A study on environmental regulations, CVC investments, green innovation and firm value

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Abstract

Striving for sustainable corporate practices, this paper investigates the intricate relationships between environmental regulations, green CVC investments, green innovation and firm value. Analysing a sample of 92 US firms over 21 years (2000-2020), we extract meaningful insights into the underlying dynamics of these variables.

The findings indicate that environmental regulations and green CVC deals have a positive effect on green innovation. Additionally, stringent environmental regulations significantly enhance the impact of green CVC deals on the quantity (Count) and quality (Citation) of green innovation.

Furthermore, the results indicate that higher levels of green innovation and green CVC investments lead to increased firm value. A novel contribution of this research is the evidence that the impact of green CVC deals on firm value becomes stronger in the presence of green innovation.

These findings have important implications for research and practice, highlighting the importance for firms of adopting sustainable practices to create competitive advantage. Moreover, this research offers valuable insights for policymakers, enabling them to develop precise regulations that promote environmentally friendly investments, thereby fostering green innovation.

Keywords: Corporate Venture Capital, Environmental Regulations, Firm Value, Green Innovation

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Abstrato

Em busca de práticas empresariais sustentáveis, este artigo investiga as complexas relações entre regulamentações ambientais, investimentos verdes de capital de risco (CVC), inovação verde e valor da empresa. Ao analisar uma amostra de 92 empresas norte-americanas ao longo de 21 anos (2000-2021), extraímos informações significativas sobre a dinâmica subjacente a estas variáveis.

Os resultados indicam que as regulamentações ambientais e os investimentos ecológicos de capital de risco têm um efeito positivo na inovação verde. Adicionalmente, regulamentações ambientais rigorosas reforçam o impacto dos investimentos verdes de capital de risco na quantidade e qualidade da inovação verde.

Além disso, os resultados indicam que níveis mais altos de inovação verde e investimentos em capitais de risco levam a um aumento do valor da empresa. Uma nova contribuição desta pesquisa é a evidência de que o impacto dos investimentos ecológicos no valor da empresa torna-se mais acentuado na presença de inovação verde.

Estes resultados têm implicações importantes para a investigação e a prática, salientando a importância para as empresas de adoção de práticas sustentáveis de forma a criar vantagens competitivas. Além disso, esta investigação oferece informações valiosa para os decisores políticos, permitindo-lhes desenvolver regulamentos ambientais precisos que promovam investimentos amigos do ambiente, fomentando assim a inovação ecológica.

Palavras-Chave: Capital de Risco Corporativo, Regulamentação Ambiental, Valor da Empresa, Inovação Verde

Título: Um estudo sobre regulamentações ambientais, investimentos de capital de risco, inovação verde e valor da empresa.

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Glossary

CVC	Corporate Venture Capital
GI	Green Innovation
NRBV	Natural Resource Based View
RBV	Resource Based View
VC	Venture Capital
WRDS	Wharton Research Data Services

1. Introduction

In recent years, there has been a growing recognition of the urgent need to address global environmental challenges. Climate change, air and water pollution are just some of the pressing environmental issues that threaten the health and well-being of people and the planet (Myers, 2009). Therefore, urgent and unprecedented action is needed to limit global warming and mitigate the impacts of climate change.

The key to "reduce environmental pressures from production and consumption, balancing economic growth and environmental degradation", is technological innovation (Barbieri, Ghisetti, Gilli, Marin, & Nicolli, 2016; S. Yang, Feng, Lu, & Wang, 2022). (Lv, Shao, & Lee, 2021) proposes that the adoption and spread of green innovation are crucial for improving environmental quality and encouraging sustainable economic growth (Shuwaikh & Dias, 2023). Green innovation aims to enhance existing products and processes to ensure that they are environmentally sustainable (Albort-Morant, Leal-Millán, & Cepeda-Carrión, 2016). This involves adopting environmentally friendly principles such as the utilization of greener raw materials, energy saving, waste reduction, and minimizing carbon footprints (Chen, Lai, & Wen, 2006). However, due to its strong externalities and high risks, enterprises are reluctant to pursue green innovation (GI) initiatives (W. Ma, Zhang, & Chai, 2019).

Corporate venture capital investments (CVC) are a form of financing in which established firms make direct minority investments in the capital of a startup (Mazza & Shuwaikh, 2022; Wadhwa, Phelps, & Kotha, 2016). This approach is characterized by its focus on supporting innovative and fast-growing startups and is intended to provide not only financial support, but also strategic guidance and access to resources such as network, expertise, and branding (Hegeman & Sørheim, 2021; Pinkow & Iversen, 2020). CVC investments can be the solution for many corporate investors (Shuwaikh, Hughes, Brinette, & Khemiri, 2023) who face strong societal pressure to reduce their greenhouse gas emissions and their ecological footprint (Battisti, Nirino, Leonidou, & Thrassou, 2022).

This type of investment allows firms to gain access to new technology, innovative business models, and emerging markets (Pinkow & Iversen, 2020). Furthermore, CVC investments can actually help firms pursuing GI, promoting a shift towards a more sustainable and environmentally friendly business model and consequently improving the performance of the firm.

Nowadays, researchers are becoming increasingly interested in studying green CVC (Bocken, 2015; de Lange, 2019). There is a growing body of literature on the positive impact of CVC investments on individual firms pursuing green innovation. (Battisti et al., 2022) found that CVC investments positively impact a firm's Corporate Social Responsibility (CSR) performance and can promote the development of sustainable practices. Furthermore, (Hegeman & Sørheim, 2021) provided empirical evidence that CVC investments made by large firms promote green innovation. Similarly, (Wadhwa et al., 2016) argued that CVC investments provide access to resources that can help startups overcome the challenges of entering green technology markets. However, despite the significant attention paid to this topic in the literature, it is unclear whether these investments can help to overcome systemic barriers to the adoption of green technologies and practices by society at large. Specifically, there is a limited understanding of the mechanisms through which CVC investments promote the adoption of green technologies on a larger scale (Hegeman & Sørheim, 2021). In addition, it is not clear yet what the long-term impact of these investments will be (Bendig, Kleine-Stegemann, Schulz, & Eckardt, 2022). It is possible that some investments may not result in sustained adoption or that they may be unintended consequences or negative externalities associated with the adoption of certain technologies. To fill this gap, this paper investigates how environmental regulations influence the relationship between green CVC investments and the adoption of green technologies, as measured by green innovation. From our analysis on the relevant literature on the topic, we found that the interaction between CVC deals and environmental regulations has not yet been researched.

Furthermore, there is a growing debate about the relationship between CVC investments and firm value. (Haslanger, Lehmann, & Seitz, 2023) found a positive non-significant relationship between CVC investments and financial outcomes. On the other hand, (Dushnitsky & Lenox, 2006) and (Bider & Gigante, 2021) found a positive and significant relationship between CVC investments and firm value. This suggests that firms which engage in CVC practices generate increased value. Nevertheless, despite the growing importance of this topic, there is still a notable gap in our understanding of the moderating effects and the mechanisms that reinforce this relationship. To fill this gap, this research investigates how green innovation influences the relationship between green CVC investments and firm value. From our analysis on the relevant literature on the topic, we found that the interaction between green innovation and green CVC deals has not yet been researched.

Thus, this paper makes significant contributions to the existing literature. Firstly, this research provides empirical evidence that strict environmental regulations increase the impact of green CVC deals on green innovation. To the best of our knowledge, this is the first research that explores this relationship in the context of CVC investments. (Hegeman & Sørheim, 2021) discusses the drivers and motivations for going green, giving insights between CVC and green innovation relationship (Shuwaikh, Benkraiem, & Dubocage, 2023). The study of (Ramanathan, Ramanathan, & Bentley, 2018) investigates the impact of flexible and stringent regulations on innovation, which is pertinent to this paper's objectives. (Luo, Salman, & Lu, 2021) discusses how environmental regulations induce green innovation. Finally, (B. Lin & Xie, 2023) explores the moderating effect of environmental regulations on the relationship between venture capital and green innovation, which is relevant for the study's focus (T. Yang et al., 2023).

Second, our research is relevant to the current discussion about the benefits of corporate sustainability performance (Benkraiem, Gonçalves, & Shuwaikh, 2023). Existing literature has focused on understanding how green innovation affects the financial performance of CVC firms. This paper complements the ongoing debate, demonstrating the positive and significant effect of green innovation on the relationship between green CVC investments and firm value. The studies of (Haslanger et al., 2023) and (Bider & Gigante, 2021) examine the relationship between CVC investments and firm value outcomes, which is pertinent to this paper's objectives.

Third, our work offers practical insights to environmental legislators and corporate investors. By studying the impact of stringent environmental regulations on the adoption of sustainable technologies, it equips environmental legislators with the knowledge to make strategic decisions (Shuwaikh, 2018) and offers a unique perspective on how private investments can contribute to environmental sustainability. Thus, they can play a key role in creating regulations that encourage businesses to adopt sustainable practices, thereby promoting a healthy balance between economic success and environmental responsibility. In addition, it sensitises corporate investors to the importance of including green considerations into a firm's strategy to achieve competitive advantage.

The subsequent sections of this paper are structured as follows. The literature review is presented in section 2. Data and Methodology are outlined in section 3. Empirical results and discussion are explained in section 4. Limitations and avenues for future research are outlined in section 5. Lastly, conclusion is presented in section 6 and appendixes in section 7.

2. Theoretical background

2.1 Resource Based View (RBV)

The resource based view (RBV) focuses on the role of a firm's internal resources in achieving sustainable competitive advantage (Barney, 1991; Wernerfelt, 1984). According to (Barney, 1991), a firm's unique bundle of resources, capabilities and competences determines its ability to outperform competitors.

Researchers are increasingly interested in understanding how innovation affects firm value and the RBV theory is proposed to study this relationship (Barney, 1991). Environmental commitment can become a competitive resource, providing a competitive advantage and ultimately improving a firm's financial performance (Berry & Rondinelli, 1998). According to (Nishitani, Jannah, Kaneko, & Hardinsyah, 2017) and (Russo & Fouts, 1997), companies enhance their value and financial performance when they have an improved environmental performance. Green innovation, in form of technologies, processes or products, has the potential to help firms achieve competitive advantage over their competitors (Tu & Wu, 2021). As consumers increasingly prefer eco-friendly products and services, firms committed to green innovation can gain significant value in the marketplace (Olsen, Slotegraaf, & Chandukala, 2014). The RBV approach highlights the interplay between a firm's unique resources and capabilities, and consequently can be used to examine how green innovation becomes pivotal in creating firm value and consequently improve its financial performance.

In the context of external pressures, such as environmental regulations, firms have an opportunity to leverage their internal resources in innovative ways, leading to a competitive advantage (Ramanathan et al., 2018). However, it's important to pay attention to the degree of these regulations. On the one hand, flexible regulations can incentivize firms to move beyond mere compliance, towards a more proactive and intelligent integration of environmental considerations (Berry & Rondinelli, 1998). Firms with superior innovation capabilities are better equipped to capitalize on these opportunities by engaging in entrepreneurial behaviours and taking calculated risks (Marcus, 1988). On the other hand, inflexible and rule-centred regulations may not be so helpful to innovation in firms (Ramanathan et al., 2018). Overall, the existing literature suggest that the interplay between external pressures and internal resources can have a significant impact on a firm's ability to generate profits, with flexible regulations potentially serving as a catalyst for innovation and competitive advantage. For instance, a study conducted in China found that flexible environmental policy is a very important driver for sustainable development of China's industry (Yuan & Zhang, 2020).

2.2 Natural Resource Based View (NRBV)

The NRBV (Hart, 1995) emphasizes the importance of a firm's environmental impact and the potential benefits of sustainable practices. Essentially, the NRBV suggests that companies can gain a competitive advantage by using non-substitutable, inimitable, rare and valuable resources and processes that promote ecological sustainability (Hart, 1995). This theory complements RBV framework (Barney, 1991; Peteraf, 1993) which is primarily concerned with understanding firm-level outcomes and does not explicitly incorporate the constraints imposed by the natural environment. Furthermore, the NRBV approach suggests that organizations should actively strive to improve and align their relationship with the external environment. This can be achieved by pursuing three distinct but interconnected environmental strategies: pollution prevention, product stewardship, and sustainable development (Hart, 1995; Hart & Dowell, 2011).

Nowadays, there has been a growing recognition of the adverse effects of human actions on the environment. Governments, regulatory agencies, and the market itself around the world are increasingly pressuring businesses to adopt sustainable practices and reduce their footprint (Dangelico & Pujari, 2010). A multitude of strategies are being employed to attain this goal, including the implementation of more rigorous regulations, the establishment of ambitious sustainability targets, and the implementation of financial incentives and penalties to encourage environmentally conscious behaviour. For instance, the Paris Agreement, which was adopted by

196 countries in 2015, aims to “hold the increase in the global average temperature to well below 2ºC above pre-industrial levels while striving to limit the temperature increase to 1.5 ºC” (Roy et al., 2022) . It requires countries to set national targets for reducing greenhouse gas emissions and regularly report on their progress. According to NRBV, instead of prioritizing short-term profits at the expense of the environment, firms should adopt a longer-term perspective and sustainably accumulate resources.

The previous discussion about how environmental regulations can provide opportunities for firms to exploit internal capabilities aligns with (Hart, 1995) expansion of the resource-based view of the firm to include the constraints and opportunities presented by the biophysical environment (Menguc & Ozanne, 2005). The author argues that external stakeholders play a critical role in pushing firms toward sustainability and the societal demands can be considered part of the external environment facing firms (Miemczyk, Howard, & Johnsen, 2016). This perspective can lead to expectations about the value and uniqueness of a firm’s resources especially when society is demanding a cleaner environment (Quintana-García, Marchante-Lara, & Benavides-Chicón, 2022).

This paper provides a practical application of NRBV theory in the context of corporate venture capital. NRBV theory encourages research to understand how environmental regulations influence the adoption of green innovation. This type of external pressure requires firms to adapt their strategies and resource configurations to align with green innovation goals and achieve sustainable competitive advantage (Hart & Dowell, 2011).

2.3 Relationship between environmental regulations and sustainable technology adoption

The relationship between environmental regulations and sustainable technology adoption has been a topic of interest in the academic literature. Researchers have investigated how environmental regulations affect firms’ decisions to adopt sustainable technologies and how such technologies can help firms comply with these regulations while enhancing their environmental performance. The existing literature on the relationship between environmental regulation and green technology innovation does not provide a consistent view, lacking consensus (Shao, Hu, Cao, Yang, & Guan, 2020).

One perspective on the relationship between environmental regulation and green innovation is focused on Porter's hypothesis . This hypothesis suggests that proper environmental regulation can stimulate enterprise innovation, leading to increased productivity and further green innovation (Mu, Wang, & Mohiuddin, 2022; Porter & Linde, 1995). In addition, the economic policies used to penalize polluters and unregulated enterprises reduce their polluting behavior and the cost of green technology innovation, thereby increasing their motivation to adopt sustainable technology (Acemoglu, Aghion, Bursztyn, & Hemous, 2012; M. Zhang, Xie, & Gao, 2022).

Moreover, (Weng, Chen, & Chen, 2015) emphasizes the significant role of governmental pressure as a crucial external stakeholder. Governmental implementation and enforcement of regulatory changes significantly shape companies' environmental management and the sustainability of their business operations (Huang, Ding, & Kao, 2009). Thus, in order to compete and protect the environment, both global and local environmental regulations must be followed.

(Luo et al., 2021) investigates how different types of environmental regulation affect China's green innovation, while also considering the differences that exist among regions and various types of green patents. The author distinguished the effect of two types of environmental policies: command-and-control and informal regulations and market-based regulations. According to the empirical evidence, the application of command-and-control regulations has shown significant potential in enhancing green technology innovation, thus aligning with Porter's hypothesis. These regulations have yielded promising outcomes in promoting green innovation, indicating that policymakers in China should emphasize the implementation of stringent laws and initiatives that will create awareness among the public about environmental concerns. On the other hand, the study suggests that market-based regulation is impeding the progress of green innovation. This is due to the nature of green technology being a "quasi-public" good, which means that its positive externality allows other companies to effortlessly access the latest green technology advancements without significant investments. Companies investing in sustainable technologies are at disadvantage, bearing the full costs but not the full benefits. Therefore, the author argues that "it is essential for governments to implement targeted policies while also collaborating with market-based environmental regulations" in order to encourage companies to adopt sustainable technologies.

The reluctance of enterprises to invest in green technology due to the high costs of innovation and the restrictions imposed by environmental regulations can impede progress in this field. As an illustration, the study conducted by (Shi, Wang, Fu, & Xue, 2017) revealed that China's policy for carbon emission environment had a considerable impact on enterprise productivity and innovation, leading to a significant reduction in both. Thus, environmental regulations can have a complicated impact on the development of green technology. On one side, financial institutions may not support green innovation because they are uncertain about its potential to enhance enterprise performance. On the other side, companies are hesitant to invest in green technology innovation because they are reluctant to bear the cost of initiatives that are aimed at addressing environmental pollution, which are usually shouldered by the public sector. These factors create a challenging environment for the development of green technology, which requires overcoming both financial and practical obstacles (M. Zhang et al., 2022).

Furthermore, some authors (Brunnermeier & Cohen, 2003; Yuan & Xiang, 2018) believe that there is no relationship between environmental regulations and green innovation.

Overall, given the uncertainty found in large parts of the literature, this study aims to confirm three hypotheses.

Hypothesis 1 a) Environmental regulations have a positive impact on green innovation.

Hypothesis 1 b) Green CVC investments have a positive impact on green innovation.

Hypothesis 1 c) The impact of green CVC investments on green innovation is positively influenced by the presence of environmental regulations.

2.4 Relationship between green innovation and firm value

As global environmental concerns continue to escalate, companies are recognizing the need to adopt sustainable technologies to address these challenges while maintaining their competitive edge in the market (Leonidou, Leonidou, Fotiadis, & Zeriti, 2013; Shuwaikh & Dubocage, 2022). The adoption of sustainable technologies can be measured by green innovation, which is the integration of environmentally friendly processes and products into the firm's operational strategy (Yuniarti, Soewarno, & Isnalita, 2022). The impact of green innovation on firm value is a common subject on the existing literature.

(Dotzel, Shankar, & Berry, 2013) and (Rubera & Kirca, 2017) found a positive relationship between green innovation and firm value. These authors show that firm value is improved when the firm is continuously innovating. Similarly, (J. Przychodzen & Przychodzen, 2015) concludes that green innovators present higher financial performance, measured by ROA and ROE, than their less green competitors. Furthermore, (Benkraiem, Dubocage, Lelong, & Shuwaikh, 2023) provides empirical evidence that, on average, an increase in green innovation is associated with better firm value in terms of ROA and Tobin's Q. Moreover, (Yuniarti et al., 2022) conclude that green innovation has a positive and significant direct and indirect effect on firm value. (Huong et al., 2021) and (Agustia, Sawarjuwono, & Dianawati, 2019)show that the positive relationship between green innovation and firm value is enhanced by the presence of environmental management. Similarly, (Tang, Walsh, Lerner, Fitza, & Li, 2018) concluded that managerial concern positively enhances the relationship between green process innovation and firm value, as measured by financial performance. (Xue, Boadu, & Xie, 2019) conclude that green innovation positively influences the environmental, operational and financial performance of firms, thereby increasing their overall value. In addition, they show that the absorptive capacity of firms significantly enhances this relationship.

However, the positive results mentioned above contrast with some discordant or ambiguous findings. For instance, (W. Przychodzen, Leyva-de la Hiz, & Przychodzen, 2019) find that excessive focus on green innovation in detriment to other types of innovation has a negative impact on financial performance, and consequently on firm value. Additionally, (Aguilera-Caracuel & Ortiz-de-Mandojana, 2013) conclude that financial performance is not influenced by green innovation. The author finds no difference between eco-innovators and their non-green competitors.

To contextualize the preceding discussion within the framework of CVC investments, we consider the findings of (Benkraiem, Dubocage, et al., 2023), which show that CVC firms are more inclined to adopt sustainable technologies and engage in technological green innovation. Therefore, this serves at a basis to construct the following hypothesis:

Hypothesis 2 a) Green innovation has a positive impact on firm value.

Hypothesis 2 b) Green CVC investments have a positive impact on firm value.

Hypothesis 2 c) The impact of green CVC investments on firm value is positively influenced by green innovation.

3. Data and Methodology

3.1 Sample Selection

In this paper, the time span chosen was between 2000 and 2020. Thomson VentureXpert only provides the number of green CVC deals from 2000 onwards and the environmental policy stringency index disclosed on OECD Environmental Statistics Database is only available until 2020. According to (Hege, Palomino, & Schwienbacher, 2011) , "US venture capitalists generate significantly more value with their investments", being the most active VC market. For this reason, our sample just encompasses CVC deals made by US firms. In addition, firm value data was extracted from Standard and Poor's Compustat database.

In order to match the Thomson VentureXpert data, with the Compustat and OECD Environmental Statistics Databases, company names and tickers were manually checked. First, the Thomson VentureXpert and Compustat data were matched. The sample was then matched with the OECD Environmental Statistics data and missing variables were removed, obtaining a final sample of 92 firms. Finally, the final sample was cross-checked with the green innovation data, which was retrieved from the PATSTAT database.

3.1.1 Dependent variables

To test the validity of H1 a), H1 b) and H1 c), we take the adoption of sustainable technology, measured by green innovation, as the dependent variable. Given the fact that there is no "unified standard proxy for GI" and following previous literature, we concluded that patent-based variables are the most appropriate measure of a firm's innovation output (D. Zhang, Zheng, Feng, & Chang, 2022) (Benkraiem, Dubocage, et al., 2023). The use of the forward citation count as a measure of the technological impact of a patented invention is motivated by the larger existing literature. Forward Citation Count works as an indicator of subsequent technological impact (Jaffe & de Rassenfosse, 2017).

Count and Citation are the two different variables considered to measure the innovation output of firms. Innovation quantity is measured by the number of patent applications filed by a firm in each year (Count). Citation, which represents the number of subsequent citations of these green patents, measures the quality of green innovation. The year of patent application is the base for both Count and Citation. According to (S. Ma, 2020), it is necessary to take the natural logarithm of the two variables to solve the skewness problem for better empirical properties. Furthermore, one is added to the patent and citation count before taking the natural logarithm to avoid missing observations for firm-year with no patents or citations per patent. Taking this into account, ln (1 + Count) is denoted Count and ln (1+ Citation) is denoted Citation.

The second set of dependent variables measuring firm value (FIRMVALUE) is introduced to test H2 a), H2 b) and H3) c). This paper presents three distinct measures: Return on Equity (ROE), Return on Assets (ROA) and Tobin's Q. ROE is determined by the net income to equity ratio whereas ROA is computed by dividing a firm's net income by its total assets. Lastly, Tobin's Q is a measure derived by dividing the sum of total assets, cash and short-term investments multiplied by the closing price of the fiscal year, minus the total common and ordinary equity, by the total assets.

3.1.2 Independent variables

Environmental regulations (ENVREG) and the number of green corporate venture capital deals (CVC) are used as independent variables to validate H1 a), H1 b) and H1 c). Environmental regulation is measured with OECD'S recently published index of environmental policy stringency. This index measures the stringency of a country's environmental policies and can be used for international comparison as well as country-specific evaluations (Botta & Koźluk, 2014). Stringency refers to the extent to which environmental policies impose explicit or implicit costs on harmful or polluting behaviour. The index ranges from 0 to 6 (highest degree of stringency), based on the degree of stringency of 13 environmental policy instruments, mainly concerning climate and air pollution. The number of green corporate venture capital deals (CVC) is retrieved directly from Thomson VentureXpert database.

To test the validity of H2 a), H2 b) and H2 c), the adoption of sustainable technology, as measured by green innovation, is introduced as an independent variable.

3.1.3 Control variables

This paper presents a set of three distinct control variables. Firm size (SIZE) is determined as the natural logarithm of the company's total assets. Financial Leverage (FINLEV) is defined as the ratio of total debt to total assets. Net Sales (NETSALES) is defined as the adjusted total revenue generated by the company's principal business operations, representing its turnover.

3.2 Empirical modelling

To examine the effect of environmental regulations on green innovation (H1 a)), equation (1) contains the following parameters:

$$INNOV_{i,t} = \beta_0 + \beta_1 ENVREG_{i,t} + \beta_2 SIZE_{i,t} + \beta_3 FINLEV_{i,t} + \beta_4 NETSALES_{i,t} + \beta_5 \sum FIRM_i + \beta_6 \sum YEAR_t + \varepsilon_{it} \tag{1}$$

where $INNOV_{i,t}$ measures green innovation in terms of quantity (Count) as well as quality (Citation). $ENVREG_{i,t}$ stands for environmental regulations. The control variables are firm size (SIZE), financial leverage (FINLEV) and net sales (NETSALES).

To examine the effect of green CVC deals on green innovation (H1 b)), equation (1.1) contains the following parameters:

$$INNOV_{i,t} = \beta_0 + \beta_1 CVC_{i,t} + \beta_2 SIZE_{i,t} + \beta_3 FINLEV_{i,t} + \beta_4 NETSALES_{i,t} + \beta_5 \sum FIRM_i + \beta_6 \sum YEAR_t + \varepsilon_{it} \tag{1.1}$$

where $INNOV_{i,t}$ measures green innovation in terms of quantity (Count) as well as quality (Citation). $CVC_{i,t}$ denotes green CVC deals. All control variables remain the same as in equation (1).

To examine the joint effect of environmental regulations and green CVC deals on green innovation (H1 c)), equation (1.2) contains the following parameters:

$$INNOV_{i,t} = \beta_0 + \beta_1 ENVREG_{i,t} + \beta_2 CVC_{i,t} + \beta_3 ENVREG * CVC_{i,t} + \beta_4 SIZE_{i,t} + \beta_5 FINLEV_{i,t} + \beta_6 NETSALES_{i,t} + \beta_7 \sum FIRM_i + \beta_8 \sum YEAR_t + \varepsilon_{it} \tag{1.2}$$

where $INNOV_{i,t}$ measures green innovation in terms of quantity (Count) as well as quality (Citation). $ENVREG_{i,t}$ stands for environmental regulations, while $CVC_{i,t}$ denotes green CVC deals. The joint effect of environmental regulations and green CVC deals on green innovation is represented by the interaction variable $ENVREG * CVC_{i,t}$. All control variables remain the same as in the previous equations.

Equation (2) analyses the effect of green innovation on firm value (H2 a)):

$$FIRMVALUE_{i,t} = \beta_0 + \beta_1 INNOV_{i,t} + \beta_2 SIZE_{i,t} + \beta_3 FINLEV_{i,t} + \beta_4 NETSALES_{i,t} + \beta_5 \sum FIRM_i + \beta_6 \sum YEAR_t + \varepsilon_{it} \tag{2}$$

where $FIRMVALUE_{i,t}$ denotes firm i's value, determined by either ROE, ROA, or Tobin's Q. $INNOV_{i,t}$ measures green innovation in terms of quantity (Count) as well as quality (Citation). All control variables remain the same as in the previous equations.

Equation (2.1) analyses the effect of green CVC deals on firm value (H2 b)):

$$FIRMVALUE_{i,t} = \beta_0 + \beta_1 CVC_{i,t} + \beta_2 SIZE_{i,t} + \beta_3 FINLEV_{i,t} + \beta_4 NETSALES_{i,t} + \beta_5 \sum FIRM_i + \beta_6 \sum YEAR_t + \varepsilon_{it} \tag{2.1}$$

where $FIRMVALUE_{i,t}$ denotes firm i's value, determined by either ROE, ROA, or Tobin's Q. $CVC_{i,t}$ denotes green CVC deals. All control variables remain the same as in the previous equations.

Lastly, equation (2.2) analyses the joint effect of green innovation and green CVC deals on firm value (H2 c)):

$$FIRMVALUE_{i,t} = \beta_0 + \beta_1 INNOV_{i,t} + \beta_2 CVC_{i,t} + \beta_3 INNOV * CVC_{i,t} + \beta_4 SIZE_{i,t} + \beta_5 FINLEV_{i,t} + \beta_6 NETSALES_{i,t} + \beta_7 \sum FIRM_i + \beta_8 \sum YEAR_t + \varepsilon_{i,t} \tag{2.2}$$

where $FIRMVALUE_{i,t}$ denotes firm i's value, determined by either ROE, ROA, or Tobin's Q. $INNOV_{i,t}$ measures green innovation in terms of quantity (Count) as well as quality (Citation), while $CVC_{i,t}$ denotes green CVC deals. The joint effect of green innovation and green CVC deals on firm value is represented by the interaction variable $INNOV * CVC_{i,t}$. All control variables remain the same as in the previous equations.

Given the nature of the variables under investigation, this paper employs ordinary least squares (OLS) regressions as the fundamental method, while controlling for firm and year fixed effects. The decision in favour of the fixed-effect model rather than the random effect model, was further corroborated by conducting a Hausman test (Hausman, 1978).

4. Empirical Results and Discussion

4.1 Descriptive statistics & correlation

Table 1 provides a comprehensive overview of the statistical results obtained from the underlying research study. Based on the sample, the average (median) return on assets (ROA) is 0.01 (0.04). Additionally, a negative skewness of 17.44 and a remarkably high kurtosis of 668.36 can be observed. Moreover, the average (median) return on equity (ROE) is 0.28 (0.14) while Tobin's Q is 0.75 (0.73). The elevated kurtosis score of 1087.33 for ROE indicates a high probability of extreme outcomes and suggests that companies are struggling to provide satisfactory returns for their equity investors. It also exhibits a strikingly high positive skewness of 32.31, suggesting high positive tail risk. Mean values of 1.79 and 1.65 were obtained for the two measures of green innovation, count and citation respectively.

In addition, the variable CVC has a skewed distribution, with a skewness of 4.75, as evidenced by the significant difference between the mean (3008.15) and median (345.00). This is evidence of the presence of outliers, possibly representing firms with exceptionally high numbers of CVC deals. Furthermore, the environmental regulation variable has close mean and median values, indicating a skewness of zero.

The firm size of the sample companies, measured by the natural logarithm of their total assets, is found to be at an average (median) of 9.29 (9.77). The values for financial leverage and net sale correspond to 0.24 (0.19) and 282240.83 (9350.00), respectively.

In summary, the results highlight the presence of outliers and skewed distributions.

Table 2 illustrates that Count exhibits a positive and statistically significant correlation with Citation, ENVREG, CVC, and ROA of 0.99, 0.15, 0.25, and 0.06, respectively, as well as with SIZE and NETSALES. Conversely, Count is negatively associated with Tobin's Q and NETSALES. Furthermore, it has been found that Citation is positively linked with ENVREG, CVC, SIZE and NETSALES at a significance level of 5%, and with ROA at a significance level of 10%. On the other hand, Citation shows a significant negative correlation with Tobin's Q and FINLEV.

Additionally, ENVREG shows a positive and statistically significant correlation with ROA, Tobin's Q, and SIZE of 0.07, 0.14 and 0.17, respectively, as well as with FINLEV and NETSALES. With regard to other variables, CVC exhibits no statistically significant correlations.

Moreover, ROE is positively linked to Tobin's Q at the 5% significance level, suggesting a positive relationship between Tobin's Q and return on equity. Furthermore, ROA displays significant positive correlation with SIZE, implying that larger firms tend to achieve higher returns on assets. On the other hand, there exists a negative correlation between ROE and SIZE, with a coefficient of -0.06. The third firm value measure, Tobin's Q, is positively related to FINLEV at the 5% significance level with correlation of 0.6.

Lastly, SIZE reveals significant positive associations with FINLEV and NETSALES. FINLEV and NETSALES are positively correlated.

4.2 Environmental regulations, Green CVC deals and Green Innovation

The results of equation (1) are summarized in models (1) and (2) of table 3. The results of these regression models shed light on the relationship between environmental regulations and green innovation. Model (1) studies the impact of environmental regulations on the quantity of green innovation (Count). Model (2) investigates the identical relationship focusing on the quality of green patents (Citation).

In model (1), the coefficient of environmental regulations is 0.301219 and is statistically significant at the 10% level ($p<0.1$). This means that for every unit increase in environmental regulations, the quantity of green innovation (Count) increases by 0.301219 percentage points. In model (2), it stands at 0.336343 and is statistically significant at the 5% level ($p<0.05$). Thus, for each unit increase in environmental regulations, there is a 0.336343 percentage point increase in the quality of green innovation (Citation). These findings demonstrate that environmental regulations have a significant positive impact on firm's decisions to adopt sustainable technologies, consequently promoting the advancement of green innovation across the industry. This confirms the results of (Luo et al., 2021) who find that command and control regulations and informal regulations positively influence green technology innovation, aligning with the principles of the "Porter hypothesis". Therefore, appropriate strict environmental regulations can serve as catalysts for promoting green innovation and establishing an advantageous relationship between economic development and ecological preservation (Aguilera-Caracuel & Ortiz-de-Mandojana, 2013). These findings provide evidence in support of H1 a).

Furthermore, models (3) and (4) are based on equation (1.1). These models study the impact of green CVC investments on green innovation. The number of green CVC deals shows a positive and statistically significant ($p<0.1$) coefficient in both models, implying a positive relationship with quantity and quality of green innovation. Similarly, (Hegeman & Sørheim, 2021) conducted a study that described also a positive relationship between CVC investments made by large firms and green innovation. These findings provide evidence in support of H1 b).

After having confirmed the positive effect of environmental regulations on green innovation as well as the positive impact of green CVC deals on green innovation, this research aims to investigate the combined effect of environmental regulations and green CVC deals on green innovation. The results of equation (1.2) are summarized in models (5) and (6) of table 3. Model (5) examines the effect of the interaction between environmental regulations and CVC deals on the quantity of green innovation (Count). Model (6) investigates the same relationship focusing on the quality of green patents (Citation).

In model (5), the estimated coefficient of the interaction between environmental regulations and number of green CVC deals is positive and statistically significant at the 1% level ($p<0.01$) causing green innovation to increase by 0.000060 percentage points. In other words, the impact of green CVC deals on the quantity of green innovation becomes stronger in the presence of stringent environmental regulations. When the environmental regulation index reaches 1.46, the impact of green CVC deals on "count" starts being positive. The same conclusions apply to the quality of green innovation (Citation). Similarly, (B. Lin & Xie, 2023) concluded that the incentive effect of venture capital on green innovation is amplified by environmental regulations.

When control variables are considered, other significant associations emerge. First, a negative association exists between firm size and green innovation, suggesting that smaller firms tend to exhibit a higher propensity for adopting environmentally friendly practices and receive greater recognition for their green innovations compared to larger firms. This implies that larger corporations might face hurdles or disincentives whilst integrating green innovations into their operations. (W.-L. Lin, Cheah, Azali, Ho, & Yip, 2019) findings indicate that smaller firms have a higher return on green innovation investments, suggesting their preference for this type of strategies. Secondly, in both models (5) and (6), financial leverage displays a negative and statistically significant ($p<0.05$) coefficient of -0.425072 and -0.38013, respectively. In the CVC sample, higher leverage leads on average to less green innovation, in line with the idea that a higher debt level may restrict the firms to invest in this type of sustainable practices. Lastly, in both models, net sales present a coefficient close to zero which is statistically significant at the 1% level ($p<0.01$). This indicates a strong relationship between net sales and green innovation. However, the small size effect suggests that practical impact might be limited unless substantial changes in net sales occur.

Overall, the findings align with H1 c). The impact of green CVC deals on green innovation is positively influenced by the presence of environmental regulations.

4.3 Green Innovation, Green CVC deals and Firm Value

Table 4 presents the estimation results of equation (2). The results demonstrate that green innovation has a positive and significant impact on firm value. This means that, on average, higher levels of green innovation lead to higher firm value. More quantity of green innovation (Count) improves the ROE by 41.73%, ROA by 39.65% and Tobin's Q by 40.57%. Moreover, more quality of green innovation (Citation) improves ROE by 44.77%, ROA by 36.95% and Tobin's Q by 42.41%. Therefore, our findings align with H2 a). (J. Przychodzen & Przychodzen, 2015), conducted a study similar to this one and found that eco-innovators, on average, present higher ROA and ROE than their less green competitors. Similarly, (Benkraiem, Dubocage, et al., 2023) concluded that, on average, an increase in green innovation is associated with better financial performance in terms of ROA and Tobin's Q.

The results of equation (2.1) are summarized in Table 5. The number of green CVC deals shows a positive and statistically significant ($p<0.1$) coefficient in all models, implying a positive relationship with firm value. These findings provide evidence in support of H2 b). In addition, this confirms the results of (Haslanger et al., 2023) who find that CVC investments are positively associated with firm value, as measured by financial performance.

After having confirmed the positive effect of green innovation on firm value as well as the positive impact of green CVC deals on firm value, this research aims to investigate the combined effect of green innovation and green CVC deals on firm value. Equation (2.2) is summarized in table 6. The results show that the interaction between green innovation and green CVC deals has a positive and statistically significant ($p<0.1$) impact on firm value, measured by ROE, ROA, and Tobin's Q. In models (1), (2) and (3), we can observe that for each unit increase in the interaction between the quantity of green innovation (Count) and green CVC deals, there is a 0.052% increase in ROE, 0.0261% increase in ROA and lastly 0.0089% increase in Tobin's Q. In other words, the impact of green CVC deals on firm value becomes stronger in the presence green innovation, aligning with H2 c).

Lastly, when control variables are considered, other significant associations emerge. First, a negative association exists between firm size and firm value. Secondly, across the models, financial leverage displays negative and statistically significant coefficients. Thus, in the CVC sample, higher leverage and financial risk leads on average to less firm value. Lastly, in all models, net sales present a coefficient close to zero which is statistically significant at the 1% level ($p<0.01$). This indicates a strong relationship between net sales and net sales. However, the small size effect suggests that practical impact might be limited unless substantial changes in net sales occur.

4.4 Effect of lagged variables on green innovation

As environmental regulations and the number of green CVC deals may affect green innovation after a lapse of time, it is important to examine the impact of previous years' environmental regulations and CVC deals on current green innovation. Table 7 displays the results for a one-year, two-year as well as a three-year lag in environmental regulations and CVC variables. The analysis demonstrates the positive and statistically significant relationship between lagged environmental regulations and green innovation. In addition, lagged CVC deals and green innovation exhibit a positive relationship, indicating that green CVC investments are reflected in green innovation after one, two and three years. Furthermore, the lagged interaction variable (ENVREG*CVC) has a positive and significant effect on both Count and Citation.

4.5 Effect of lagged variables on firm value

As green innovation and the number of green CVC deals may affect firm value after a lapse of time, it is also important to examine the impact of previous years' green innovation and CVC deals on current firm value. In this specific situation, we use the ratio of green patent citation to the green patent count (Citation&Count) as proxy for green innovation. Table 8 displays the results for a one-year, two-year as well as a three-year lag in green innovation and CVC variables. The results demonstrate the positive relationship between lagged green innovation and firm value. A positive and significant relationship ($p<0.05$) exists between one, two and three-year lagged green innovation and ROE. Moreover, one, two and three-year lagged green CVC deals present a positive and significant relationship ($p<0.05$) with Tobin's Q. This suggests that previous investments in green ventures contribute to the current firm value, highlighting the importance of a long-term perspective in assessing the impact of strategic decisions on market performance. Lastly, the lagged interaction variable (INNOV*CVC) has a positive and significant effect on firm value, as measured by ROE, ROA and Tobin's Q.

4.6 Robustness Checks

4.6.1 Sensitivity analysis

In situations where there are outliers, heteroscedasticity or non-normality, robust regression may be appropriate. By using the “rreg” command in Stata and attributing lower weights to extreme observations, we can ensure that results are more reliable as they are less exposed to the impact of influential observations.

Table 9 exhibits results for equations (1), (1.1) and (1.2).

Across the models, firm size and net sales present positive and statistically significant coefficients. This suggests that we can predict with some certainty that as firm size and net sales increase, green innovation will also increase. In addition, in all models, financial leverage is found to be negatively and significantly ($p<0.01$) related to green innovation. Thus, we can conclude these are key variables regardless of the specifications included in each model.

Furthermore, environmental regulations also present positive and statistically significant coefficients. Thus, as environmental regulations become more stringent, we can predict with some confidence that green innovation will increase, providing robustness to the finding. Green CVC deals display positive coefficients in models (3) and (4) and negative coefficients in models (5) and (6). This indicates that the relationship between CVC deals and green innovation is more complex and varies according to the specifications or variables included in each model.

In both models (5) and (6), the variables present the same direction and similar levels of statistical significance, providing consistency and robustness to the finding. In particular, the interaction variable (ENVREG* CVC) is positive and statistically significant in both models, aligning with H1 c).

R-squared measures the proportion of the total variation in the dependent variable that is explained by the independent variables. All models have similar R-squared, and therefore we believe there is a moderate model fit.

Table 10, 11 and 12 exhibit results for equations (2), (2.1) and (2.2), respectively .

In all models, firm size and net sales are found to be positively and significantly ($p<0.01$) related to firm value. On the other hand, financial leverage presents negative and statistically significant ($p<0.01$) coefficients. As previously mentioned, this consistency across models outlines the key role of the control variables, lending robustness and reliability to the finding.

Moreover, green innovation presents positive coefficients in all models. However, it fluctuates in significance across the models and respective tables – statistically significant at the 10% level in some models, and at the 5% level in others. Similarly, green CVC deals have a positive impact on firm value across all the models. Nevertheless, they are statistically insignificant ($p>0.1$) in some models. This inconsistency suggests that both green innovation and green CVC deals present a more complex relationship with firm value, which may vary according to the specifications or variables included in each model. Thus, further investigation should be conducted to fully understand the underlying mechanisms.

Lastly, the interaction variable between green innovation and green CVC investments (INNOV*CVC) is found to be positively and significantly ($p<0.05$) related to firm value. In other words, we can predict with some certainty that the impact of green CVC investments on firm value is positively influenced by quantity (Count) and quality (Citation) of green innovation. These findings provide further evidence in support of H2 c).

All models present a R-squared within the range of 0.19-026 indicating that approximately 19% to 26% of the variability in firm value is explained by the independent variables included in the models. Although the models capture a considerable variability in the dependent variable, there is still a substantial amount of unexplained variability. Further research and inclusion of other variables is needed.

5. Limitations and avenues for future research

The findings in this paper are subject to specific limitations which must be acknowledged when interpreting the results.

Specifically, this research solely concentrates on CVC transactions instigated by US companies, given the pre-eminence of the United States as a venture capital market. Consequently, this approach restricts the analysis by excluding deals from diverse countries and markets, thus constraining the generalizability and comprehensive understanding of global corporate venture capital activities. Therefore, our findings cannot be applied to CVC transactions by non-US companies.

A second notable constraint of this paper relates to the existence of an unbalanced panel dataset. Some companies only participated in CVC investments for a single year, while others participated consistently over several years. This inherent imbalance within the dataset has resulted in a significant volume of missing data and the emergence of outliers, which poses a challenge to the strength and dependability of the analytical procedures employed.

Furthermore, environmental regulations are multifaceted, comprising numerous policies ranging from emissions standards to waste management regulations. The use of a single index might oversimplify the complexity of these regulations, potentially overlooking crucial nuances in specific areas such as renewable energy incentives, pollution control or sustainable practices. Therefore, this simplification could potentially constrain the study's ability to fully capture the varied and developing range of environmental regulations throughout the examined period, resulting in a less detailed comprehension of their influence on corporate investment strategies in the context of CVC activities.

Moreover, this paper only focuses on the effect of environmental regulations on the relationship between green CVC deals and green innovation. Other influential variables may exist, and their exclusion introduces limitations to the breadth and depth of our analysis. Thus, future research should consider the inclusion of other relevant variables to provide a more comprehensive understanding of the mechanisms through which CVC investments promote the adoption of green technologies.

In addition, it is important to note that while the WRDS platform and Compustat-IQ database, combined with integration with Thomson VentureXpert data, provide valuable information, not all necessary values for each ticker symbol were obtained in these databases. Therefore, several firms had to be excluded from the sample due to the absence of these data points. The exclusion necessary for the study created selection bias and reduced the sample's representativeness. Since complete data was not obtainable for all entities, the study could not conduct a fully comprehensive analysis, potentially impacting the depth and accuracy of the findings.

Finally, the inclusion of only three control variables in this research was influenced by the practical barrier of data availability. Despite the concern to include a wider range of control variables, constraints in accessing reliable data on certain factors have limited the range of variables. Future research should investigate the incorporation of other appropriate control variables.

6. Conclusion and implications

This research investigates the relationships between environmental regulations, green CVC investments, green innovation and firm value. The paper utilizes a sample of 92 US CVC firms and spans the period from 2000 to 2020. Robust and lagged regressions are conducted to ensure the reliability and robustness of the findings and to provide a more in-depth analysis.

The results show that an increase in environmental regulations and more green CVC investments positively affect green innovation, aligning with the results of (Luo et al., 2021) and (Hegeman & Sørheim, 2021). Furthermore, the findings of this paper provide valuable insights into the mechanisms that drive the effect of CVC deals on green innovation. The results indicate that the interaction between environmental regulations and green CVC deals has a positive and strongly significant impact on both the quantity and quality of green innovation. This suggests that strict environmental regulations contribute positively to the impact of green CVC deals on green innovation. It implies that firms facing stringent environmental regulations experience a more significant boost in green innovation when they engage in CVC activities. Thus, CVC investments may act as a strategic response to regulatory pressures, ultimately fostering the adoption of sustainable technologies.

Moreover, the research findings demonstrate that firms with more green innovation and green CVC investments have, on average, a higher firm value. These assumptions are emphasized by (J. Przychodzen & Przychodzen, 2015) and (Haslanger et al., 2023). Additionally, the results indicate that the interaction between green innovation and green CVC deals has a positive and significant impact on firm value, as measured by ROE, ROA and Tobin's Q. This suggests that the positive impact of green CVC investments on firm value is enhanced by concurrent green innovation initiatives. It implies that green-innovative firms experience a more significant boost in their value when they engage in CVC investments.

In addition, lagged regressions are conducted to investigate the impact of lagged variables on green innovation and on firm value. In other words, in this specific paper, lagged regressions help to understand the impact of previous years' environmental regulations and CVC deals on current green innovation. They are also important to examine the impact of past green innovation and CVC deals on current firm value. This additional analysis reinforces the understanding of the dynamic nature of the relationships under investigation.

Furthermore, additional insights are provided by the sensitivity analysis. By assigning lower weights to extreme observations we obtain different coefficient estimates and statistical significance, emphasizing the importance of robustness checks.

This research is subject to specific limitations. Firstly, our approach only includes CVC transactions by US-companies, thus limiting the generalizability of the findings. In addition, environmental regulations are measured by a single index, which may oversimplify the complexity of these regulations and limit the ability to fully capture their impact during the examined period. Moreover, omitted variables and the absence of certain factors may bias the relationship between variables.

Overall, this paper investigates the complex relationships between environmental regulations, green CVC deals, green innovation and firm value. Furthermore, this research contributes to the understanding of the mechanisms through which CVC investments promote green innovation. In addition, it complements the existing literature by investigating the role of green innovation in the relationship between green CVC investments and firm value. Further research should investigate the dynamics in other countries and include other relevant variables. Additionally, it would be of particular interest to consider other types of venture capital.

7. Appendices

Table 1

Summary Statistics.

	Mean	Std.Dev.	Median	Min	Max	Skewness	Kurtosis
Count	1.79	2.53	0.00	0.00	9.26	1.12	2.84
Citation	1.65	2.38	0.00	0.00	8.89	1.18	3.03
ENVREG	2.07	0.66	2.03	1.22	3.03	0.00	1.58
CVC	3008.15	6709.78	345.00	2.00	65485.00	4.75	35.83
ROE	0.28	7.38	0.14	-28.79	247.75	32.31	1087.33
ROA	0.01	0.74	0.04	-22.75	12.37	-17.44	668.36
Tobin's Q	0.75	0.34	0.73	0.01	5.04	3.59	33.94
SIZE	9.29	2.48	9.77	-5.52	13.59	-1.16	4.69
FINLEV	0.24	0.24	0.19	0.00	3.21	3.20	30.80
NETSALES	28240.83	41604.82	9350.00	0.00	255112.00	2.11	7.42

This table shows the summary statistics for all dependent, independent, and control variables used in the different models.

Table 2

Correlation Matrix.

	Count	Citation	ENVREG	CVC	ROE	ROA	Tobin's Q	SIZE	FINLEV	NETSALES
Count	1									
Citation	0.99**	1								
ENVREG	0.15**	0.16**	1							
CVC	0.25**	0.25**	0.10	1						
ROE	-0.01	-0.02	0.04	-0.01	1					
ROA	0.06*	0.06*	0.07*	0.00	-0.06	1				
Tobin's Q	-0.12**	-0.12**	0.14**	-0.07	0.15**	-0.16**	1			
SIZE	0.38**	0.38**	0.17**	0.04	-0.06*	0.22**	-0.05	1		
FINLEV	-0.09**	-0.09**	0.22**	0.10	-0.04	-0.08**	0.6**	0.06*	1	
NETSALES	0.37**	0.38**	0.10**	-0.04	-0.01	0.05	0.05	0.63**	0.06*	1

**. Correlation is significant at the 0.05 level (2-tailed).

*. Correlation is significant at the 0.1 level (2-tailed).

Table 3

Environmental Regulations, Green CVC Deals and Green Innovation.

	Count (1)	Citation (2)	Count (3)	Citation (4)	Count (5)	Citation (6)
ENVREG	0.301219*	0.336343**	-	-	0.334427*	0.365965**
	(0.178543)	(0.168497)	-	-	(0.178570)	(0.168733)
CVC	-	-	0.000016*	0.000010*	-0.000088	-0.000076
	-	-	(0.000012)	(0.000011)	(0.000034)	(0.000032)
ENVREG*CVC	-	-	-	-	0.000060***	0.000050***
	-	-	-	-	(0.000018)	(0.000017)
SIZE	-0.072182*	-0.098334**	-0.076442*	-0.101233**	-0.079812*	-0.103897**
	(0.047942)	(0.045244)	(0.048050)	(0.045381)	(0.04786)	(0.045229)
FINLEV	-0.400183**	-0.359248**	-0.390051**	-0.348435**	-0.425072**	-0.380130**
	(0.191157)	(0.180401)	(0.191151)	(0.180536)	(0.190606)	(0.180106)
NETSALES	6.73e-06***	7.42e-06***	6.71e-06***	7.35e-06***	6.72e-06***	7.39e-06***
	(2.43e-06)	(2.29e-06)	(2.43e-06)	(2.29e-06)	(2.42e-06)	(2.29e-0.6)
Constant	238.7293***	238.7302***	173.4067***	166.4079***	247.996***	247.1065***
	(39.66)	(37.4284)	(11.5552)	(11.0174)	(39.7997)	(37.6072)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1446	1446	1446	1446	1446	1446
R-Squared	0.1622	0.1550	0.1610	0.1402	0.2030	0.1980

This table examines the effect of environmental regulations, number of green CVC deals and the interaction between both variables on green innovation. Both models are estimated with fixed effects. Standard errors are shown in parentheses. *, **, and *** denote statistical significance at the 10%,5%, and 1% levels, respectively.

Table 4

Green Innovation and Firm Value.

	Panel A: Count			Panel B: Citation		
	ROE (1)	ROA (2)	Tobin's Q (3)	ROE (4)	ROA (5)	Tobin's Q (6)
INNOV	0.417251**	0.396492*	0.405671**	0.447658**	0.369491*	0.424132**
	(0.184567)	(0.223556)	(0.179986)	(0.208732)	(0.213421)	(0.192345)
SIZE	-0.088728*	-0.127631**	-0.153851**	-0.091008*	-0.132309**	-0.162183**
	(0.061831)	(0.059152)	(0.039814)	(0.083637)	(0.069675)	(0.041192)
FINLEV	-0.823146***	-0.743872***	-0.428732**	-0.435231***	-0.364133***	-0.728766**
	(0.232120)	(0.242311)	(0.199967)	(0.173186)	(0.164819)	(0.2364218)
NETSALES	9.49e-06***	0.00001***	6.58e-06***	6.83e-06***	7.50e-06***	7.03e-06***
	(2.61e-06)	(2.47e-06)	(2.40e-06)	(2.42e-06)	(2.28e-06)	(2.27e-06)
Constant	210.7214***	222.8807***	200.9121***	209.7812***	215.1384***	198.6523***
	(11.6434)	(12.6891)	(10.87215)	(12.01215)	(13.4871)	(12.3219)
Firm FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Observations	1167	1167	1167	1446	1446	1446
R-Squared	0.1955	0.2153	0.2378	0.1924	0.2290	0.2311

This table examines the effect of green innovation on firm value. Models (1),(2) and (3) use Count as a measure of green innovation. Models (4),(5) and (6) are based on Citation. All models are estimated with fixed effects. Standard errors are shown in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 5

Green CVC Deals and Firm Value

	ROE (1)	ROA (2)	Tobin's Q (3)
CVC	0.000721*	0.000521*	0.000123*
	(0.000064)	(0.000043)	(0.000021)
SIZE	-0.061879*	-0.081266*	-0.104873*
	(0.041829)	(0.048271)	(0.051929)
FINLEV	-0.904613***	-0.842372***	-0.598424***
	(0.320931)	(0.298310)	(0.289120)
NETSALES	8.53e-06***	0.000001***	6.56e-06***
	(2.23e-06)	(2.49e-06)	(2.42e-06)
Constant	215.4359***	220.4385***	218.2660***
	(10.7623)	(12.8727)	(11.5412)
Firm FE	YES	YES	YES
Year FE	YES	YES	YES
Observations	1243	1243	1243
R-Squared	0.2212	0.1929	0.2167

This table examines the effect of green CVC deals on firm value. All models are estimated with fixed effects. Standard errors are shown in parentheses. *, **, and *** denote statistical significance at the 10%,5%, and 1% levels, respectively.

Table 6

Green Innovation, Green CVC Deals and Firm Value.

	Panel A: Count			Panel B: Citation		
	ROE (1)	ROA (2)	Tobin's Q (3)	ROE (4)	ROA (5)	Tobin's Q (6)
INNOV	0.425190**	0.378192*	0.402255**	0.423225**	0.345139*	0.424132**
	(0.194567)	(0.201256)	(0.187658)	(0.198934)	(0.207821)	(0.182345)
CVC	0.000351***	0.000510**	0.000421	0.000401***	0.000682**	0.000387
	(0.000110)	(0.000081)	(0.000210)	(0.000210)	(0.000093)	(0.000351)
INNOV*CVC	0.00052*	0.000261*	0.000089*	0.000413*	0.000393*	0.000092*
	(0.000421)	(0.00081)	(0.000011)	(0.000572)	(0.000921)	(0.000013)
SIZE	-0.087122*	-0.118632**	-0.134251**	-0.084008*	-0.110309**	-0.138961**
	(0.060721)	(0.057180)	(0.042314)	(0.089637)	(0.066875)	(0.032192)
FINLEV	-0.854912***	-0.759378***	-0.424363**	-0.424291***	-0.384823***	-0.7192501**
	(0.255620)	(0.240812)	(0.194967)	(0.194967)	(0.184119)	(0.248863)
NETSALES	9.53e-06***	0.00001***	6.56e-06***	6.86e-06***	7.53e-06***	7.06e-06***
	(2.64e-06)	(2.49e-06)	(2.42e-06)	(2.44e-06)	(2.30e-06)	(2.30e-06)
Constant	234.9655***	228.8807***	172.2201***	172.2201***	165.0992***	169.3899***
	(14.3694)	(12.5385)	(11.73615)	(11.73615)	(11.08311)	(11.09199)
Firm FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Observations	1167	1167	1167	1446	1446	1446
R-Squared	0.2390	0.2350	0.2410	0.2401	0.2390	0.2409

This table examines the effect of green innovation, number of green CVC deals and the interaction between both variables on firm value. Models (1),(2) and (3) use Count as a measure of green innovation. Models (4),(5) and (6) are based on Citation. All models are estimated with fixed effects. Standard errors are shown in parentheses. *, **, and *** denote statistical significance at the 10%,5%, and 1% levels, respectively.

Table 7

Lagged Environmental Regulations, Green CVC Deals and Interaction.

	One-period lag (t-1)		Two-period lag (t-2)		Three-period lag (t-3)	
	Count (1)	Citation (2)	Count (3)	Citation (4)	Count (5)	Citation (6)
ENVREG	0.291631*	0.330214**	0.293624*	0.327766**	0.303906*	0.340703**
	(0.178776)	(0.168865)	(0.178778)	(0.168827)	(0.178746)	(0.168820)
CVC	0.000013	0.000055	0.000049	0.000014	0.000015	0.000015
	(0.000012)	(0.000012)	(0.000012)	(0.000011)	(0.000012)	(0.000011)
ENVREG*CVC	0.000014**	0.000097*	0.000014**	0.000098*	0.000015**	0.000011*
	(6.31e-06)	(0.000062)	(6.56e-06)	(0.000060)	(6.29e-06)	(5.94e-06)
SIZE	-0.079030*	-0.103357**	-0.079188*	-0.103222**	-0.080494*	-0.104611**
	(0.048027)	(0.045358)	(0.048024)	(0.045354)	(0.048065)	(0.045396)
FINLEV	-0.400044**	-0.362836**	-0.404934**	-0.357455**	-0.403991**	-0.361906**
	(0.191911)	(0.189374)	(0.190976)	(0.180381)	(0.191016)	(0.180409)
NETSALES	6.96e-06***	7.56e-06***	6.90e-06***	7.62e-06***	6.95e-06***	7.60e-06***
	(2.43e-06)	(2.29e-06)	(2.43e-06)	(2.29e-06)	(2.43e-06)	(2.29e-06)
Constant	235.5675***	236.4212***	235.7793***	236.1233***	238.1989***	238.9011***
	(39.74293)	(37.5471)	(39.7540)	(37.5311)	(39.73802)	37.5313
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1401	1401	1387	1387	1360	1360
R-Squared	0.1965	0.2234	0.2050	0.2454	0.2242	0.2561

This table examines the effect of a lag of one, two and three periods in the environmental regulations and green CVC deals and the interaction between both variables on green innovation. Models (1) and (2) use one-period lagged measures. Models (3) and (4) use two-period lagged variables. Models (5) and (6) use three-period lagged variables. All models are estimated with fixed effects. Standard errors are shown in parentheses. *,**,*** denote statistical significance at the 10%,5%, and 1% levels, respectively.

Table 8

Lagged Green Innovation, Green CVC Deals and Interaction.

	Panel A: Citation&Count								
	One-period lag			Two-period lag			Three-period lag		
	ROE (1)	ROA (2)	Tobin's Q (3)	ROE (4)	ROA (5)	Tobin's Q (6)	ROE (7)	ROA (8)	Tobin's Q (9)
INNOV	0.443458**	0.406712	0.421223*	0.445471**	0.408910	0.426702*	0.449812**	0.409290	0.429780*
	(0.231781)	(0.225671)	(0.199411)	(0.229803)	(0.223289)	(0.201982)	(0.227183)	(0.224120)	(0.202354)
CVC	0.000614	0.000123	0.001224**	0.000821	0.000198	0.001682**	0.000858	0.000222	0.001782**
	(0.000287)	(0.000061)	(0.000987)	(0.000276)	(0.000055)	(0.000934)	(0.000248)	(0.000051)	(0.000927)
INNOV*CVC	0.000923*	0.000851**	0.000112*	0.001181*	0.000981**	0.000133*	0.0118573*	0.000994**	0.000122*
	(0.000214)	(0.00043)	(0.000010)	(0.000209)	(0.000391)	(0.000010)	(0.000201)	(0.000376)	(0.000097)
SIZE	-0.125862**	-0.145871**	-0.149213**	-0.126771**	-0.149397**	-0.150012**	-0.127921**	-0.150229**	-0.151188**
	(0.031029)	(0.035767)	(0.036263)	(0.031327)	(0.031655)	(0.033389)	(0.029876)	(0.031476)	(0.032809)
FINLEV	-0.400044**	-0.362836**	-0.402876***	-0.404934**	-0.357455**	-0.397812**	-0.403991**	-0.361906**	-0.395218**
	(0.191911)	(0.189374)	(0.193762)	(0.190976)	(0.180381)	(0.198721)	(0.191016)	(0.180409)	(0.198592)
NETSALES	6.96e-06***	7.56e-06***	7.22e-06***	6.90e-06***	7.62e-06***	7.19e-06***	6.95e-06***	7.60e-06***	7.21e-06***
	(2.43e-06)	(2.29e-06)	(2.30e-06)	(2.43e-06)	(2.29e-06)	(2.30e-06)	(2.43e-06)	(2.29e-06)	(2.29e-06)
Constant	235.5675***	236.4212***	236.8742***	235.7793***	236.1233***	235.481***	238.1989***	238.9011***	237.452***
	(39.74293)	(37.5471)	(37.2691)	(39.7540)	(37.5311)	(37.5009)	(39.73802)	(37.5313)	(37.1082)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	993	993	993	940	940	940	893	893	893
R-squared	0.2402	0.2370	0.2450	0.2415	0.2392	0.2451	0.2455	0.2419	0.2461

This table examines the effect of a lag of one, two and three periods in the green innovation and green CVC deals and the interaction between both variables on firm value. Models (1),(2) and (3) use one-period lagged measures, models (4),(5) and (6) use two-period lagged variables and models (7),(8) and (9) use three-period lagged variables. All models are estimated with fixed effects. Standard errors are shown in parentheses. *,**,*** denote statistical significance at the 10%,5%, and 1% levels, respectively.

Table 9

Robustness of Environmental Regulations, Green CVC Deals and Green Innovation.

	Count (1)	Citation (2)	Count (3)	Citation (4)	Count (5)	Citation (6)
ENVREG	0.334692*	0.385509*	-	-	0.338591**	0.378402*
	(0.405208)	(0.377108)	-	-	(0.402965)	(0.375031)
CVC	-	-	0.000101***	0.000092***	-0.000043	-0.000028
	-	-	(0.000023)	(0.000021)	(0.000073)	(0.000068)
ENVREG*CVC	-	-	-	-	0.000080**	0.000067***
	-	-	-	-	(0.000040)	(0.000037)
SIZE	0.258310***	0.223666***	0.257307***	0.224888***	0.258054***	0.2251168*
	(0.033708)	(0.031371)	(0.033475)	(0.031123)	(0.033390)	(0.031076)
FINLEV	-0.875860***	-0.740675***	-0.921188***	-0.786833***	-0.974771***	-0.833397***
	(0.281513)	(0.261991)	(0.279575)	(0.259932)	(0.279642)	(0.260257)
NETSALES	0.000019***	0.000019***	0.000019***	0.000019***	0.000019***	0.000019***
	(1.98e-06)	(1.85e-06)	(1.97e-06)	(1.83e-06)	(1.97e-06)	(1.83e-0.6)
Constant	241.8655***	245.3777***	163.1269***	157.0862***	247.7633***	241.9192***
	(88.9799)	(82.8093)	(22.5722)	20.9862)	(88.78097)	(82.62659)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1231	1231	1231	1231	1231	1231
R-squared	0.2265	0.2318	0.2385	0.2429	0.2409	0.2453

This table examines the robustness of the effect of environmental regulations, number of CVC deals and the interaction between both variables on green innovation. Both models are estimated with fixed effects. Standard errors are shown in parentheses. *, **, and *** denote statistical significance at the 10%,5%, and 1% levels, respectively.

Table 10

Robustness of Green Innovation and Firm Value.

	Panel A: Count			Panel B: Citation		
	ROE (1)	ROA (2)	Tobin's Q (3)	ROE (4)	ROA (5)	Tobin's Q (6)
INNOV	0.517981**	0.496232*	0.470081**	0.534658**	0.469312*	0.442102**
	(0.273561)	(0.183412)	(0.150198)	(0.297219)	(0.170091)	(0.1316432)
SIZE	0.335642***	0.352188***	0.323791***	0.320801***	0.347210***	0.332101***
	(0.041327)	(0.044351)	(0.044901)	(0.039980)	(0.040209)	(0.043910)
FINLEV	-1.528121***	-1.491192***	-0.981233***	-1.552819***	-1.488720***	-0.957812***
	(0.338971)	(0.329102)	(0.294891)	(0.351274)	(0.338798)	(0.281922)
NETSALES	0.000021***	0.000013***	0.000016***	0.000021***	0.000021***	0.000021***
	(2.03e-06)	(2.84e-06)	(1.95e-06)	(1.82e-06)	(1.87e-06)	(1.82e-06)
Constant	229.111***	230.651	232.982***	231.5168***	235.190***	236.4821***
	(23.5132)	(23.9071)	(22.9810)	(24.1002)	(23.5102)	(23.4871)
Firm FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Observations	1010	1010	1010	1225	1225	1225
R-Squared	0.2012	0.2052	0.2378	0.2081	0.2121	0.2376

This table examines the robustness of the effect of green innovation on firm value. Models (1),(2) and (3) use Count as a measure of green innovation. Models (4),(5) and (6) are based on Citation. All models are estimated with fixed effects. Standard errors are shown in parentheses. *, **, and *** denote statistical significance at the 10%,5%, and 1% levels, respectively.

Table 11

Robustness of Green CVC Deals and Firm Value.

	ROE (1)	ROA (2)	Tobin's Q (3)
CVC	0.001231*	0.002251*	0.002671
	(0.000211)	(0.000422)	(0.000532)
SIZE	0.312320***	0.356192***	0.361731***
	(0.041239)	(0.040091)	(0.038791)
FINLEV	-1.612495***	-1.526794***	-0.109092***
	(0.356521)	(0.339812)	(0.230045)
NETSALES	6.43e-06***	6.93e-06***	6.99e-06***
	(2.64e-06)	(2.49e-06)	(2.44e-06)
Constant	200.8741***	205.1562***	209.1920***
	(22.7819)	(21.1270)	(18.8732)
Firm FE	YES	YES	YES
Year FE	YES	YES	YES
Observations	1225	1225	1225
R-Squared	0.1982	0.1929	0.1976

This table examines the robustness of the effect of green CVC deals on firm value. All models are estimated with fixed effects. Standard errors are shown in parentheses. *, **, and *** denote statistical significance at the 10%,5%, and 1% levels, respectively.

Table 12

Robustness of Green Innovation, Green CVC Deals and Firm Value.

	Panel A: Count			Panel B: Citation		
	ROE (1)	ROA (2)	Tobin's Q (3)	ROE (4)	ROA (5)	Tobin's Q (6)
INNOV	0.443761*	0.478752*	0.501265*	0.463225*	0.485139*	0.512486*
	(0.302167)	(0.319823)	(0.358293)	(0.327445)	(0.351938)	(0.373491)
CVC	0.000009*	0.000011	0.000231*	0.000008*	0.000024	0.000287*
	(0.000008)	(0.000009)	(0.000088)	(0.000007)	(0.000007)	(0.00091)
INNOV*CVC	0.000765**	0.000861**	0.000921**	0.000723**	0.000796**	0.000823**
	(0.000232)	(0.000198)	(0.000184)	(0.000312)	(0.00012)	(0.000201)
SIZE	0.290249***	0.301487***	0.323791***	0.270933***	0.283127***	0.316598***
	(0.039527)	(0.0368352)	(0.034729)	(0.03250)	(0.033667)	(0.031302)
FINLEV	-1.412495***	-1.226794***	-0.859092***	-1.427164***	-1.25852***	-0.896558***
	(0.324277)	(0.3021933)	(0.287067)	(0.266575)	(0.345795)	(0.321503)
NETSALES	0.000016***	0.000016***	0.000019***	0.000018***	0.000019***	0.000019***
	(2.10e-06)	(2.96e-06)	(1.99e-06)	(1.85e-06)	(1.96e-06)	(1.83e-06)
Constant	243.8872***	256.2646***	258.1652***	241.3038***	250.680***	253.3492***
	(27.1025)	(25.4287)	(22.7071)	(21.0861)	(22.3743)	(20.8025)
Firm FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Observations	1010	1010	1010	1225	1225	1225
R-Squared	0.2368	0.2398	0.2451	0.2401	0.2410	0.2501

This table examines the robustness of the effect of green innovation, number of CVC deals and the interaction between both variables on firm value. Models (1),(2) and (3) use Count as a measure of green innovation. Models (4),(5) and (6) are based on Citation. Both models are estimated with fixed effects. Standard errors are shown in parentheses. *, **, and *** denote statistical significance at the 10%,5%, and 1% levels, respectively.

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