et al., 2024).

Research into the impact of venture capital (VC) on the development of green innovation (GI) thus plays a fundamental role in understanding how financial capital can accelerate the transformation towards a sustainable economy (Chehabeddine et al., 2023; Rahman et al., 2024; Ribeiro-Navarrete et al., 2025).

Despite the issue's urgency, currently, there are only two systematic reviews of the literature in this area based on our knowledge. Although the first study focuses on venture capital (VC), it examines its role in the broader context of sustainable development. The study analyzes explicitly how venture capital (VC) supports cleantech, policy initiatives, and sustainability, identifying key trends such as the impact of the Paris Agreement on increased interest in venture capital (VC) investments in green innovation (GI) (Dhayal et al., 2023). The second study has an even broader scope. Although it analyses the financing of green innovation (GI) startups, it focuses on different financing models, not just venture capital (VC), discussing the risks and barriers associated with traditional forms of financing, innovative public policies, as well as the need for a holistic entrepreneurial financing ecosystem (Mukherjee et al., 2024). Although both studies cover venture capital (VC) as part of their research, their primary interest includes broader aspects of green innovation (GI) financing. Therefore, knowledge in this area remains fragmented (Shuwaikh et al., 2025) and requires a more systematic approach.

Based on the research gap identified above, this study focuses on identifying key research trends in green innovation (GI) financing through venture capital (VC) to identify opportunities for further research.

The guiding principle for this systematic literature review is based on two key concepts, namely the Resource-Based View (RBV) (Barney, 1991; Wernerfelt, 1984) and Natural Resource-Based View (NRBV) (Hart & Dowell, 2011; Hart, 1995), which provide a comprehensive framework for understanding how firms' resources and capabilities in the form of green innovation (GI), supported by venture capital (VC) financing, can contribute to long-term competitive success while achieving environmental sustainability (Benkraiem et al., 2023; Kato, 2024).

The study will provide a systematic summary of existing knowledge on the impact of venture capital (VC) in supporting green innovations (GI) and identify key research gaps, thereby creating a foundation for future research in this area. It will also enrich the Resource-Based View (RBV) and Natural Resource-Based View (NRBV) theories by confirming the role of venture capital (VC) as a strategic tool for supporting innovative and sustainable entrepreneurship.

The first part provides a literature review focusing on the role of venture capital (VC) in supporting green innovation (GI). It describes how venture capital (VC) helps companies overcome financial barriers, obtain strategic resources, and develop their innovative potential. This part also classifies the main types of venture capital (VC) in the form of independent venture capital (IVC), corporate venture capital (CVC), and government venture capital (GVC). Moreover, it examines their specificities, objectives, and benefits in supporting green innovation (GI). The second part focuses on the characteristics of the chosen methodological approach, which combines a systematic literature review and bibliometric analysis. The section "Results and Discussion" provides an analysis of bibliometric indicators and identifies key trends, challenges, and research gaps in the field of venture capital (VC) and green innovation (GI) while emphasizing their interdisciplinary nature and regional specificities. The conclusion summarizes the key findings and highlights the benefits of the study for theory and practice.

Literature review

Venture capital (VC) as a specific form of investment capital. Venture capital (VC) is a specific form of investment capital that investors provide to innovative companies, often in the early, high-risk stages of development. This form of financing allows companies to obtain necessary resources in exchange for an ownership stake, intending to achieve a significant return on their investment within a specified time frame (Siefkes et al., 2024). Although VC investments carry a high level of risk, they also offer the potential for extremely attractive returns for investors (Yi et al., 2023).

Venture capitalists are experienced investors who can identify promising business opportunities that combine innovative solutions with market potential. Companies seeking venture capital (VC) support must present, in addition to unique innovations and creative ideas, a realistic and sustainable plan for their profitable application, often in new or emerging markets (Gompers & Lerner, 2000; Lerner, 2012; Malen & Marcus, 2017).

In addition to financial capital, venture capitalists often provide companies with valuable expert advice and access to extensive networks of contacts. As Dong et al. (2021) emphasize, venture capitalists play a key role in strengthening the capabilities of innovative companies to scale their operations, optimize processes, and successfully penetrate new markets. In this way, they contribute to their financial stability, strategic growth, and long-term competitiveness (Dong et al., 2021). Moreover, as Siefkes et al. (2024) and Yu et al. (2024) point out, venture capitalists help build a solid foundation for the successful establishment of innovative companies in global markets, thereby significantly contributing to their international success and sustainable development (Siefkes et al., 2024; Yu et al., 2024).

Venture capital (VC) also catalyzes attracting top talent, strengthening companies' human capital, and supporting innovation communities (Criscuolo & Menon, 2015). It significantly contributes to strengthening the ability of innovative companies to cope with technological challenges, as it often mediates expertise and supports multidisciplinary collaboration between research and commercial entities. This collaboration is key to solving complex green innovation (GI) problems and accelerating development (Hegeman & Sørheim, 2021).

Last but not least, venture capital (VC) reduces perceived risk as it increases trust and helps attract additional capital sources (Guerini & Quas, 2016).

Published studies generally distinguish three main types of venture capital: corporate venture capital (CVC), independent venture capital (IVC), and government venture capital (GVC), each with specific characteristics, objectives, and strategies. These types of venture capital differ in their investment approach, allowing them to fulfill different roles in supporting innovative enterprises.

Independent venture capital (IVC) includes venture capital funds that raise capital from external investors, such as pension funds, foundations, or private investors (Colombo & Murtinu, 2017; Shuwaikh et al., 2025). The primary goal of IVC is to maximize financial returns by investing in startups with high growth potential (Fulghieri & Sevilir, 2009; Shuwaikh et al., 2025). IVC operates independently from corporations, which allows it greater flexibility in choosing investments and a strategic approach to supporting startups. It also provides financing, expertise, and mentoring, helping startups scale their businesses and commercialize products (Benkraiem et al., 2023; Chemmanur et al., 2014).

Corporate venture Capital (CVC) is the investment of large corporations in startups or young companies. These investments go beyond financial support and involve close relationships between the parent company and the startup (Benkraiem et al., 2023; Shuwaikh & Dubocage, 2022). In addition to profit, CVC aims to gain strategic synergies, such as access to new technologies, markets, or strategic alliances (Chemmanur et al., 2014). Companies use CVC to support innovation in their operations and to gain a competitive advantage in green technologies and eco-innovations (Benkraiem et al., 2023). Research shows that CVC investments have a long-term investment horizon and pursue the parent companies' strategic and financial goals (Benkraiem et al., 2023; Lerner, 2012).

Government venture capital (GVC) is a specific type of venture capital organized and financed by government institutions to promote innovation, entrepreneurship, and economic growth. Unlike private venture capital, which primarily focuses on achieving financial returns, GVC emphasizes strategic goals such as promoting green technologies, reducing regional inequalities, and fulfilling public policy priorities (Colombo et al., 2016; Gavurova et al., 2019; Du et al., 2024).

Venture capital (VC) as a support for green innovation (GI) and sustainable development. Green innovations (GI) are a key pillar of a sustainable development strategy (Flammer et al., 2019; Sun, 2024), as they harmoniously integrate environmental, economic, and social aspects into a holistic approach aimed at long-term sustainability (Bendig et al., 2022; Hegeman & Sørheim, 2021). These innovations include technological, process, and organizational changes, the main goal of which is to minimize the negative impacts of human activities on the environment while supporting environmentally responsible development (Bendig et al., 2022; Hegeman & Sørheim, 2021; Skare et al., 2024a; Li et al., 2024).

The main areas of green innovation (GI) include energy recovery, new materials development, pollution reduction technologies, and recycling technologies (Cuerva et al., 2014; Tseng et al., 2013). Research suggests that these innovations not only increase resource efficiency and reduce environmental risks (Castellacci & Lie,

2017) but also support economic growth and employment and improve the quality of services (Kunapatarawong & Martínez-Ros, 2016; Roy & Khastagir, 2016).

Green innovations (GI) also significantly improve the competitive position of firms, enhancing their reputation and creating green organizational identities (Chang, 2011; Yousaf et al., 2022). Leadership in green innovation supports creative thinking and a culture of green learning, which contributes to developing the dynamic capabilities of enterprises and a sustainable economy (Begum et al., 2022; Pham et al., 2023).

In addition to environmental protection, green innovations (GI) allow businesses not only to meet the requirements of increasingly stringent environmental regulations but also to effectively respond to the growing expectations of consumers, who increasingly prefer environmentally friendly products and services (Criscuolo & Menon, 2015; Yu et al., 2024) and thus focus on satisfying preferences that reflect the consumer's style and identity (Rózsa et al., 2024).

One of the main reasons for the need for venture capital (VC) in financing green innovations (GI) is to overcome financial constraints and risks. Green innovations (GI) require long-term research, development, and commercialization investments. At the same time, traditional sources of financing, such as bank loans, are often unsuitable, as these investments involve high risk and long payback periods, which reduces their attractiveness to ordinary investors (Wei et al., 2015; Zhong et al., 2017).

Based on the Resource-Based View (RBV) theory (Barney, 1991; Wernerfelt, 1984) and its extension, the Natural Resource-Based View (NRBV) theory (Barney, 1991; Wernerfelt, 1984), venture capital (VC) plays a key role in strengthening the competitiveness of firms. These theoretical approaches emphasize the importance of strategically using scarce and inimitable resources. NRBV specifically points out the potential of environmental strategies as a source of competitive advantage. Since VC allows firms to respond flexibly to market challenges and improve their ability to innovate and adapt to dynamic conditions, its activities fulfill the principles of both theories (Kato, 2024; Porter & van der Linde, 1995).

Methods

This study uses an integrated approach combining a systematic literature review and bibliometric analysis to examine the empirical studies published in venture capital (VC) and green innovation (GI). Through this approach, the study aims to identify key research trends in venture capital (VC) financing of green innovation (GI) in order to provide a comprehensive picture of the current state of the research topic (Rózsa et al., 2023) and to identify opportunities for further research in the form of uncovered research gaps. The following research questions further define the research objective:

- RQ1: What is the development of the number of publications, and where is the discussion on venture capital (VC) and green innovations (GI) taking place?
- RQ2: What are the key research trends and gaps in venture capital (VC) and green innovations (GI)?
- RQ3: What areas should future research focus on to effectively contribute to developing knowledge about the connection between venture capital (VC) and green innovations (GI)?

To identify empirical studies, we used the Web of Science and Scopus databases, with the search restricted to articles in the research areas of Economics, Management, Business, and Business Finance. Within the Web of Science, we further restricted the search to SSCI, ESCI, and Science Citation Index Expanded (SCIE) to ensure the relevance and quality of the included sources.

The search string was taken from Dhayal et al. (2023). We then expanded it to include "Eco-innovation*" to capture a broader range of relevant contributions. The final search string is formulated as follows:

“Venture Capital” OR “Alternative Financing” OR “Venture Capital Investment” OR “Green Venture Capital” OR “Sustainable Venture Capital” AND “Green Economy” OR “Circular Economy” OR “Sustainable Development” OR “Climate Change” OR “Environmental Sustainability” OR “Renewable Energies” OR “Cleantech” OR “Clean Energy” OR “Greentech” OR “Sustainable Development Goal” OR “Green Investments” OR “Green Innovation*” OR “Eco-innovation*”.**

This expanded chain allows us to capture key themes related to investments in sustainability and innovation (Skare et al., 2023; Dhayal et al., 2023).

To ensure that the study meets the standards of systematic reviews with an emphasis on transparent and systematic data processing, we used the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) methodology (Page et al., 2021) (see Fig 1).

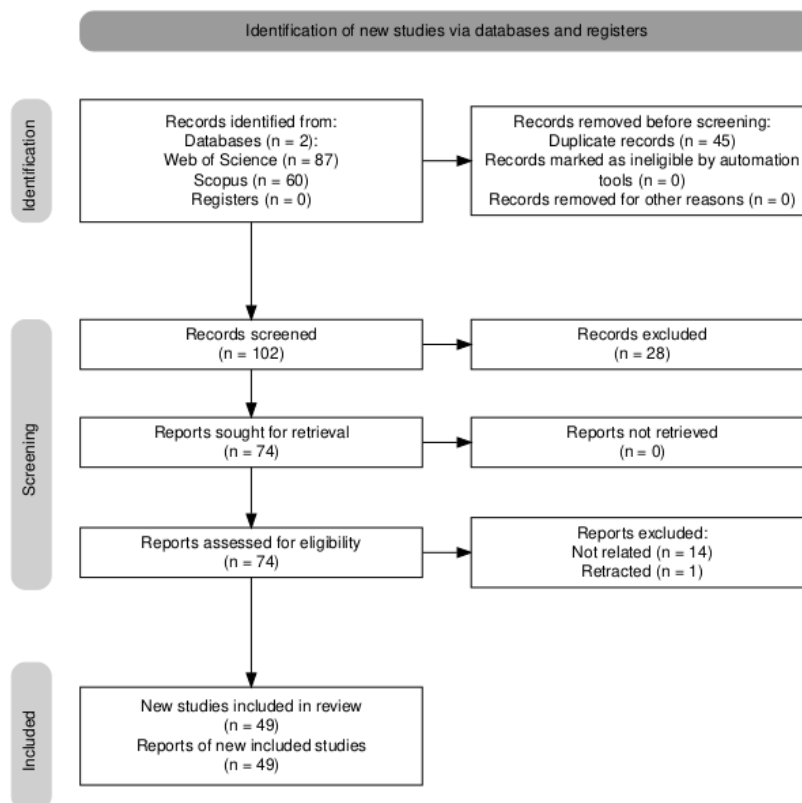


Fig. 1. Prisma SLR framework (Haddaway et al., 2022)

A total of 147 studies were collected during the identification process: 87 from the Web of Science database and 60 from Scopus. After the initial review, 45 records were marked as duplicates and discarded before screening, ensuring the uniqueness and relevance of the remaining data for further evaluation. The list and characteristics of the studies used in the review are provided in the Appendix (Table 1).

During the initial screening, 28 studies were excluded as their content did not correspond to the focus of the systematic literature review (SLR). This step ensured that only relevant and thematically appropriate studies were included in further analysis.

Furthermore, 28 studies were also excluded because their content did not correspond to the focus of the systematic literature review (SLR) to examine empirical articles (book, guest editorial, policy letter, other SLR). In the second step of the eligibility assessment, 14 further studies were subsequently excluded because they were not thematically relevant (investigating other variables), and 1 study was excluded due to retraction. The total number of studies included in the final analysis was 49.

To support the analysis of qualitative data, we used NVivo software, which allowed us to systematically code texts, identify key themes, and visualize relationships between the concepts being analyzed. This approach contributed to increasing the accuracy and transparency of our analysis.

The main limitations of this study include the choice of databases used. Although Web of Science and Scopus are leading sources of academic publications, focusing exclusively on these two databases may have led to the omission of relevant studies published in other sources, such as PubMed, Google Scholar, or lesser-known regional databases. Furthermore, narrowing the search to articles in the fields of Economics, Management, Business, and Business Finance, as well as the SSCI, ESCI, and SCIE indexes, may have eliminated publications that are relevant to the research topic but fall under other disciplines, such as environmental sciences, technology, or political studies.

Although the search string used was quite broad, there is a risk that some relevant studies may have been missed due to the use of different terms or synonyms that were not included in the string. Another limitation is the exclusion of non-empirical publications such as books, editorials, policy documents, or other systematic literature reviews, which may have deprived the analysis of broader context or alternative perspectives.

The selection of studies was further limited to publications in English, which may have led to the omission of relevant works in other languages. Despite using the PRISMA methodology, subjective decision-making during evaluating the eligibility of studies, for example, when assessing their thematic relevance, may have led to potential bias. Considering these limitations when interpreting the results and formulating conclusions is important

Results and discussion

Bibliometric indicators. The distribution of publications reflects the growing interest in venture capital (VC) and green innovation (GI) and highlights its importance in current research. The first study in this area was published in 2006. The following period (2009–2016) is characterized by sporadic publication, with a maximum of 1 to 3 studies published per year in those years, indicating a slow development of interest in this topic. This trend gradually changed, with a significant increase in activity occurring in 2023 and 2024, when 9 and 12 studies were published, respectively. The year 2024 thus represents the peak of published activity to date, indicating the growing importance of this issue in academic discourse (Fig. 2).

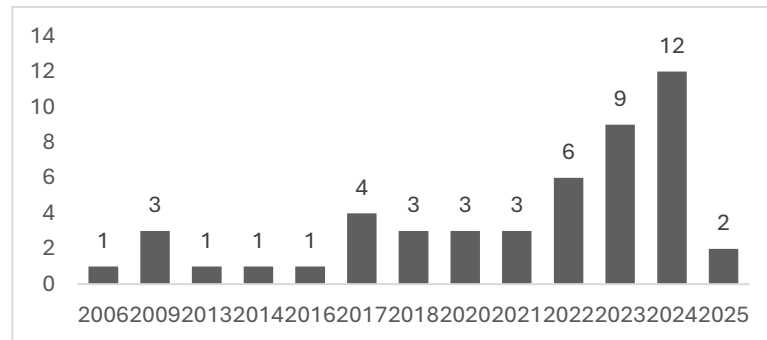


Fig.2. Distribution of publications

The research topic was discussed in a wide range of scientific journals (Table 2 in the Appendix), with the largest concentration of publications observed in journals focused on energy, environment, and sustainability policy. The most frequently published contributions were in *Energy Economics*, *Energy Policy*, and *Journal of Cleaner Production*, each of which included three articles (6.1% of the total). These journals reflect the research focus on linking venture capital with energy transformation and environmental sustainability.

Other journals with a higher concentration of publications (2 articles, 4.1%) include *Business Strategy* and the *Environment and International Review of Economics & Finance*, indicating a focus on strategic business issues and economic implications.

The remaining publications were distributed among many other journals, each containing 1 article (2%), which indicates the interdisciplinary nature of the issue, which cuts across the fields of management, finance, innovation, entrepreneurship, and politics. The discussion on this topic is widespread across different academic fields, underlining its importance and relevance in current research.



Fig.3. Most frequent terms in the discussion

The word cloud visualization (Fig. 3) shows the most frequent terms in the discussion, with dominant terms indicating the main areas of interest and debate. The most significant terms, such as "investing," "innovators," "green," "capitalism," and "venturing," highlight key topics related to investing in eco-innovation and entrepreneurial activities. This suggests that the discussion focuses on financing and supporting innovative projects

aimed at sustainability and ecological development. Terms such as "technology," "cleantech," "energy," "environmentally," and "sustaining" indicate the focus of research on new technologies and renewable energy sources that support environmentally sustainable solutions. Words such as "firms," "funds," "investors," "managers," and "financiers" reflect the interest in the role of actors in the business environment, including investors, managers, and financial institutions, in supporting eco-innovation. The prominent presence of terms such as "developments," "policy," "governments," and "reforms" highlights the importance of regulatory measures, government interventions, and policy frameworks in shaping sustainable development and supporting green investments. The presented results point to the interdisciplinary nature of the issue, combining aspects of business, technology, finance, and policy with the aim of supporting green and sustainable economic growth. Topics such as "cleantech" and "sustainability" are clear indicators that the discussion focuses on solving climate challenges and the transition to a green economy.

Key trends and research gaps in venture capital (VC) and green innovation (GI). A large part of the studies reviewed confirm the positive impact of venture capital (VC) on green innovation (GI), not only in large companies but also in small and medium-sized enterprises and the economy in general.

Venture capital (VC) investments reduce the financial constraints of companies and support their ability to develop and apply green solutions (Dong et al., 2021; Maiti, 2022; Marcus et al., 2013; Wüstenhagen & Teppo, 2006; Yu et al., 2024; Zhao et al., 2021), contribute to a higher number and quality of green patents (Bendig et al., 2022), and improve their resilience to economic and environmental challenges (Incekara, 2022; Kato, 2024). Last but not least, venture capital (VC) supports job creation (Gucciardi, 2024; Shuwaikh et al., 2025), improving the technological capacities of companies (Gucciardi, 2024; Hua et al., 2023; Shuwaikh et al., 2025) and reducing emissions (Hua et al., 2023). This effect is particularly significant in achieving Sustainable Development Goals (SDGs) (Gucciardi, 2024; Shuwaikh et al., 2025).

Green innovation (GI) (e.g., in the form of grants or patents for environmental technologies) is a key factor in attracting venture capital (VC) investments. These innovations directly increase the attractiveness of companies to investors (Bellucci et al., 2023; Benkraiem et al., 2023), as they act as a strong signal of legitimacy to other investors (Islam et al., 2018; Wu et al., 2020). At the same time, Roma et al. (2023) draw attention to the different preferences of investors, arguing that this signal may not be attractive enough (Roma et al., 2023).

Despite numerous studies confirming the positive impact of venture capital (VC) on green innovation (GI), the results of some studies indicate that this impact varies significantly depending on the goals of investors, often based on the specific type of venture capital.

The dilemma between profitability and environmental goals is highlighted, for example, by studies by Hegeman and Sørheim (2021) and Siefkes et al. (2024) and others, who argue that investors often prioritize profits, which can jeopardize the achievement of positive environmental impacts (Gaddy et al., 2017; Hegeman & Sørheim, 2021; Luo et al., 2023; Siefkes et al., 2024) and that venture capital, due to its emphasis on short-term goals, can harm other aspects of sustainability (Luo et al., 2023). Specifically in the case of cleantech investments, Gaddy et al. (2017) even argue that the traditional venture capital (VC) model is explicitly inappropriate because it does not take into account long development cycles, high capital requirements, and low profits (Gaddy et al., 2017). In this context, Agrawal & Jespersen (2024) emphasize the need to balance financial and social goals, with social impact being as important to investors as return on investment (Agrawal & Jespersen, 2024).

In the context of individual investor types, Shuwaikh et al. (2025) found that independent venture capital (IVC) has better results in terms of financial performance and environmental sustainability compared to corporate venture capital (CVC), as it focuses on long-term goals and less polluting sectors (Shuwaikh et al., 2025).

Corporate venture capital (CVC) investments focus more on strategic and profit-oriented goals. Their less sustainable approach focuses on short-term profits (Bendig et al., 2022; Shuwaikh et al., 2025). Furthermore, Hegeman & Sørheim (2021) showed that the motivations of corporate venture capital (CVC) investors vary depending on the size of the company, which affects their investment strategies (Hegeman & Sørheim, 2021) and organizational culture (Teppo & Wüstenhagen, 2009).

Li et al. (2024) highlighted that government venture capital (GVC) can significantly support green innovation. However, its effectiveness depends on the investment structure (e.g., partnerships are more effective than corporate structures) (Li et al., 2024; Skare et al., 2024b). Du et al. (2024) and Sun (2024) pointed out the inverted U-effect of government venture capital (GVC), which suggests that too high a level of investment can limit innovation potential (Du et al., 2024; Sun, 2024) and even that government venture capital (GVC) can hinder innovation due to risk aversion and excessive regulation. Excessive reliance on government venture capital (GVC) can also lead to reduced efficiency and loss of flexibility in innovation processes (Dong et al., 2021; Du et al., 2024).

Other research also points to the specific role of partnerships in supporting green innovation (GI), arguing that partnerships contribute to overcoming investment barriers, developing innovative solutions, and achieving synergistic effects between businesses, investors, and policy initiatives, thereby supporting green innovations and their broader impact on the economy and the environment (Ginsberg & Marcus, 2018; Laachach & Ettahri, 2023; Li & Zheng, 2023; Michelfelder et al., 2022; Owen et al., 2020; van Rijnsoever, 2022).

The relationship between venture capital (VC) and green innovation (GI) is also closely influenced by geographical factors and cultural context, as highlighted by several studies focusing on specific regions and sectors. Kulanov et al. (2020) highlighted the challenges that venture capital (VC) faces in developing markets, such as regulatory barriers and insufficient infrastructure, and pointed out the significant potential of renewable energy investments in these areas (Kulanov et al., 2020).

Similarly, Kato (2024) examined the role of venture capital (VC) in sub-Saharan Africa, where it helps small businesses implement sustainable business models, thereby supporting economic growth and environmental protection (Kato, 2024). Furthermore, Ejdys et al. (2019) and Hain et al. (2018) analyzed international venture capital (VC) investments in sub-Saharan Africa, focusing on Kenya, where the emerging entrepreneurial ecosystem shows a shift from dependence on foreign aid to more diverse and profit-oriented investments. They also highlight the importance of digital entrepreneurship in overcoming infrastructure challenges and supporting economic growth, making international venture capital (VC) crucial for the development of innovative firms that respond to both local and global needs (Ejdys et al., 2019; Hain & Jurowetzki, 2018).

In China, Lin and Xie (2024) highlighted that venture capital (VC) is key to increasing productivity and innovation in the renewable energy sector, especially in gradually reducing government subsidies. Their findings suggest that venture capital (VC) can effectively support the transition to sustainable technologies, even as traditional forms of financial support weaken (B. Lin & Y. Xie, 2024; B. Q. Lin & Y. J. Xie, 2024, Skare et al., 2025).

Cultural context also significantly influences the attractiveness of cleantech investments (Christensen et al., 2009). Cumming et al. (2016) showed that in countries with high uncertainty avoidance, cleantech investments are less attractive if they are not accompanied by public policy support (Cumming et al., 2016). In contrast, Chen et al. (2024) found that in authoritarian regimes such as China, regulations and state support can effectively overcome cultural barriers, creating favorable conditions for cleantech investments (X. Y. Chen et al., 2024).

These findings highlight that geographic factors and cultural context not only shape venture capital (VC) investment strategies but also determine the effectiveness of their support for the development of green innovations. Integrating these factors into venture capital (VC) strategies can fundamentally affect cleantech investments' success across different regions and cultural environments.

The relationship between venture capital (VC) and green innovation (GI) is significantly influenced by government regulations that shape the environment for entrepreneurship and innovation. Studies confirm that the regulatory environment plays a key role in determining venture capital's (VC) effectiveness. Du et al. (2024) and Yang et al. (2022) found that moderately strict regulations maximize the benefits of venture capital (VC) for green innovation (GI). Conversely, excessive regulation can limit the flexibility and effectiveness of venture capital (VC), while insufficient regulatory frameworks do not provide sufficient support for developing green projects (Du et al., 2024; Yang et al., 2022).

(Wu et al., 2020) et al. (2020) show a strong positive impact of government subsidies on green innovation (GI) investment, especially in the case of state-owned enterprises (SOEs). However, their effectiveness in supporting private firms is limited (Wu et al., 2020). On the contrary, Bürer and Wüstenhagen (2009) and Li and Zheng (2023) argue that North American and European investors prefer stable market policies, such as feed-in tariffs, to direct subsidies. These instruments provide more predictable conditions and lower risk for venture capital (VC) investors (Bürer & Wüstenhagen, 2009; Li & Zheng, 2023; Migendt et al., 2017; Wu & Liew, 2024).

Malen and Marcus (2017) also emphasize that the success of clean energy businesses is closely linked to the local context. Policies, community interests, and local conditions fundamentally influence the effectiveness of government measures. This emphasis on the local context underscores the need to adapt regulatory measures to regional specificities (Malen & Marcus, 2017).

A favorable regulatory environment and support for innovation significantly enhance venture capital's (VC) effectiveness. Yang et al. (2022) and Hua et al. (2023) emphasize that correctly set market and innovation conditions increase the effectiveness of venture capital (VC) in supporting green projects (Hua et al., 2023; Yang et al., 2022). In China, as shown by Dong et al. (2021) and Kulanov et al. (2020), venture capital (VC) is more effective in developing green innovations in developing regions, where regulatory shortcomings and market barriers limit its effectiveness (Dong et al., 2021; Kulanov et al., 2020).

Further research recommendations. The identified research gaps highlight several areas that require further investigation. One key gap is the lack of understanding of the relationship between profitability and environmental objectives, with a lack of studies addressing the optimization of the balance between short-term financial objectives of venture capital (VC) and long-term environmental impacts, particularly in sectors such as cleantech. In addition, comparative analyses of the effectiveness of different types of venture capital (VC), such as independent (IVC), corporate (CVC), and government venture capital (GVC), and their specific approaches and objectives in supporting green innovations (GI), are limited.

Another gap is the insufficient consideration of geographical and cultural differences that can affect the success of venture capital (VC) in different regions, especially in developing markets or economies with lower regulatory stability. In this context, more profound analyses of regulatory frameworks and their impact on the

effectiveness of venture capital (VC) are also lacking. At the same time, the optimal setting of public policies and legislation is still poorly explored (Cera et al., 2021). Similarly, research on synergistic partnerships between public and private entities and their role in overcoming investment barriers is still limited.

The attractiveness of green innovations (GI) for venture capital (VC) investors represents another significant research gap, as there is little knowledge about how environmental technologies influence investor decision-making. In the field of cleantech investments, there is a lack of understanding of how the traditional venture capital (VC) model can be adapted to address the specific challenges of this sector, such as long development cycles and high capital costs. Furthermore, the long-term impacts of venture capital (VC) on the environmental, economic, and social dimensions of sustainability, especially in the context of achieving Sustainable Development Goals (SDGs), are underexplored.

These research gaps highlight the need for further studies to expand our understanding of the role and effectiveness of venture capital (VC) in supporting green innovations (GI) while providing practical recommendations for investors, businesses, and policymakers.

Conclusion

The study's results confirm the key importance of venture capital (VC) in supporting green innovations (GI) and their positive impact on businesses of all sizes and the broader economic environment. Venture capital (VC) not only overcomes financial barriers but also enables businesses to develop green solutions, increase the number and quality of green patents, and improve resilience to economic and environmental challenges. Moreover, investments in green innovations (GI) support job creation, technological progress, and emission reduction, thereby contributing to achieving Sustainable Development Goals (SDGs).

The study enhances Resource-Based View (RBV) and Natural Resource-Based View (NRBV) theories by demonstrating how venture capital (VC) can serve as a strategic tool to boost firms' competitive advantage and support environmental sustainability. VC enables firms to access and optimize rare, valuable, and inimitable resources while overcoming financial barriers. By complementing internal resources with external funding, VC maximizes a firm's strategic potential.

VC financing also provides access to strategic networks, expert advice, and mentorship, enhancing firms' capacity to innovate and remain competitive. Additionally, environmental strategies supported by VC help firms address regulatory pressures and create a competitive edge. By acting as a catalyst for green innovations (GI), such as cleantech and renewable energy, VC fosters technological and organizational advancements aligned with ecological goals. Supporting GI through VC not only attracts investors but also promotes firms' long-term environmental and economic sustainability.

The study also has important practical implications for companies, investors, and policymakers who endorse more effective use of venture capital (VC) in supporting green innovations (GI). For companies, the results provide necessary guidance on improving access to finance by highlighting the need to understand better venture capital (VC) investors' preferences and present green innovations more effectively. In addition, companies can leverage synergistic partnerships between public and private entities to overcome financial and technological barriers that hinder the development of green solutions. Sectors such as cleantech can benefit from optimizing business models to address specific challenges associated with high costs and long development cycles.

For investors, the study offers insights into more efficient resource allocation by identifying projects with high environmental and economic impact potential. The differences between types of venture capital (VC), such as independent (IVC), corporate (CVC), or government venture capital (GVC), allow investors to tailor their strategies according to their preferred objectives, whether financial return, strategic synergies or support for public policies. Policymakers can gain valuable insights into optimizing regulatory frameworks to support venture capital (VC) investments in green innovations. Predictable and transparent policies can reduce risks and increase the attractiveness of green projects. In addition, specific support for the cleantech sector, such as subsidies, tax breaks, or public-private partnerships, can accelerate the development and implementation of green technologies. Policies should also reflect the geographical and cultural differences affecting venture capital's (VC) success, with a special emphasis on developing markets.

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Appendix

Tab. 1. Characteristics of studies included in the systematic literature review

Name, Year	Title	Summary
Agrawal et al. (2024)	How do impact investors evaluate an investee social enterprise? A framework of impact investing process	The study investigates how impact investors evaluate social enterprises for investment, recognizing the distinct motivations behind such investment compared to traditional venture capital, which primarily seeks financial gain. The research identifies a four-step evaluation framework consisting of context, investment focus, venture analysis, and decision-making, where social values are central. A database of 115 impact-investing firms was built, leading to interviews with 32 professionals in this field. Key findings emphasize the influence of socioeconomic and institutional contexts on investment decisions, the importance of innovative solutions to social issues, and the need for investees to have strong business and social value propositions. The study also highlights the significance of entrepreneurial background and the empathy of the team in the selection process. Furthermore, it discusses the complexities of balancing social missions with profitability, and provides insights into risk management within impact investing, with implications for both practitioners and scholars.
Bellucci et al. (2023)	Venture Capital Financing and Green Patenting	The study examines the influence of green innovation on attracting venture capital (VC) financing using a dataset from 2008 to 2017, which combines venture capital transactions, financial metrics, and patent data. The study finds that companies with green patents have a significantly higher probability (up to 20%) of receiving VC funding compared to those without green patents, reinforcing the idea that patents serve as a positive signal to investors. The attractiveness of green patents is particularly noted in the context of ambitious climate goals and substantial investment needs for sustainability. Results indicate that while green patents enhance the likelihood of securing venture financing, other dimensions like firm size, age, leverage, and R&D activity also play crucial roles. The analysis includes robustness checks and varied specifications, confirming that green patenting is a pivotal factor in securing VC investment and supporting the development necessary for transitioning towards greener economies. Furthermore, the results underscore the importance of public and private cooperation in channeling financial resources toward green initiatives to facilitate environmental innovation and growth.
Bendig, D. (2022)	The effect of green startup investments on incumbents' green innovation output	The study investigates how corporate venture capital (CVC) investments in green startups influence the green innovation output of established firms (incumbents). Green innovation is vital for addressing climate change, and while startups develop green technologies, incumbents often lack the agility to adopt them. This research, based on a dataset of 1,568 observations from U.S. firms (2000-2018), confirms that higher CVC investments in green startups correlate with increased green patent applications by incumbents. The study highlights the critical role of absorptive capacity, enabling firms to assimilate external green knowledge. This relationship contributes to understanding the dynamics between startups and incumbents, suggesting that CVC can enhance both environmental and financial performance for established firms while underscoring the impact of startups on broader market transformations. Practical implications for managers, startup founders, and policymakers are discussed, advocating for strategic CVC engagement to drive sustainability. Limitations and avenues for future research are also noted.
Benkraiem et al. (2023)	The effects of environmental performance and green innovation on corporate venture capital	The study investigates the impact of greenhouse gas (GHG) emissions and green innovation on corporate venture capital (CVC) financial performance, using data from 133 U.S. firms over an 18-year period (2002-2019). The findings indicate that reducing GHG emissions significantly enhances financial performance, particularly through metrics like Tobin's Q. Moreover, green innovation—quantified by green patent counts and citations—also positively affects financial results, though the impact on return on equity (ROE) is less pronounced. Importantly, the combined effect of improved environmental performance and increased green innovation leads to even greater financial benefits for firms. The research highlights the importance of adopting sustainable practices as core elements of corporate strategy to drive competitive advantage and profitability, suggesting a shift in investment strategies toward ecological considerations. This report calls for greater support from policymakers to drive green innovation and investment in GHG emission reductions.
Büreret et al. (2009)	Which renewable energy policy is a venture capitalist's best friend? Empirical evidence from a survey of international cleantech investors	The study examines the preferences of venture capitalists regarding renewable energy policies, particularly focusing on the effectiveness of various policies to stimulate investments in clean energy technologies. A survey was conducted involving 60 investment professionals from North America and Europe. The results indicate that investors perceive feed-in tariffs as the most effective renewable energy policy, especially among those in Europe. The study also highlights the importance of consistent and stable policy environments for fostering investor confidence. Furthermore, the research suggests a complementary mix of technology-push (like government grants for demonstration projects) and market-pull policies (such as reducing fossil fuel subsidies) is necessary to support clean energy innovation. Venture capitalists expressed skepticism towards government intervention, preferring market-driven approaches, but acknowledged the critical role of supportive policies in mitigating regulatory risks and encouraging investments. The findings advocate for policymakers to align renewable energy strategies with investor preferences to leverage private investment effectively.
Chen et al. (2024)	Institutional logics and organizational filters: Differential responses to innovation and	The study investigates how different organizational attributes influence responses to institutional logics in China's cleantech sector, specifically focusing on venture capital (VC) and private equity (PE) investments. It identifies two main logics—market and proenvironmental—that shape investment decisions across various provinces. Organisational attributes, notably state ownership and business models, modulate these

	environmentalism in China's cleantech sector	logics' effects differently. The research finds that market logic drives investments in cleantech through enhanced market infrastructure, while proenvironmental logic fosters investments by increasing environmental awareness among consumers and regulatory pressures. Surprisingly, state ownership does not enhance sensitivity to either logic, contrasting with expectations. Conversely, the VC business model amplifies responsiveness to market logic, but not to proenvironmental logic. The findings contribute to understanding institutional logics in non-Western contexts and emphasize the distinct nature of proenvironmental activism in China, aligning it with state mechanisms rather than community-led initiatives.
Christensen et al. (2009)	Of acting principals and principal agents: goal incongruence in the venture capitalist-entrepreneur relationship	This qualitative study examines the motivations for venture capitalists and entrepreneurs to act opportunistically toward one another. Structured interviews with 14 employees and five investors in a VC-funded startup revealed that venture capitalists expect opportunistic behaviour from entrepreneurs during investment rounds, but largely trust entrepreneurs between financing rounds. Both the venture capitalists and entrepreneurs reported that venture capitalists act opportunistically towards the entrepreneur and other venture partners during all stages of the startup development. These findings have important implications for entrepreneurship research, most notably, the applicability of agency theory as a theoretical perspective from which to view the complex relationship between venture capitalists and entrepreneurs.
Cumming et al. (2016)	Cleantech' venture capital around the world	The study explores the determinants of cleantech venture capital (VC) investments globally, emphasizing that such investments are capital-intensive and face unique technology risks. Unlike traditional VC, cleantech initiatives often yield societal benefits, raising concerns of underinvestment due to their public good nature. The authors analyze factors influencing cleantech VC across 31 countries from 1996 to 2010, finding that oil prices are a key driver, positively impacting investment activity but with diminishing returns at high levels. Media attention also significantly correlates with increased cleantech VC deals, while uncertainty avoidance and weak governance structures negatively affect investment. The paper concludes that to boost cleantech VC, policymakers should create stable environments fostering sustainable development and effective regulatory frameworks, especially in high uncertainty avoidance cultures. Future research could further explore public-private partnerships and governance improvements to mitigate market failures in cleantech investment.
Dong et al. (2021)	How does venture capital spur the innovation of environmentally friendly firms? Evidence from China	The study examines the impact of venture capital (VC) on the green innovation of environmentally friendly firms in China, highlighting a gap in existing literature about the differing effects of VC from government and foreign sources. It uses patent data, focusing on both quantity (patent applications and grants) and quality (citations) of innovations. The findings indicate that VC enhances the likelihood of patent approvals and increases their citation value, highlighting the quality of innovations developed by VC-backed firms. Conversely, government venture capital (GVC) has a negative effect on innovation, attributed to risk aversion and the governance structures of GVC managers. The study shows that foreign venture capitalists (FVC) are more effective in fostering green innovation, likely due to their experience and less restrictive investment practices. The results imply that improving the efficiency of GVC could significantly benefit the green innovation landscape in China, suggesting that both GVC and independent VC should emulate successful practices used by FVC.
Du et al. (2024)	Government venture capital and innovation performance in alternative energy production: The moderating role of environmental regulation and capital market activity	The study investigates the effect of government venture capital (GVC) on innovation performance in alternative energy production (AEPI) in China, addressing the moderating roles of environmental regulation and capital market activity. Using data from 30 provinces (2003-2019), the findings indicate an inverted U-shaped relationship between GVC and AEPI, suggesting that while GVC initially benefits innovation, excessive GVC can be detrimental. Environmental regulation amplifies this effect, whereas active capital markets attenuate it. Notably, GVC enhances AEPI through increased R&D investment. The research contributes to understanding the complexities of GVC's role in fostering innovation and emphasizes the need for balanced government intervention alongside vibrant capital market structures. Finally, it highlights avenues for future research, focusing on firm-level impacts and the influence of private and foreign venture capital.
Gaddy et al. (2017)	Venture Capital and Cleantech: The wrong model for energy innovation	The study analyzes the significant decline in venture capital (VC) investments in clean energy technology (cleantech) from 2006 to 2011, revealing that VC firms invested over \$25 billion with less than half being returned. The authors observe that cleantech investments carried high risks with low returns, especially in "deep technology" sectors like materials and hardware, which consumed substantial capital but yielded poor outcomes. Unlike software and medical technology, which performed better, cleantech struggled with commercialization, contributing to a funding withdrawal by VCs. The authors suggest that future cleantech innovations require broader support from policymakers, corporations, and alternative investment sources, as traditional VC models may not align well with cleantech's long development and capital demands. To foster success, they recommend enhancing public funding for research and commercialization, and encouraging diversified investment partnerships to support early-stage cleantech companies.
Ginsberg et al. (2018)	Venture capital's role in creating a more sustainable society: the role of exits in clean energy's investment growth	The study explores the role of venture capital (VC) in promoting clean energy (CE) technologies, highlighting the constraints driven by the financial expectations of their investors. These backers demand high returns to justify the significant risks of funding unproven startups. The research analyzes how these financial pressures influence VC investment decisions in CE, particularly in response to CE exits like IPOs and acquisitions. The findings indicate that VCs increase investments in CE only when their cumulative exits far surpass those of their peers, but they scale back investments when their exits moderately

		exceed their peers. This behavior underscores the tension between meeting financial backers' expectations and supporting sustainable innovation.
Gucciardi (2024)	Do venture capital investments contribute to the achievement of the sustainable development goals?	The study investigates the relationship between venture capital (VC) investments and the achievement of Sustainable Development Goals (SDGs) across 132 countries from 2015 to 2021. It utilizes a fixed effect panel data model to analyze whether higher levels of VC are tied to improved SDG performance, focusing on how various characteristics of VC investments affect this relationship. The findings reveal a positive correlation between VC volumes and SDG achievement, with significant effects primarily seen in economic and governance dimensions. Heterogeneous results indicate that the effectiveness of VC on SDGs varies by the type of investor (independent vs. corporate), the industry of the backed startups, and the level of economic development in countries. The study suggests that while VC investments can support sustainable development, particularly in advanced economies, their impact on environmental sustainability is limited. Policymakers are encouraged to foster VC activity in developing regions and to address the investment risks associated with green startups to maximize sustainable impacts.
Hain et al. (2018)	Local competence building and international venture capital in low-income countries: Exploring foreign high-tech investments in Kenya's Silicon Savanna	The study examines evolving patterns of international venture capital (VC) investments in Kenya, focusing on their role in local competency development and sustainable economic growth in Sub-Saharan Africa (SSA). It introduces a novel taxonomy classifying investors based on their motivations (for-profit vs. social impact) and start-ups according to their market focus (local vs. global). The authors highlight a shift towards the recognition of local innovations by foreign investors, emphasizing the integration of global and local knowledge. They identify high-tech investments primarily in the information and communications technology (ICT) sector, which benefit from recent advancements in mobile and internet infrastructure. The paper suggests that this new investment landscape can spur economic growth and local capacity building, providing insights for policymakers, investors, and entrepreneurs on leveraging these dynamics for sustainable development. Future research directions include exploring investor-startup interactions and further refining the proposed investment taxonomy.
Hegeman et al. (2021)	Why do they do it? Corporate venture capital investments in cleantech startups	The study investigates corporate venture capital (CVC) investments in cleantech startups, focusing on the diversity of investors and their motivations. Analyzing 26 cases of companies that invested in cleantech startups in Norway (1999-2012), the research highlights the growing involvement of both large firms and SMEs in CVC. Findings reveal that motivations for investment extend beyond financial return, also encompassing strategic aims related to green technology and sustainability. Large companies tend to view investments as opportunities for learning and responding to environmental challenges, while many SMEs pursue investments for business expansion without fully recognizing their contributions to green innovation. The paper notes that government-owned firms frequently invest in alignment with stakeholder expectations and local development goals. These insights emphasize the need for inclusive policies that consider all corporate investors in fostering a greener economy.
Hua et al. (2023)	The path towards sustainable finance: Venture capital and air pollution in China	The study examines the impact of venture capital (VC) on air pollution in China, analyzing data from 2003 to 2016. It finds that VC significantly reduces local air pollution, with a one standard deviation increase in VC leading to a 4% decrease in PM2.5 levels and a 6% reduction in industrial SO2 emissions. The effects are more pronounced in cities with stricter environmental regulations, better business environments, and stronger innovation incentives. VC fosters improvements in air quality by enhancing both general and green innovation and redirecting investments from polluting to green enterprises. The findings indicate that VC serves as a sustainable finance source, promoting cleaner air through technological advancement and changes in investment structure. The study contributes to understanding the role of VC in environmental governance, highlighting its capacity to drive green innovation and improve urban air quality in China.
Incekara (2022)	The Impact of External Financial Factors on the Eco-Innovation Practices of Small and Medium-Sized Businesses	The study investigates the influence of external financial factors on the eco-innovation practices of small and medium-sized enterprises (SMEs), utilizing the Flash Eurobarometer 441 dataset from a 2016 survey of 5,873 SMEs across 28 EU states. It employs logistic regression to assess the impact of various financing approaches, revealing that traditional bank loans assess positively on renewable energy use but not on other eco-innovation areas. Traditional public funding, including EU funds and grants, aids water re-design and energy planning but fails in waste minimization and product re-design. In contrast, modern financing sources like crowdfunding significantly enhance all green initiatives, while peer-to-peer lending aids waste management. The study also highlights that firm size, type of market, age, and R&D investment levels considerably influence eco-innovation adoption. The results underline the need for improvements in financing strategies to support SMEs in implementing sustainable practices, particularly emphasizing the distinct roles of traditional and modern financing approaches.
Islam (2018)	Signaling by early stage startups: US government research grants and venture capital funding	The study explores the role of signaling for early-stage startups in the U.S. clean energy sector, particularly how government research grants can enhance their legitimacy and access to venture capital (VC) funding. It finds that startups awarded grants are approximately 12% more likely to secure subsequent VC funding compared to those that do not receive such grants. The signaling effect is strongest within six months following the grant award and is particularly beneficial for startups with fewer patents, suggesting that these grants can help level the playing field by providing less endowed ventures with valuable validation. The research highlights the importance of quickly leveraging these signals to attract funding and suggests that government support for startups can help redistribute opportunities in emerging industries. Additionally, the study provides insights into the dynamics of resource acquisition strategies that differ across various stages of a startup's life cycle.

Kato (2024)	Building resilience and sustainability in small businesses enterprises through sustainable venture capital investment in sub-Saharan Africa	The study explores the role of sustainable venture capital (VC) in enhancing resilience and sustainability among small and medium enterprises (SMEs) in sub-Saharan Africa. It highlights the potential of VC to drive sustainable business models, improve market performance, and foster innovation while addressing regional challenges. The research used explanatory factor analysis on data from 61 VC firms across South Africa, Kenya, and Uganda from 2015-2021. Results indicate that VC investment significantly contributes to SMEs' resilience and sustainability, emphasizing the importance of supportive government policies and knowledge transfer from VC investors. Challenges include limited access to green financing, insufficient awareness of sustainability practices, and economic disparities affecting implementation. Ultimately, the study proposes a framework for sustainable VC finance, urging stakeholders to recognize VC's transformative potential in promoting sustainable growth and market expansion within SMEs in the region.
Kulanov et al. (2020)	Venture financing and the fuel and energy complex: Investing in alternative energy	The study explores venture financing in renewable energy, analyzing its trends and barriers through data and expert opinions. It emphasizes the growing need for investments in renewable energy to improve energy efficiency and address environmental issues, while the global investment in green energy has reached \$2.9 trillion since 2004. The authors identify that venture capital (VC) is crucial for startups due to the high risks of untested technologies. Factors influencing VC investments include regulatory environments, demand for renewable sources, and technological infrastructure. Despite a decline in VC investments in 2017, there was a rebound in 2018, particularly in solar and biomass sectors. Experts suggest that stimulating free capital flow and creating supportive legislation are essential for attracting VC. Recommendations include adopting international practices like crowdfunding and tax incentives to enhance investment attractiveness in renewable energy projects.
Laachach et al. (2023)	The effects of organizational learning on innovation and performance of venture capital-backed firms: the moderating effect of syndication	The study investigates how organizational learning (OL) affects innovation and performance in venture capital (VC)-backed firms, specifically focusing on the moderating role of VC syndication. Through a literature review and empirical research based on a sample of 78 VC-backed firms in Morocco, the study finds that OL positively influences both innovation and firm performance. Additionally, innovation is shown to enhance performance. Notably, VC syndication significantly moderates the relationship between OL and firm performance, as well as between innovation and performance, while having no significant effect on the relationship between OL and innovation. The findings underscore the importance of OL and syndication in enhancing competitiveness in the Moroccan VC sector, suggesting policymakers encourage such collaborations to spur innovation and financial success in emerging markets. Limitations include the small sample size and the need for longitudinal studies to deepen insights into VC impacts over time.
Li et al. (2023)	How Do Sustainability Stakeholders Seize Climate Risk Premia in the Private Cleantech Sector?	The study investigates how venture capital (VC) fund managers and entrepreneurs in the private cleantech sector can capture climate risk premia. It highlights that adopting long-term investment strategies and optimistic climate risk management practices are essential for success. The study shows that government policies, particularly feed-in tariffs (FITs), positively influence these investment strategies, encouraging a shift from short-term to long-term approaches, which effectively seizes more climate risk premia. The findings suggest that cleantech investments perform better in harsher economic conditions, exhibiting greater growth opportunities particularly in emerging economies. The analysis indicates that the captured climate risk premia stem from both the increased market power of cleantech products and the legitimacy acquired during start-up development. Robustness tests support the argument that the FITs policy aids in enhancing VC investment performance in cleantech. Future research is recommended to explore climate risk premia capture in emerging economies and the implications of legal regulations.
Li et al. (2024)	Does governmental venture capital (GVC) advance green innovation? Big data evidence from China	The study investigates the effects of governmental venture capital (GVC) on green innovation in China from 2009 to 2018, utilizing a dataset comprising 317,870 firm-year observations. Results indicate that GVC investments positively and significantly enhance green innovation, particularly increasing the number of granted green patents by 3.8% to 9.8%. However, the effect is notably smaller for start-ups compared to other firms, likely due to cash flow constraints that limit long-term innovation investments. GVCs also facilitate additional funding from private sources, supporting the "certification effect," which boosts firms' appeal to private venture capital and other funding entities. The study also reveals that GVCs structured as limited partnerships are more effective in promoting green innovation than those in corporate structures. Furthermore, geographic proximity enhances the impact of GVCs on innovation, suggesting local investments yield better results. Finally, GVC investments also improve the quality of green innovation, as indicated by higher patent citations and claims.
Lin et al. (2024)	The role of venture capital in determining the total factor productivity of renewable energy enterprises: In the context of government subsidy reduction	The study investigates the impact of venture capital (VC) on the total factor productivity (TFP) of renewable energy (RE) firms in China, particularly in the context of decreasing government subsidies (GS). Over the period from 2011 to 2021, the study finds that VC significantly enhances TFP, primarily by promoting R&D investment and alleviating financing constraints. Notably, the positive impact of VC is only significant when GS is below 1.07%. The research also highlights the varying effects of VC across different types of enterprises, indicating a more pronounced effect on non-state-owned and larger firms compared to state-owned and smaller enterprises. The authors suggest targeted policy interventions to encourage VC investment in RE sectors and caution against excessive subsidies that might hinder productivity improvements. Overall, this study adds to the understanding of how external financing interacts with government support in shaping productivity dynamics within the renewable energy industry.
Lin et al. (2024)	Driving renewable energy innovation	The study investigates the influence of venture capital (VC) on renewable energy innovation investments (REII) in China, utilizing data from 114 publicly listed renewable energy

	investments: Is venture capital a novel strategic choice? Evidence from China	companies between 2011 and 2023. The findings demonstrate that VC significantly stimulates REII, especially in high-growth and profitable firms. VC's positive effects are attributed to its ability to alleviate financial mismatches and reduce rent-seeking costs, thereby enabling better innovation capacity in these firms. The research also identifies that joint VC, state-owned VC, and long-term VC are particularly effective in promoting innovation investments. Policy recommendations suggest creating a supportive environment for VC in the renewable energy sector, enhancing financial access, and encouraging collaborations between different types of VC to maximize innovation outcomes. The study emphasizes the crucial role of VC in advancing China's renewable energy transition while addressing challenges related to financing and innovation capabilities.
Luo et al. (2023)	Does venture capital improve corporate social responsibility performance?	The study examines the impact of venture capital (VC) on corporate social responsibility (CSR) performance using data from Chinese nonfinancial A-share listed firms from 2010 to 2019. The findings suggest that VC participation may negatively affect CSR performance, particularly in small and medium-sized enterprises (SMEs). The research identifies internal control quality as a significant mechanism through which VC influences CSR. The study also highlights that venture capital tends to prioritize short-term profits over social responsibility, which can diminish firms' CSR initiatives. Additionally, the negative effects of VC on CSR are more pronounced in private and smaller firms compared to larger or state-owned firms. The study suggests possible regulatory strategies to enhance CSR engagement among VC-backed companies and emphasizes the importance of considering internal control systems in CSR efforts. Overall, the research contributes to understanding the complex relationship between venture capital and CSR performance in emerging markets.
Maiti (2022)	Does development in venture capital investments influence green growth?	The study aimed to investigate whether venture capital (VC) investment developments contribute to green growth, using different stages of VC funding as threshold variables. It applied dynamic panel threshold models and analyzed panel data from 23 countries between 2007 and 2015. The results indicate that a 1% increase in seed capital improves CO2 productivity, while similar increases in early-stage and later-stage VC investments enhance environmental technology innovation and renewable energy supply. When accounting for enhanced environmental policies, seed and later-stage VC investments further boost CO2 productivity, and early-stage VC investments are particularly effective in fostering green technology innovation and renewable energy growth.
Malen et al. (2017)	Promoting clean energy technology entrepreneurship: The role of external context	The study investigates the influence of political, social, and economic factors on clean energy technology entrepreneurship (CETE) in the U.S. It identifies that government policies supporting clean energy create opportunities for CETE, but success depends on favorable external contexts. By analyzing a novel dataset connecting policy indicators with clean energy startup information from 2000 to 2006, it finds that strong local attention to clean energy and the presence of successful clean energy firms enhance CETE. The research highlights that while technological and market opportunities are critical, their effectiveness is magnified by local environmental support, suggesting that public policies alone may not suffice without a conducive entrepreneurial context. The findings call for policymakers to foster local awareness and successful clean energy businesses to enhance CETE, emphasizing the importance of engagement beyond just technical support or market creation initiatives.
Marcus et al. (2013)	The Promise and Pitfalls of Venture Capital as an Asset Class for Clean Energy Investment: Research Questions for Organization and Natural Environment Scholars	The study examines the potential and limitations of venture capital (VC) as a funding source for clean energy and its role in creating a sustainable society. It highlights emerging trends in VC practices, including increased investment amounts over longer periods, a shift away from high-risk manufacturing and production companies, and a focus on the intersection of information technology and energy. VCs are also experimenting with highly risky technologies that could significantly impact the environment if successfully commercialized. The paper calls for further research into how VC can evolve to play a more transformative role, addressing questions about its ideal role, necessary changes, and potential for catalyzing breakthroughs akin to the transformative impact of the Internet on society and the economy.
Michelfelder (2022)	Attracting venture capital to help early-stage, radical cleantech ventures bridge the valley of death: 27 levers to influence the investor perceived risk-return ratio	The study examines how early-stage, radical cleantech ventures can attract venture capital to overcome the "valley of death" between research and commercialization. Given the high capital requirements, long development cycles, and perceived risks associated with radical innovations, the study identifies 27 actionable levers that can improve the investor-perceived risk-return ratio for cleantech investments. The authors conducted in-depth interviews with 45 cleantech investors and utilized a mixed-methods approach to analyze past investment decisions and evaluate these levers. Key findings suggest that improving financial models, engaging public authorities for support, and focusing on recurring revenue can significantly enhance venture appeal. Importantly, various stakeholders (e.g., ventures, investors, public authorities) must collaborate to implement these levers effectively. The research informs policy and practical strategies to mobilize funding for cleantech ventures, thus facilitating their growth and contribution to sustainable development.
Migendt et al. (2017)	Beyond venture capital: an exploratory study of the finance-innovation-policy nexus in cleantech	The study explores the interplay between innovation financing and policy, focusing on private equity (PE) and venture capital (VC) in cleantech sectors in the United States and Germany. It highlights the overlooked dynamics along the equity financing value chain and the indirect effects of innovation and financial policies on PE and VC supply and demand. Through a comparative case study, the research identifies systemic interdependencies among institutional investors, VC/PE, and policymakers—the "finance-innovation-policy nexus." It concludes that policies impacting financial markets, especially those affecting institutional investors, must account for these interdependencies to effectively mobilize private investment for cleantech innovation.

Owen (2023)	Lessons From Government Venture Capital Funds to Enable Transition to a Low-Carbon Economy: The UK Case	The study investigates the role of government-backed venture capital funds (GVCFs) in supporting early-stage cleantech innovation to meet climate change net-zero targets. It addresses the challenges of venture capital in commercializing new technologies where socio-environmental returns may exceed economic returns. Focusing on four U.K. GVCFs, the research uses a systems framework and absorptive capacity lens to analyze qualitative data from over 100 interviews conducted over a decade. A model is developed to assess GVCF learning evolution, focusing on the nascent precommercialization cleantech investment market. The study provides qualitative insights to inform policy, practice, and theory, avoiding premature evaluation of long-term investment outcomes.
Owen et al. (2020)	Early stage investing in green SMEs: The case of the UK	The study examines the role of early-stage investment in cleantech SMEs in the UK in light of a proposed Green New Deal (GND). It discusses the need for targeted government policies to address financing gaps faced by cleantech ventures, particularly as traditional investors often perceive these investments as high-risk. The UK Innovation Investment Fund (UKIIF) is highlighted as a key government initiative aimed at overcoming market failures by facilitating public-private co-financing. The authors argue that through various case studies of companies supported by UKIIF, government involvement can significantly influence venture capital (VC) dynamics, enhance management skills, and promote innovative green technologies capable of reducing CO2 emissions. However, they also identify challenges such as insufficient attention to transaction costs and the selection process for viable cleantech investments, indicating the need for better metrics to evaluate the socio-environmental impacts of investments.
Petkova et al. (2014)	Reputation and decision making under ambiguity: a study of us venture capital firms' investments in the emerging clean energy sector	The study examines the role of reputation on decision making under ambiguity. Drawing on social cognition and behavioral theories, we propose that a firm's reputation exerts dual pressures on its decision making under ambiguity. On the one hand, a firm's reputation increases its aspirations for future performance and promotes its engagement in risky strategies to achieve them. On the other hand, preserving the already established reputation requires a firm to deliver consistent performance over time, which promotes greater use of risk reduction strategies. Our analyses of the U.S. venture capital firms' investments in the clean energy sector from 1990 to 2008 demonstrate that while reputable firms are more likely to invest in the emerging sector, they also employ risk reduction strategies more extensively. The sector's legitimization further influences these firms' investment decisions both directly and through its interaction with firm reputation.
Pradhan et al. (2017)	Venture Capital and Innovation: Evidence from European Economic Area Countries	The study examines the long-run relationship between venture capital and innovation in the 19 European Economic Area (EEA) countries over the period 1989-2014. We use three different indicators of venture capital (VC), such as VC at early stage investment, VC at later stage investment, and VC total investment, and seven different indicators of innovation, such as patents-residents, patents-nonresidents, patents-total, research and development expenditure, researchers in research and development activities, high-technology exports, and scientific and technical journal articles, to examine this long-run relationship. Using cointegration technique, the study warrants the support of long-run relationship between venture capital and innovation in few cases, typically with reference to a particular VC indicator and innovation indicator. Expanding the Granger causality test, the study finds the presence of both bidirectional and unidirectional causality between venture capital and innovation. However, these results vary from country-to-country within the EEA countries, depending upon the types of VC indicator and innovation indicator that we use in a particular empirical exploration process. The policy implication of this study is that the economic policies should recognize the differences in the venture capital and innovation in order to maintain the sustainable development in these EEA countries.
Rehman et al. (2023)	Does Institutionalism Coupled with Venture Capital Drive Green Innovation?	The study explores the drivers of green innovation in BRICS countries, focusing on the roles of institutional frameworks and venture capital (VC) through the lens of institutional theory. Using panel regression analysis with fixed effects, the research finds that stringent environmental regulations and the integration of VC significantly promote green innovation. The study uniquely combines institutional and financial perspectives to identify factors that enhance environmental sustainability through green innovation, addressing the critical challenge of climate change.
Roma et al. (2023)	Environmental Sustainability Orientation, Reward-Based Crowdfunding, and Venture Capital: The Mediating Role of Crowdfunding Performance for New Technology Ventures	The study investigates the impact of Environmental Sustainability Orientation (ESO) on crowdfunding performance and venture capital acquisition for new technology ventures. Analyzing data from 508 hardware ventures on Kickstarter, the findings reveal that ESO negatively affects crowdfunding performance, implying that ventures with ESO are less likely to achieve their funding goals. Nevertheless, the presence of ESO has a positive direct effect on the likelihood of receiving subsequent venture capital funding, which counters the negative impact stemming from poor crowdfunding performance. The performance in crowdfunding acts as a mediator, leading to decreased likelihood of securing venture capital for ventures with ESO due to their lower crowdfunding success. This highlights a complex relationship where ESO presents a dual effect on attracting funding. The paper contributes to understanding the dynamics of crowdfunding and venture capital in the context of environmentally oriented ventures, suggesting that such ventures need to balance their communication strategies to appeal to both crowdfunders and professional investors.
Shuwaikh et al. (2025)	Insights for sustainable business practices: Comparative impact of independent and corporate venture capital funding on financial and	The study evaluates the impact of independent venture capital (IVC) versus corporate venture capital (CVC) funding on the financial and environmental performance of 325 U.S. firms from 2002 to 2022. Results indicate that companies backed by IVC exhibit superior financial health, reflected in higher return on equity (ROE), return on assets (ROA), and Tobin's Q compared to those supported by CVC. Additionally, IVC-backed firms receive higher environmental, social, and governance (ESG) scores and demonstrate lower greenhouse gas (GHG) emissions, indicating a stronger commitment to sustainability. The

	environmental performance	research also highlights how different funding types influence business sustainability practices and investor strategies, suggesting that IVCs typically foster better ESG performance due to their focus on financial growth and innovative, sustainable practices, whereas CVCs often prioritize strategic corporate alignments. This study emphasizes the relevance of VC type in guiding investment decisions and fostering sustainable business models.
Siefkes et al. (2024)	Profit first, environmental impact second? Investigating hybrid institutional logics in venture capital investment approaches	The study examines the investment strategies of European cleantech venture capital firms (VCs) and the alignment of their approaches with hybrid institutional logics, combining profit motives with environmental impact. The authors mapped 36 VCs and conducted interviews with nine investors, revealing a landscape dominated by incremental innovations in highly emissive sectors, often prioritizing financial returns over environmental objectives. Many VCs articulate ambitious green missions publicly but fail to implement effective impact management. The research identifies a disconnect between VCs' claimed green objectives and their investment behaviors, suggesting that pressures from limited partners (LPs) typically focus on financial performance, hindering the funding of radical innovations necessary for a sustainable transition. The study highlights the challenges VCs face in balancing profitability and genuine environmental impact and suggests improvements, including more patient investment strategies and better-established measurement frameworks for sustainability.
Siefkes et al. (2025)	Business angels investing in green ventures: how do they add value to their start-ups?	The study examines how business angels (BAs) contribute to the sustainability of green ventures, focusing on the differences between "green angels" and "light green angels." Using qualitative interviews with 14 BAs from Germany and the Nordics, the research identifies two main groups with varying motivations for investing in green startups. Green angels, motivated by altruistic factors and sustainability, engage in activities that directly enhance the sustainability performance of their ventures. They provide strategic advice, sustainability monitoring, and facilitate resource acquisition. In contrast, light green angels invest primarily for economic returns and offer conventional support akin to traditional BAs. The findings highlight the significance of sustainability characteristics in shaping the value-added activities of BAs and emphasize the potential role of green angels in bridging the financing gap for early-stage green startups, fostering a deeper understanding of the investor-entrepreneur relationship within the green venture ecosystem.
Sun (2024)	Smart city and green innovation: Mechanisms and industrial emission reduction effect	The study examines the relationship between smart city construction and green innovation in China, focused on data from 2005 to 2019. Utilizing a causal identification framework, the study finds a significant positive impact of smart city initiatives on green innovation, though this effect exhibits a weak inverted U-shaped trend over time. It identifies several mechanisms through which smart city construction influences green innovation, including optimized labor allocation, enhanced venture capital attraction, and improved market accessibility. The results indicate heterogeneity based on city characteristics like population size, administrative rank, and marketization levels. Additionally, smart cities and green innovation collaboratively help reduce industrial emissions. The study suggests that smart city construction could be a critical factor in fostering environmental sustainability and calls for tailored policies to maximize its benefits across different city contexts.
Teppo et al. (2009)	Why corporate venture capital funds fail - Evidence from the European energy industry	The study examines the role of corporate venture capital (CVC) in driving innovation within large energy firms, focusing on the industry's challenges with CVC fund discontinuation, described as the "sudden death syndrome." Through 27 in-depth qualitative interviews with corporate and independent VCs, the research identifies organizational culture as a critical, previously overlooked factor in CVC fund failures. A conceptual model is developed to explain how organizational culture impacts CVC fund survival, moderated by decision-making practices and the parent firm's ability to manage and measure success. The findings highlight the importance of aligning organizational culture with CVC objectives to ensure long-term viability.
van Rijnsouwer (2022)	Intermediaries for the greater good: How entrepreneurial support organizations can embed constrained sustainable development startups in entrepreneurial ecosystems	study discusses the role of entrepreneurial support organizations (ESOs) in embedding sustainable development startups (SDSs) within entrepreneurial ecosystems (EEs). It highlights the challenges faced by SDSs, particularly regarding market and technology constraints, which hinder their profitability and access to venture capital (VC). Policymakers aim to create conducive EEs that benefit such startups, emphasizing the importance of a dense financial support network. ESOs serve as intermediaries, facilitating connections between startups and VCs, but face a dilemma on whether to focus exclusively on SDSs or include non-SDSs to enhance overall network brokering. The paper applies an agent-based model to analyze various ESO admission strategies and support mechanisms, revealing that ESOs are essential for EEs rich in constrained SDSs, particularly when technology constraints prevail. Effective support strategies vary depending on the developmental stage of the EE, underscoring the need for tailored approaches in promoting sustainable entrepreneurship.
Wu et al. (2020)	Impacts of government R&D subsidies on venture capital and renewable energy investment -- an empirical study in China	The study investigates the impact of government R&D subsidies on renewable energy investment (REI) and venture capital (VC) in China, using data from 129 publicly listed renewable energy companies from 2009 to 2015. It employs ordinary least squares (OLS) and propensity score matching (PSM) methods. The findings reveal that government R&D subsidies significantly boost REI, particularly in state-owned enterprises (SOEs), while having inconsistent results for private firms. The study also shows that R&D subsidies act as a positive signal for attracting VC, leading to increased REI by approximately 1.086 billion RMB, indicating the critical role of R&D funding in overcoming financing constraints. The research contributes to understanding the interplay between government policies and capital markets in promoting sustainable development in China's renewable energy sector. Additionally, it addresses issues of ownership differences in the effect of

		subsidies and highlights the need for a phased approach to taper government support while fostering private sector growth in REI.
Wu et al. (2024)	Corporate social responsibility practices, corporate sustainable development, venture capital and corporate governance: evidence from Chinese public-listed firms	The study investigates the relationships among corporate social responsibility (CSR), corporate sustainable development (CSD), venture capital (VC), and corporate governance (CG) in the context of Chinese publicly listed firms from 2013 to 2020. It finds a significant positive relationship between CSR and CSD for A-share and Growth Enterprise Market (GEM) firms, with CG positively moderating this relationship but VC showing no significant impact for A-share firms. In contrast, GEM firms demonstrate no significant moderating influence from either VC or CG. The research also highlights that capital allocation efficiency (CAE) mediates the relationship between CSR and CSD in both types of firms. Notably, it emphasizes the negative moderating effect of VC on shareholder responsibility for CSD and the detrimental effect of poor CG on GEM firms' sustainable development. This research offers insights for policy recommendations to enhance corporate governance and ensure sustainable growth in the Chinese market.
Wüstenhagen et al. (2006)	Do venture capitalists really invest in good industries? Risk-return perceptions and path dependence in the emerging European energy VC market	The study investigates the limited expansion of venture capital (VC) into the energy technology sector, despite VC's critical role in commercializing innovation. Based on a survey of European energy technology VCs, the research identifies factors influencing the emergence of energy as a VC market. While energy offers significant investment opportunities, it accounts for only 2–5% of VC investments. Three key factors explain this disparity: high perceived risks (market adoption, exit, technology, people, and regulatory risks), relatively lower perceived returns compared to other sectors, and the sector's evolutionary immaturity as a VC investment area. These insights shed light on barriers to energy VC growth.
Yang et al. (2022)	The effect of venture capital on green innovation: Is environmental regulation an institutional guarantee?	The study investigates the impact of venture capital (VC) on urban green innovation (GI) in 150 Chinese cities, exploring whether environmental regulation acts as an institutional guarantee. Key findings indicate that VC significantly enhances urban GI, and this effect strengthens with higher levels of GI. The research identifies that VC fosters GI by promoting urban investments and clustering innovative talent, primarily due to high-quality human capital accumulation. Moreover, the influence of VC exhibits a threshold effect dependent on environmental regulation intensity; its effectiveness peaks at moderate levels of regulation. The study highlights spatial heterogeneity, revealing that VC's impact is stronger in central cities and resource-rich areas. It asserts that the mechanisms underpinning VC's influence on GI include capital investment and talent agglomeration, with VC-backed firms demonstrating better GI performance. The authors call for supportive governmental policies to further harness VC's potential in fostering a green economy.
Yu et al. (2024)	How does venture capital play a role in corporate green innovation? Evidence from China	The study investigates the influence of venture capital (VC) on corporate green innovation in China, using panel data from 2010 to 2021. It finds that VC plays a critical role in enhancing green innovation by lowering debt financing costs and reducing corporate risk-taking levels. The analysis reveals that VC's impact is stronger in eastern China and among state-owned enterprises (SOEs), highlighting regional and ownership-based disparities. The research suggests that VC not only provides essential financial support but also enhances corporate governance to promote green initiatives. Results reveal a significant positive relationship between VC and green innovation, with mediation effects confirmed for both debt financing costs and risk-taking behavior. The findings underscore the importance of fostering VC development and tailored policies to facilitate green innovation across various regions, recommending corporations to strategically leverage VC for sustainable growth. Limitations of this research include its focus on financial mechanisms, recommending broader future studies encompassing additional factors affecting innovation.
Zhao et al. (2021)	Influences of venture capital on enterprise financing constraints and sustainable growth abilities from the perspective of lifecycle	The study investigates the impact of venture capital (VC) on financing constraints and sustainable growth across different enterprise lifecycle stages, using data from China's A-share listed companies (2009–2018) and a multiple regression model. It reveals that growth-stage enterprises experience more severe financing constraints than mature-stage firms, with VC playing a more significant role in alleviating these constraints at the growth stage. However, VC contributes more effectively to sustainable growth in mature-stage enterprises. Additionally, VC has a stronger impact on reducing financing constraints for non-state-owned growth-stage firms and enhancing sustainable growth in state-owned mature-stage enterprises. These findings deepen understanding of VC's nuanced effects and inform strategic decisions to support enterprise sustainability.

Tab. 2. Distribution of studies in the journals

Journal	Frequency	Percent
Academy of Management Journal	1	2.0
ACRN Journal of Finance and Risk Perspectives	1	2.0
Asian Academy of Management Journal of Accounting and Finance	1	2.0
Business Process Management Journal	1	2.0
Business Strategy and the Environment	2	4.1
China Economic Review	1	2.0
Cogent Economics & Finance	1	2.0
Ecological Economics	1	2.0
Ege Academic Review	1	2.0
Energy Economics	3	6.1
Energy Policy	3	6.1
Heliyon	1	2.0
Ieee Transactions on Engineering Management	1	2.0
Ieee Transactions on Engineering Management	1	2.0
Industrial and Corporate Change	1	2.0
Industry and Innovation	1	2.0
International Journal of Energy Economics and Policy	1	2.0
International Journal of Entrepreneurship and Small Business	1	2.0
International Journal of Innovation and Technology Management	1	2.0
International Journal of Technology Management	1	2.0
International Review of Economics & Finance	2	4.1
International Review of Financial Analysis	1	2.0
Journal of Business Research	1	2.0
Journal of Business Venturing	1	2.0
Journal of Cleaner Production	3	6.1
Journal of East-West Business	1	2.0
Journal of Entrepreneurship in Emerging Economies	1	2.0
Journal of Environmental Management	1	2.0
Journal of Risk and Financial Management	1	2.0
Journal of Small Business and Enterprise Development	1	2.0
Organization & Environment	1	2.0
Renewable Energy	1	2.0
Research in International Business and Finance	1	2.0
Research Policy	1	2.0
Resources Policy	1	2.0
Review of Economics and Finance	1	2.0
Sustainability, Stakeholder Governance, and Corporate Social Responsibility	1	2.0
Technological Forecasting and Social Change	1	2.0
Transformations in Business & Economics	1	2.0
Venture Capital	1	2.0
World Review of Entrepreneurship, Management and Sustainable Development	1	2.0
Total	49	100.0