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RESEARCH ARTICLE

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Firm-level energy and carbon performance: Does sustainable investment matter?

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Abstract

Pollution reduction is one of the important challenges confronting contemporary business and society. Firms are largely responsible for undertaking sustainable business practices and initiatives as they are major contributors to global pollution. This study empirically examines how sustainable investment influences firm energy and carbon performance. Using a sample of 23,501 firm-year observations from 2440 unique firms over the period of 2002 to 2018 in G-6 countries (Canada, France, Germany, Japan, the United Kingdom, and the United States), we demonstrate that sustainable investment leads to better energy and carbon performance without compromising financial return. Our findings are robust to alternative variables, subsamples, and different estimation techniques. This study contributes to the global discussion on sustainability and a low-carbon economy.

KEYWORDS

carbon intensity, energy intensity, G-6 countries, sustainable investment

1 | INTRODUCTION

Increasing global temperature with its significant adverse impact on climate change is a worldwide concern. The major cause of global warming is greenhouse gas emissions, of which a staggering 72% comes from carbon dioxide (CO_2) alone. Such emissions pose serious environmental challenges that impact economic activities, health, and social welfare. These repugnant effects have forced nations to undertake effective policies and initiatives to keep the surface temperature at an endurance level. For example, policymakers and regulators urge corporations to be more environmentally friendly by raising energy efficiency (increasing renewable energy consumption) and reducing carbon emissions. In response to such pressure, firms need to consider green business practices (Journeault et al., 2016; Tolliver et al., 2020), such as sustainable investment, which may help improve energy and carbon performance to a great extent. Connectedly, Dutta et al. (2020) report that investors are now shifting towards green investments as they tend to form portfolios that include eco-friendly firms.

Sustainable investment is the amount of money a firm spends on environmental and green initiatives for emission reduction, such as investment in energy efficiency, clean power, pollution reduction, recycling, and employee training initiatives.[1] We use delegated philanthropy theory and the natural resource-based view (NRBV) to consider the theoretical arguments regarding why a firm should deploy its scarce resources in sustainability. Both theories argue that firms are forced to act pro-socially in their response to immense pressure from their governments, customers, and community stakeholders (Bénabou & Tirole, 2010; Hart, 2005). Sustainable investment is an increasingly important goal for managers across all industries

Abbreviations: 2SLS, two-stage least squares; CSR, corporate social responsibility; GDP, gross domestic product; GFC, global financial crisis; GICS, Global Industry Classification Standards; IV, instrumental variable; NRBV, natural resource-based view; OECD, Organisation for Economic Co-operation and Development; PSM, propensity score matching; S&P, Standard & Poor's; VIF, variance inflation factor.

[1]For details, refer to Thomson Reuters Eikon's ASSET4 data definitions.

(Meuer et al., 2020). We argue that sustainable investment is one such pro-social activity that may improve a firm's energy and carbon performance without compromising its financial return[2] through both eco-innovation and the development of environment-friendly equipment and technology. This green innovation augments productivity through its minimal energy consumption and low-carbon emissions (Stucki, 2018; Wu & Kung, 2020). Likewise, sustainable investment increases a firm's capabilities to better manage its industrial waste and promotes recycling and reuse. It also nurtures the advancement of more efficient and clean-energy sources that play a major role in conversion towards a total sustainable energy mix that in turn reduces emissions. Thus, sustainable investment is an important business strategy for improving a firm's energy and carbon performance.

While the sustainable investment may play a pivotal role in enhancing a firm's energy efficiency and carbon reduction, no empirical study has yet examined this important issue at the firm level.[3] Our study aims to fill this gap in the existing literature by investigating the effect of sustainable investment on energy and carbon performance using firm-level data from G-6[4] countries: Canada, France, Germany, Japan, the United Kingdom, and the United States. We consider G-6 for this study for two reasons. First, according to Bloomberg (2018), firms operating in the G-6 countries are the pioneers of sustainable investment, as they generally undertake rapid advancement of energy-efficient and renewable energy technologies in order to develop green infrastructures. Such substantial investment in sustainability in these countries is expected to help drive the improvement of a firm's energy efficiency and carbon performance. Connectedly, the sample countries are all active and leading signatories of the Paris Agreement and have collectively agreed to boost sustainable investment, particularly in private sectors, to limit the rise of global temperature by approximately 1.5°C (UNCC, 2017). Although the United States had left this agreement under the Trump administration, the current Biden administration brought the United States back to the Paris Agreement as a priority in February 2021 (US State Government, 2021). Therefore, the sample countries considered in our study have a strong commitment to strengthening their cooperation financially, scientifically, and technologically.

Second, G-6 countries are the leading economies in terms of energy consumption and carbon emissions. As can be seen in Figure A1, the energy use per capita in G-6 countries is nearly 2.5 times higher compared to the rest of the world. Such higher energy consumption is also reflected in per capita carbon emissions. Figure A2 indicates that the per capita carbon emissions in G-6 countries are almost double that of the other economies in the world. However, Figure A2 highlights that per capita carbon emissions have decreased significantly (from 11.89 metric tons in 1990 to 9.37 metric tons in 2019) in G-6 countries due to their strong commitment to curbing carbon emissions and tackling climate change. Hence, the findings derived from the sample countries will have significant policy implications.

Through employing a comprehensive sample of 23,501 firm-year observations from 2002 to 2018 in the G-6 countries, we find that sustainable investment has a negative relationship with the intensities of energy consumption and carbon emissions. This notion suggests that sustainable investment improves energy efficiency and clean-energy use, thereby decreasing carbon emissions without compromising firms' financial performance. However, our results may suffer from a potential endogeneity bias due to managerial motivation of investing in eco-friendly technologies in response to the pressure from regulatory authorities, or extreme business cycles (e.g., the global financial crisis [GFC]) may cause a funding shortage leading to poor environmental performance. To address this potential endogeneity bias, we have implemented three strategies: the inclusion of country-level (macro-level) variables, the use of two-stage least squares (2SLS) with an instrumental variable (IV) approach, and the use of the propensity score matching (PSM). Our empirical results are upheld across these three strategies. In addition to dealing with the potential endogeneity issue, we have used alternative variables, sub-samples, and different estimation techniques to ensure the robustness of our findings.

This study contributes to policy formulation and knowledge creation in three ways. First, to the best of our knowledge, this is the first study that provides empirical evidence between a firm's sustainable investment and its energy and carbon performance at the firm level. The robust econometric analysis in our study highlights the importance of sustainable investment at the firm level in promoting better environmental performance. Thus, the finding of this study provides insights into the global discussion on the role of firms in climate change adaptation and mitigation. Second, our study contributes to the business sustainability literature (e.g., Cao & Karplus, 2014; Jiang et al., 2014) that investigates the determinants of energy and carbon performance at the firm level. While most of the existing studies (e.g., Filipović et al., 2015; Paramati et al., 2021) focus on macro-level (country-level) data, their analyses merely provide specific guidelines to improve environmental performance at the firm level (Dowell et al., 2000). In contrast, our study provides specific evidence in this regard by presenting firm-level evidence contributing to the recently emerged strand of literature (Monasterolo & Raberto, 2018; Reboredo et al., 2020), which highlights the importance of a low-carbon economy. Third, our study contributes to an emerging strand of literature (Atif et al., 2021; Gull, Atif, & Hussain, 2022; Lu & Wang, 2021; Zhang et al., 2021) that examines the relationship between a firm's environmental initiatives, financial performance, and CSR disclosure. While the extant literature report mixed evidence on the association between a firm's environmental endeavor and its financial competence, we reveal a context in which firms' sustainable investment increases their financial performance. Overall, our empirical evidence

[2]A large number of studies, such as Sharfman and Fernando (2008) and Nandy and Lodh (2012), find that eco-friendly firms enjoy various financial privileges, including easy access to loans and reduced cost of capital.

[3]A strand of empirical literature focuses on the (voluntary) disclosure of sustainability practices with different firm-level outcomes (e.g., Broadstock et al., 2018; Brooks & Oikonomou, 2018; Li et al., 2018; Liao et al., 2015).

[4]We initially included all G-7 countries for this study, but due to the unavailability of data for Italy, we restricted our empirical analysis to G-6 countries (Alam et al., 2019).

suggests that sustainable investment helps to improve a firm's position both environmentally and financially.

The remainder of this study is structured in four sections. Section 2 discusses the theoretical framework of the study and reviews the literature. Section 3 presents the research design. Section 4 discusses empirical findings, while Section 5 concludes the study.

2 | THEORETICAL FRAMEWORK AND LITERATURE REVIEW

Section 2.1 reviews the delegated philanthropy theory and the NRBV, which provides a number of arguments as to why firms should invest in sustainability in order to improve their energy and carbon performance. It also discusses sustainable investment channels that affect firm environmental performance. Finally, Section 2.2 reviews the extant literature in broader areas of environmental investment, technology, and sustainability to develop our hypotheses.

2.1 | Theoretical framework

The theoretical basis for the importance of corporate sustainable investment can be derived from delegated philanthropy theory and the NRBV. Both of these theories underpin how sustainable investment helps firms to improve their environmental performance.

Delegated philanthropy theory is one of the dominant theoretical frameworks that work to contextualize firms' pro-social activities, such as using the sustainable investment to gain both social and financial benefits. Proponents of this theory view firms as a channel for the expression of citizens' values (Bénabou & Tirole, 2010), where both shareholders and other stakeholders expect firms to engage in philanthropic activities to benefit both society and their respective business environments. In line with this assertion, we argue that philanthropic firms should respond to stakeholders' demand to "do good for the environment," on their behalf, by replacing traditional investment with sustainable investment.

Business enterprises face substantial pressures from regulators and government authorities to improve their environmental performance; thus, environmental competitiveness has become extremely important in the contemporary business model. The NRBV argues that a firm can achieve both financial and environmental advantages by employing its internal assets and resources to clean technologies, such as having environment-friendly machinery and equipment through sustainable investment. Prior literature (e.g., González-Benito & González-Benito, 2005; Klassen & Whybark, 1999) theoretically claim that environmental investment improves a firm's operational performance, which in turn minimizes the negative impact on the environment. Similarly, López-Gamero et al. (2009) reveal that environmental management helps to improve environmental quality.

While these two theories highlight the motivation for a firm to invest in sustainability, a follow-up question asks which sustainable investment channels improve a firm's environmental performance. We contend that sustainable investment increases a firm's energy and carbon performance through green product and service innovation, green technology and process development, and green organization cultural promotion. First, sustainable investment promotes green product and service innovation by producing new products and services or by upgrading existing ones that have no (or relatively less) negative impact on the environment than the current ones (Wong et al., 2012). Second, sustainable investment improves the firm's energy efficiency, enhances renewable energy consumption, and reduces carbon emissions through the invention of green technology, production process, and the improvement of existing ones. In other words, sustainable investment reduces firm-level carbon emissions by increasing firm productivity in terms of energy consumption as well as increasing the share of clean energy in a firm's total energy mix in the long run. Stucki (2018) argues that investing in sustainability fosters green and cost-effective technology and know-how, augmenting both productivity and energy efficiency. In this connection, Rissman and Marcacci (2019) argue that investment in green activities advances low-carbon and clean-energy technology from the laboratory to the marketplace, which helps to cut the energy cost significantly and to make renewable energy cheaper and affordable for business enterprises.

Third, sustainable investment helps to develop effective and efficient management methods (Porter & Van der Linde, 1995) to ensure a green organizational culture through training, apprenticeship, and other managerial supportive measures. Such green culture promotes the environmental performance of a firm within and outside of its business operations, including suppliers, logistics, and markets. Overall, sustainable investment helps to achieve eco-innovation, which in turn stimulates climate change mitigation and adaptation activities, including energy efficiency, renewable energy use, recycling, treatment, industrial pollution abatement, and biodiversity protection, without compromising financial return (Busch et al., 2022).

2.2 | Literature review and hypotheses development

The above theoretical arguments in section 2.1 point out that sustainable investment improves firm energy and carbon performance; however, there is no analytical or empirical study that examines these links. A few available studies do examine the connection between a firm's investment in R&D and the technology innovations that promote better environmental performance. Margolis and Kammen (1999) claim that energy R&D spending and patents for innovative technology are positively correlated in the United States. Such technological advances increase energy supplies through innovating new sources of renewable energy and by improving the efficacy of the conversion of raw energy to the required ultimate-use forms and lowering the economic costs and adverse environmental impacts (Sagar & Holdren, 2002).

A few analytical studies have suggested that high-tech modernization is essential for improving energy efficiency and lowering energy intensity. For example, the study by Fisher-Vanden et al. (2004) documents technological development as a crucial factor in decreasing energy intensity in China. From a theoretical point of view, Yongping (2011) argues that the magnitude of the technological development effect on energy intensity has a direct relationship with energy efficiency. Yang et al. (2014) find that industrial R&D spending significantly minimizes industrial carbon emissions in 30 Chinese provinces. More recently, Fernández et al. (2018) concur that R&D spending has a substantial positive influence on minimizing carbon emissions in China, the United States, and the European Union. Hunt and Weber (2019) report that divestment in fossil fuels is not only an ethical investment approach but also that it helps firms address financial risks caused by climate change. Moreover, technological innovation creates prospects for highly energy-dependent countries to switch from fossil fuel to clean-energy sources (Sohag et al., 2015). However, if technological advancements marginally decrease energy use, they might not have the capabilities to reduce a truly significant portion of the energy consumed.

Some studies have used micro-level data regarding the connection between investment in R&D and socially responsible activities (CSR). These earlier studies, such as McWilliams and Siegel (2000), Hull and Rothenberg (2008), and Padgett and Galan (2010), examine the impact of R&D spending on CSR by including a firm's environment-friendly activities as an integral part of its CSR. The empirical evidence concludes that R&D spending leads to better corporate social activities. Relatively recent studies, such as Chakrabarty and Wang (2012), Jiang et al. (2014), and De Sousa Gabriel and Rodeiro-Pazos (2020) put more focus on environmental performance instead of CSR. For example, Chakrabarty and Wang (2012) report empirical evidence that the multinational companies which invested a higher amount in R&D activities had better sustainability practices. Likewise, considering Chinese manufacturing firms as a sample, Jiang et al. (2014) suggest that investment in R&D has a significant adverse relationship with industrial soot emissions. Lee and Min (2015), who explore the association between green R&D spending and carbon emissions, show a significant negative association.

More recent studies, such as OECD (2017), Monasterolo and Raberto (2018), Reboredo et al. (2020), and Lin et al. (2021) describe the green bond as one of the best financial investments means to promote low-carbon economic growth. Similarly, Gevorkyan et al. (2016) and Flaherty et al. (2017) claim that green bonds have the lucrative ability to revamp the cost of minimizing the negative impacts of climate change across various generations. In this connection, Flammer (2021) investigates the impact of green bonds on firms' environmental ratings and carbon emissions. The study used 368 corporate green bonds data dating from 2013 to 2017 to reveal that corporate green bonds do improve firm environmental performance. Similarly, Gianfrate and Peri (2019) suggest that green bonds help to address climate change, although they yield lower returns to the investors compared to conventional (non-green) bonds.

Based on the literature review, there is no empirical study as yet that examines the impact of sustainable investment on firms' energy and carbon performance. Our study investigates the impact of sustainable investment on firm energy and carbon performance based on the two hypotheses:

> **H1.** Firm sustainable investment is negatively associated with energy intensity, ceteris paribus.

> **H2.** Firm sustainable investment is negatively associated with carbon intensity, ceteris paribus.

3 | RESEARCH DESIGN

3.1 | Sample

We collected data for this study from four different databases. Both energy and carbon emission intensity and sustainable investment were directly sourced from Thomson Reuters Eikon's ASSET4 database. We obtained data on institutional ownership from the FactSet Ownership database. We used Thomson Reuters Eikon Datastream for financial and other control variables. Country-level variables were obtained from the World Development Indicators. We used firms' ISINs as the identifiers to merge the datasets obtained from different sources.

Our preliminary sample comprised firm-level (listed) data, regardless of differences in firm industries from the market indices of the G-6 countries: Toronto TSX (Canada), Paris CAC40 (France), Frankfurt DAX30 (Germany), Tokyo Nikki500 (Japan), London FTSE350 (the United Kingdom), and S&P1500 (the United States). Our sample covers a total of 17 years, from 2002 to 2018 based on the data availability of our variables, which has allowed this study to examine the variations in energy use and carbon emissions in response to sustainable investment. Our initial search from all six indices produced 45,118 firm-year observations, providing data on all the variables. We restricted our study to countries with no less than 100 firm-year observations. We further restricted the firm years to have necessary data on all of the variables to be part of our final sample. Finally, we obtained 23,501 firm-year observations on 2440 firms for G-6 countries.[5] Further detail on sample selection is provided in Table A1.

3.2 | Estimation model

We investigated the effects of sustainable investment on energy and CO_2 emission intensities through the following model:

$$\begin{aligned} Y_{it} = {} & \alpha + \beta_1 (SUS\_INV)_{it} + \beta_2 (firm\ characteristics)_{it} \\ & + \beta_3 (governance\ characteristics)_{it} + \beta_4 \sum (Industry\ effects)_i \\ & + \beta_5 \sum (Year\ effects)_t + \varepsilon_{it}, \end{aligned} \tag{1}$$

[5]Twenty-two percent of firms report data, and we deemed sustainable investment to be zero if not reported, following prior studies (e.g., Chen, Dou, et al., 2015; Kim et al., 2019).

where Y_{it} denotes the dependent variables in our analysis, namely, energy intensity and CO_2 emission intensity. The variable energy intensity (*ENE_INT*) is employed to investigate H1, with carbon emission intensity (CO_INT) to examine H2. We used sustainable investment (*SUS_INV*) as our main independent variable in both hypotheses to capture the amount of money invested and spent by individual firms for environmental and green initiatives in regard to emission reduction. A firm's spending on environmental initiatives may also be affected by different firm-specific and corporate governance characteristics. Therefore, we controlled for both firm and corporate governance characteristics to minimize the estimation error. For example, return on assets, leverage, capital intensity, growth opportunities, and board size are included in our models as control variables.

We used OLS as a baseline regression to explore the differences in the time-series and cross-sectional aspects of the panel data while controlling for industry (four-digit Global Industry Classification Standards), year (2002 to 2018), and country effects. We also executed a Hausman test to select between the random or fixed effects (FEs) and the results (un-tabulated) sanction the appropriateness of the FEs. FE assists to controls for year fluctuations and removes the omitted variable bias. In addition, we estimated 1-year lagged independent variables to replace the concurrent variables (Harford et al., 2008). The justification for this estimation is that sustainable investment requires some time to affect energy consumption and carbon emissions. We follow Petersen (2009) to adjust the standard errors for residuals clustering at each firm level to control for heteroscedasticity.

3.3 | Dependent and independent variables

Our measure of energy intensity (*ENE_INT*) is total energy consumption divided by total sales that shows an average value of 4.568 megawatt hours (MWh) in the sample (see Panel A in Table 2). Our measure of CO_2 emission intensity (*CO_INT*) is total CO_2 emissions deflated by total sales in a year. The sample average of CO_2 emission intensity per sale is 49.337 (tons). We use this measure because it represents carbon emission in the manufacturing process. We scale both variables by sales to minimize the heterogeneity problem, following Lee et al. (2015). We also use alternative measurements of dependent variables *ENE_INT/TA* (measured as total energy consumption scaled by total assets) and *CO_INT/TA* (measured as total carbon emission scaled by total assets) for the robustness checks. The main independent variable in our analysis, sustainable investment (*SUS_INV*), has an average value of 0.758 (Panel B in Table 2) and is calculated as the natural log of total investment in sustainability (e.g., the amount of money in million USD invested and spent by a firm for environmental and green initiatives for emission reduction). We included corporate governance characteristics that may affect the energy intensity and carbon intensity. Table 1 defines all the variables used in the model.

3.4 | Control variables

Table 2 presents the summary statistics of the firm characteristics in Panel C. Following the extant literature (Atif et al., 2019;

TABLE 1 Variable definitions

Notation	Variable name	Measure
Panel A: Dependent variable		
CO_INT	Carbon emission intensity per sales	Total carbon emission over total sales
ENE_INT	Energy intensity per sales	Total energy consumption over total sales
Panel B: Independent variable		
SUS_INV	Sustainable investment	Natural log of total sustainable investment
Panel C: Firm characteristics		
LEV	Leverage	Total debt to total assets
ROA	Return on assets	Firm net income divided by total assets
MTB	Market-to-book ratio	Market value equity plus book value of assets minus book value of equity over book value of assets
GFCD	Global Financial crises dummy	A dummy variable equaling 1 for 2007–2009 and 0 otherwise
LN_MKP	Market capitalization	Natural log of market capital
IO	Institutional ownership	The percentage of shares held by institutional owners in total outstanding capital
CAP_INT	Capital intensity	Total assets scaled by total sales
Panel D: Corporate governance characteristics		
BSIZE	Board size	The number of directors on the board
CEOD	CEO duality	Takes the value of 1 if the CEO is also the chairman of the board and 0 otherwise
BIND	Board independence	Percentage of independent directors on the board
FEMB	Percentage of women on the board	Percentage of women directors on board

TABLE 2 Descriptive statistics

Variable	Mean	Median	SD	Min	Max
Panel A: Dependent variable					
CO_INT	49.337	154.741	748.498	0.016	1483.785
ENE_INT	4.568	15.265	107.988	0.106	9219.860
Panel B: Independent variable					
SUS_INV	0.758	1.658	2.453	0.000	12.342
Panel C: Firm characteristics					
LEV	0.242	0.209	0.353	0.000	57.000
ROA	4.815	4.950	5.063	−1.981	30.170
MTB	2.492	1.810	31.760	−2.244	32.115
GFCD	0.150	0.000	0.357	0.000	1.000
LN_MKP	6.822	6.584	1.114	1.505	10.605
IO	0.545	0.592	0.329	0.000	1.000
CAP_INT	14.972	1.296	12.515	−12.451	18.220
Panel D: Corporate governance characteristics					
BSIZE	10.604	10.000	3.391	1.000	39.000
CEOD	0.237	0.000	0.425	0.000	1.000
BIND	69.903	80.000	26.343	0.000	96.000
FEMB	13.223	12.500	11.583	0.000	75.000

Note: Table 2 provides descriptive statistics for all the variables used in our study during the whole sample period. All variables are defined in Table 1.

Liu et al., 2014), we controlled for firm characteristics that may influence firm policies and decisions (i.e., sustainable investment). We included leverage (*LEV*), the sum of both short-term and long-term debt divided by total assets, with a mean value of 0.242. Our measure of return on assets (*ROA*), a profitability measure, calculated as net income over total assets, indicates a 4.815 mean value. The firm's characteristics group includes growth opportunities as calculated by the market-to-book ratio, with a mean value of 2.492. The *GFCD* variable indicates a liquidity crunch during the period of the GFC 2007–2009. The GFC, caused by the deregulation and insolvency of key financial organizations in the United States, has affected economies across the world. Notably, the GFC aggravated the ambiguity and significantly increased the risk of under-investment. The undesirable effect of the GFC on sustainable investment through a bearish stock market resulted in decreased sales turnover. This was measured by the dummy (*GFCD*) variable equaling 1 during 2007–2009, and 0 otherwise. We measured the size of a firm as the natural logarithm of market capital (*LN_MKP*), which averages 6.822. Institutional ownership (*IO*), which may affect firm energy and carbon performance, was measured as total shareholdings by institutional owners in total share capital, with an average value of 0.545. Capital intensity (*CAP_INT*) was measured as sales divided by total assets, showing a 14.972 mean value in the sample.

Our selection of corporate governance variables in Panel D was also based on prior literature (e.g., Chen et al., 2017; Harford et al., 2008). For instance, Chen et al. (2017) argued that board characteristics are the key factors influencing corporate policies. Hence, we incorporate several board-level control variables, including board size (*BSIZE*) with an average of 10.604 (measured by the number of directors on the board); CEO duality (*CEOD*) (a dummy variable equaling one if the CEO is also the board chair, and zero otherwise), which indicates 0.237 mean value; board independence (*BIND*) (measured by the percentage of independent directors on the board), with 69.903 average value; and the percentage of females on the board (*FEMB*) (measured as the percentage of female directors on the board), indicating a mean value of 13.223.

In Table 3, Panels A and B illustrate the sample based on year and country. Panel A shows the classification of firm-year observations across different years in the sample. It also shows an incremental trend in the number of observations due to improved disclosure. Panel B illustrates the classification of the sample across different countries. Among these, the United States leads in firm-year observations (51.883%), followed by Japan (19.986%) and then the United Kingdom (14.663%).

3.5 | Multi-collinearity analysis

Table 4 shows the matrix of correlation to check for multi-collinearity among all variables (independent and control). The correlations among *SUS_INV*, *CO_INT*, and *ENE_INT* are negative, which supports our argument (hypotheses) that sustainable investment decreases energy and CO_2 emission intensities. The correlations among the remaining variables are less than .60. Moreover, the variance inflation factor

TABLE 3 Sample description

Panel A			Panel B		
Firm-year (FY) distribution 2002–2018			Country composition		
Year	*N*	% of FY	Country	*N*	% of FY
2002	337	1.434	USA	12,193	51.883
2003	376	1.600	Japan	4697	19.986
2004	644	2.740	UK	3446	14.663
2005	915	3.893	Germany	410	1.745
2006	933	3.970	Canada	2175	9.255
2007	1042	4.434	France	580	2.468
2008	1243	5.289	Total	23,501	100
2009	1379	5.868			
2010	1458	6.204			
2011	1493	6.353			
2012	1507	6.412			
2013	1535	6.532			
2014	1564	6.655			
2015	2022	8.604			
2016	2361	10.046			
2017	2434	10.357			
2018	2258	9.608			

Note: Table 3 presents the distribution of our sample based on firm years in Panel A. The country composition of the sample is illustrated in Panel B.

(VIF) for the variables is smaller than 2.81, and an overall VIF is 1.39.[6] Therefore, the analyses from our empirical models are expected to provide unbiased results as our selected variables have no multicollinearity issue.

4 | MAIN FINDINGS

4.1 | Energy intensity and sustainable investment

Table 5 illustrates the impact of sustainable investment on energy intensity. Column 1 of Panel A depicts results without considering the effect of the control variables; Column 2, results without industry, year, and country effects. Column 3, however, presents results where industry, year, and country effects are controlled along with control variables. The sustainable investment shows a significantly negative impact on energy intensity (*ENE_INT*), which suggests that higher sustainable investment increases energy efficiency. Columns 4 and 5 show similar relationships using 1-year lagged independent variables and firm fixed effect regression, respectively.

Our results show that sustainable investment (*SUS_INV*) has a significantly negative impact (at the 5% or better level) on the energy intensity (Column 3, −1.264) in the full sample, after controlling for the industry, year, and country effects.[7] For example, a 1-point increase in sustainable investment is followed by a decline in energy consumption of 1.264 MWh (Column 3). The economic significance of this result is also imperative. For instance, a rise in the *SUS_INV* would decrease energy consumption between 0.175 and 2.565 MWh.

As a robustness check, we redefined and replaced the dependent variable in our model with firms' energy consumption scaled by total assets (*ENE_INT/TA*). We then re-estimated the model and reported findings in Panel B (Columns 6–10). Panel B presents equivalent regressions as in Panel A. We concluded that *SUS_INV* has a (significantly) negative effect on energy intensity (*ENE_INT/TA*), as shown in our main model. Our results are statistically significant and consistent with the main results supporting H1. Overall, our findings support the theoretical discussion based on both delegated philanthropy theory and the NRBV and are similar to prior studies documenting that sustainable investment is beneficial for the environment (e.g., Porter & Van der Linde, 1995; Wong et al., 2012). Our results are also similar to those of Garrone and Grilli (2010) and of Chen et al. (2019), who show that R&D investment plays a significant role in cutting energy intensity at the country level. Thus, our results are reliable, supporting an important policy recommendation that firms should invest in sustainability to improve their environmental performance.

[6]According to Lardaro (1993, p.446), the multi-collinearity is not an issue if the VIF is less than 10.

[7]One may argue that different products may require a different level of energy consumption. To address such concerns, we run regression on the absolute values of energy intensity and find similar results (un-tabulated).

TABLE 4 Correlation matrix

Sr. No.	Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	CO_INT	1.000													
2	ENE_INT	.000	1.000												
3	SUS_INV	−.005	**−.012**	1.000											
4	LEV	−.004	−.025	**.019**	1.000										
5	ROA	.006	−.023	−.092	**−.109**	1.000									
6	MTB	−.001	−.001	−.014	**−.015**	**.014**	1.000								
7	GFCD	.000	−.003	**.000**	−.005	−.019	−.008	1.000							
8	LN_MKP	−.007	**−.042**	**.422**	−.038	**−.059**	−.011	**−.010**	1.000						
9	IO	.005	**.028**	**−.308**	**.035**	.115	.016	**−.048**	**−.493**	1.000					
10	CAP_INT	**.440**	.000	−.007	.003	.001	.000	−.003	−.011	.010	1.000				
11	BSIZE	.004	**−.021**	**.120**	**.060**	**−.130**	**−.002**	.033	.335	−.147	**.002**	1.000			
12	CEOD	−.011	.023	**−.021**	**.002**	.009	.015	**.054**	**.022**	**.235**	.000	**.034**	1.000		
13	BIND	.008	.001	**−.339**	**.057**	**.112**	.018	**−.020**	**−.581**	**.582**	.010	**−.063**	**.146**	1.000	
14	FEMB	−.004	**−.024**	**−.190**	**.067**	**.070**	.001	**−.101**	**−.291**	**.385**	.003	**.055**	.041	**.533**	1.000

Note: Table 4 reports the Pearson correlation coefficients among variables in our study. Coefficients in bold are significant at the 5% level.

TABLE 5 The effect of sustainable investment on energy intensity

Variables	Panel A: (ENE_INT) (1) Without controls	(2) Without industry/ year/country effects	(3) With industry/ year/country effects	(4) One-year lagged variables	(5) Firm fixed effects	Panel B: (ENE_INT/TA) (6) Without controls	(7) Without industry/ year/country effects	(8) With industry/ year/country effects	(9) One-year lagged variables	(10) Firm fixed effects
SUS_INV	−2.565*** (−13.28)	−1.242*** (−3.81)	−1.264*** (−3.49)	−1.210*** (−3.60)	−0.175** (−2.122)	−1.850*** (−4.01)	−0.925*** (−5.99)	−0.488*** (−2.88)	−0.443*** (−2.86)	−0.021* (−1.87)
LEV	-	−19.173*** (−3.45)	−29.278*** (−4.90)	−26.202*** (−4.70)	−6.635* (−1.74)	-	−7.045** (−2.01)	−12.576*** (−3.14)	−8.838** (−2.19)	−6.675 (−1.47)
ROA	-	−0.418*** (−2.96)	−0.461*** (−3.12)	−0.443*** (−3.21)	0.035 (0.57)	-	0.187* (1.94)	0.330*** (3.28)	0.347*** (3.69)	0.038 (0.88)
MTB	-	−0.006 (−0.14)	−0.024 (−0.63)	−0.019 (−0.53)	−0.001 (−0.91)	-	0.002 (0.13)	0.006 (0.36)	0.007 (0.48)	−0.000 (−0.46)
GFCD	-	−2.514 (−0.93)	9.708 (1.10)	8.916 (1.08)	4.436* (1.65)	-	−2.501 (−1.55)	−9.233 (−0.99)	−1.159 (−0.14)	−7.670 (−1.61)
LN_MKP	-	−9.756*** (−6.60)	−8.546*** (−3.78)	−8.634*** (−4.09)	−3.383 (−0.64)	-	−6.824*** (−8.19)	−11.999*** (−8.45)	−11.190*** (−8.59)	−3.503 (−1.29)
IO	-	16.276*** (3.55)	11.762* (1.70)	11.004* (1.71)	−7.131* (−1.80)	-	8.598*** (2.81)	−5.733 (−1.08)	−5.486 (−1.13)	3.150 (0.73)
CAP_INT	-	−0.000 (−0.04)	0.000 (0.14)	0.000 (0.11)	−0.000 (−0.37)	-	−0.011 (−0.69)	−0.005 (−0.37)	−0.004 (−0.26)	−0.001 (−0.31)
BSIZE	-	0.153 (0.44)	−0.269 (−0.71)	−0.226 (−0.64)	0.027 (0.26)	-	−0.322* (−1.73)	−0.198 (−0.91)	−0.193 (−1.00)	−0.208** (−2.18)
CEOD	-	5.982*** (2.79)	3.641 (1.58)	3.110 (1.45)	0.275 (0.39)	-	4.405*** (3.61)	2.189 (1.61)	2.184* (1.76)	−0.460 (−1.14)
BIND	-	−0.205*** (−3.38)	−0.476*** (−5.44)	−0.394*** (−4.82)	0.017 (0.69)	-	−0.027 (−0.82)	0.052 (1.12)	0.053 (1.26)	0.014 (1.18)
FEMB	-	−0.330*** (−3.02)	−0.517*** (−4.35)	−0.427*** (−3.85)	0.075 (0.80)	-	−0.127* (−1.89)	0.040 (0.51)	0.080 (1.10)	0.047 (1.17)
CONSTANT	2.328*** (4.37)	85.375*** (7.08)	96.915*** (4.36)	89.186*** (4.30)	29.970* (1.85)	8.556*** (3.39)	55.669*** (7.75)	91.784*** (6.24)	75.913*** (5.77)	41.183** (2.17)
Industry effect	N	N	Y	Y	N	N	N	Y	Y	N
Year effect	N	N	Y	Y	Y	N	N	Y	Y	Y
Country effect	N	N	Y	Y	Y	N	N	Y	Y	Y
N	23,501	23,501	23,501	21,031	23,501	23,501	23,501	23,501	21,031	23,501

(Continues)

TABLE 5 (Continued)

Variables	Panel A: (ENE_INT) (1) Without controls	(2) Without industry/year/country effects	(3) With industry/year/country effects	(4) One-year lagged variables	(5) Firm fixed effects	Panel B: (ENE_INT/TA) (6) Without controls	(7) Without industry/year/country effects	(8) With industry/year/country effects	(9) One-year lagged variables	(10) Firm fixed effects
Adj. R^2	.114	.161	.180	.171	.150	.122	.132	.185	.184	.106

Note: Table 5 presents the results of the impact of sustainable investment on energy intensity. In Panel A (Columns 1–5), the dependent variable is energy intensity per sale, while in Panel B (Columns 6–10), the dependent variable is energy intensity per asset. Both panels show regressions without control variables, without and with industry/year/country effects, 1-year lagged variables, and firm fixed effect regression. The robust *t*-statistics of each coefficient are shown in parentheses. All variables are defined in Table 1.

*Significance level at the 10% level.

**Significance level at the 5% level.

***Significance level at the 1% level.

4.2 | Carbon emission intensity and sustainable investment

Table 6 presents the findings of the impact of sustainable investment on CO_2 emission intensity (*CO_INT*). Column 1 of Panel A presents the OLS specification results without considering the effect of the control variables. Column 2 is without industry, year, and country effects, Column 3 shows the findings after controlling for these three effects along with control variables. Moreover, Column 4 shows such an effect using 1-year lagged variables, as does Column 5 using firm fixed effect regression.

Our results show that sustainable investment (*SUS_INV*) has a significantly negative impact (at the 5% or better level) on the CO_2 emission intensity in the full sample (Column 3, −9.678), despite controlling for industry, year, and country effects.[8] For example, a 1-point increase in sustainable investment followed by a decrease in CO_2 emission of 9.678 tons (Column 3), which is significant at the 5% level. The economic importance of the results is also vital. For example, an increase in *SUS_INV* by 1 point would decrease the carbon emissions per sale between 2.217 and 23.687 tons. Overall, these results support H2.

Furthermore, we replaced the dependent variable with carbon emission intensity per asset (*CO_INT/TA*) and re-estimated the model to test the robustness of our results. We report equivalent regressions in Panel B and found that sustainable investment has a (significantly) negative impact on carbon emission intensity per asset, consistent with our main results. This finding is consistent with previous studies, which reported that R&D investment helps to reduce carbon emissions and improve sustainability significantly at both country level (e.g., Alam et al., 2021; Paramati et al., 2021) and firm level (e.g., Jiang et al., 2014; Lee et al., 2015). Our results are also similar to those of Flaherty et al. (2017) and Gianfrate and Peri (2019), who advocate the role of green bonds in promoting a low-carbon economy. Thus, our findings are statistically significant and consistent in supporting H2.

Overall, our findings (energy and carbon emission intensities) are in line with delegated philanthropy theory, which concurs that firms respond to stakeholders' demand to "do good for the environment" by replacing traditional investment with sustainable investment. The overall reduction in carbon emissions and energy intensity is a step towards doing well for major stakeholders. These findings are also supported by the NRBV, as firms investing in sustainability are contributors to the environment and may be perceived as good by stakeholders and society at large, thus leading to better financial performance in the market.

[8] One may argue that different products in firms may require distinct manufacturing processes thus resulting in different level of carbon emissions. To address such concern, we run regression on absolute values of carbon emissions and find similar results (un-tabulated).

TABLE 6 The effect of sustainable investment on carbon emission intensity

Variables	Panel A: (CO_INT) (1) Without controls	(2) Without industry/ year/country effects	(3) With industry/ year/country effects	(4) One-year lagged variables	(5) Fixed effects	Panel B: (CO_INT/TA) (6) Without controls	(7) Without industry/ year/country effects	(8) With industry/ year/country effects	(9) One-year lagged variables	(10) Fixed effects
SUS_INV	−13.346*** (−2.63)	−7.368** (−2.03)	−9.678** (−2.14)	−23.687*** (−5.34)	−2.217** (−2.10)	−0.015*** (−5.71)	−0.019*** (−7.39)	−0.023** (−2.20)	−0.034*** (−2.75)	−0.053** (−2.16)
LEV	-	−20.946 (−0.63)	−7.576 (−0.04)	−26.975*** (−3.09)	43.158 (0.09)	-	0.156*** (7.41)	0.078*** (3.51)	0.079*** (3.61)	0.012 (0.41)
ROA	-	3.497 (0.71)	5.346 (1.00)	3.517* (1.95)	4.626 (0.66)	-	0.000 (0.82)	0.000 (0.49)	0.000 (0.80)	0.000 (0.42)
MTB	-	−0.169 (−0.12)	−0.146 (−0.11)	−0.338 (−0.73)	−0.021 (−0.01)	-	0.000 (0.20)	0.000 (0.00)	−0.000 (−0.13)	0.000 (0.32)
GFCD	-	7.573 (0.08)	189.528*** (3.42)	63.104 (0.57)	60.809*** (2.98)	-	0.052*** (5.10)	0.124*** (3.81)	0.135*** (4.08)	0.152*** (7.21)
LN_MKP	-	−2.811 (−0.05)	−111.917 (−1.37)	−38.759 (−1.39)	42.302 (0.19)	-	−0.045*** (−8.01)	−0.027*** (−3.28)	−0.026*** (−3.18)	0.064*** (4.37)
IO	-	18.277 (0.11)	−77.072 (−0.31)	−34.516 (−1.59)	−47.008 (−0.48)	-	−0.025 (−1.44)	0.083*** (3.25)	0.069*** (2.71)	−0.067** (−2.09)
CAP_INT	-	0.147*** (19.99)	0.152*** (16.58)	1.989*** (14.29)	0.135*** (12.66)	-	0.000 (0.27)	0.000 (0.51)	0.000 (0.65)	0.000 (0.72)
BSIZE	-	8.490 (0.70)	29.117** (2.11)	43.611*** (9.16)	5.985 (0.28)	-	−0.000 (−0.03)	−0.002 (−1.33)	−0.002 (−1.14)	0.003** (2.08)
CEOD	-	−118.526 (−1.59)	−164.900* (−1.91)	93.894*** (3.32)	−153.678 (−1.30)	-	−0.038*** (−4.72)	−0.010 (−1.22)	−0.006 (−0.71)	−0.033*** (−4.28)
BIND	-	1.614 (0.76)	0.714 (0.23)	−3.820*** (−3.52)	0.824 (0.18)	-	0.001*** (5.91)	0.002*** (5.58)	0.002*** (6.23)	−0.000 (−0.17)
FEMB	-	−4.404 (−1.16)	−3.506 (−0.82)	−1.949 (−1.33)	−11.257* (−1.86)	-	0.001*** (2.85)	0.000 (0.94)	0.000 (0.04)	0.001 (1.42)
CONSTANT	117.364 (1.54)	−43.901 (−0.10)	−610.232 (−0.76)	60.435 (0.22)	−114.444 (−0.63)	0.102*** (32.06)	0.300*** (6.57)	−0.102 (−1.25)	−0.123 (−1.51)	−0.447*** (−4.25)
Industry effect	N	N	Y	Y	N	N	N	Y	Y	N
Year effect	N	N	Y	Y	Y	N	N	Y	Y	Y
Country effect	N	N	Y	Y	Y	N	N	Y	Y	Y
N	23,501	23,501	23,501	21,031	23,501	23,501	23,501	23,501	21,031	23,501

(Continues)

TABLE 6 (Continued)

Variables	Panel A: (CO_INT) (1) Without controls	(2) Without industry/year/country effects	(3) With industry/year/country effects	(4) One-year lagged variables	(5) Fixed effects	Panel B: (CO_INT/TA) (6) Without controls	(7) Without industry/year/country effects	(8) With industry/year/country effects	(9) One-year lagged variables	(10) Fixed effects
Adj. R^2	.104	.193	.193	.191	.068	.010	.028	.137	.147	.093

Note: Table 6 presents the results of the impact of sustainable investment on carbon emission intensity. In Panel A (Columns 1–5), the dependent variable is carbon intensity per sale, while in Panel B (Columns 6–10), the dependent variable is carbon intensity per asset. Both panels show regressions without control variables, without and with industry/year/country effects, 1-year lagged variables, and firm fixed effect regression. The robust *t*-statistics of each coefficient are shown in parentheses. All variables are defined in Table 1.

*Significance level at the 10% level.

**Significance level at the 5% level.

***Significance level at the 1% level.

4.3 | Endogeneity checks

Our independent variable, sustainable investment, may face criticism due to its increased level in response to regulatory pressure on implementing the latest technologies to control emissions. Another reason for such biasness may be the lack of availability of funds for sustainable investment, which is impacted by an extreme business cycle leading to poor energy and carbon performance. These factors would eventually contribute to firms' environmental performance rendering our results spurious due to causality. Therefore, we implement three strategies, including the use of macro-level variables to address omitted variables bias, the PSM estimator, and 2SLS (Harford et al., 2008), to address the potential endogeneity bias.

First, we included the country-level variables of GDP growth, government effectiveness, and corruption control index in our model. This was to address the concern that our results may be biased due to omitted variables, such as country policy and governance. We followed Pinkowitz et al. (2006) and Acharya et al. (2011) to control for GDP growth (*LN_GDP*, measured as the natural logarithm of GDP), which measures economic development. It can be argued that various countries may not have comparable funds available for environmental spending, leading to differences in economic development. We also included government effectiveness (*GEFF*) as a control variable because the prior literature suggested that the extent of government control in various countries can lead to distinct environmental financing strategies and protocols. We used a corruption index (*CCON*) as a country-level variable to represent the level of corruption. Countries with a high weight in the index are generally corrupt: their firms offer various illegal and unethical benefits, including bribery to administrators, in order to avoid spending on environmental performance and to meet legal requirements. We present our findings in Columns 1 and 2 of Table 7. The findings are identical to those in Tables 5 and 6, despite including these additional country-level variables. As expected, government effectiveness reduces the energy intensity, while corruption positively affects the energy intensity.

Second, we employed the PSM estimator (e.g., Atif et al., 2022; Rosenbaum & Rubin, 1983) to investigate the change in energy and carbon emission intensities resulting from sustainable investment. First, we used the logit regression for *SUS_dummy* (a dummy variable equaling one in case of sustainable investment and zero otherwise) with other control variables (as specified in Model 1). We formed our treatment (with sustainable investment) and control (without sustainable investment) groups. For the next step, we used matching scores to form one-to-one matched sets for *SUS_dummy*, based on the propensity scores.[9] After this scrutiny, 3712 and 3678 firm-year observations for *SUS_dummy* were matched for energy and carbon emission intensities, respectively. After the matching, the two groups (the treatment and control) were almost identical with all the explanatory variables except one (*SUS_INV*). Therefore, any variation in

[9]To establish that firms in the treatment and control groups are not different, we used a test (un-tabulated) that investigates the mean differences (mean differences between the two groups are based on the average treatment effect on the treated; Ahmed & Atif, 2021) in each variable between the two groups, and we report no significant difference in variables.

TABLE 7 Endogeneity analysis

Variables	CL (1) ENE_INT	(2) CO_INT	PSM (3) ENE_INT	(4) CO_INT	2SLS First-stage (5) SUS_INV	Second-stage (6) ENE_INT	(7) CO_INT
SUS_INV_MED	-	-	-	-	−76.134*** (−3.45)	-	-
SUS_INV-fitted	-	-	-	-	-	−12.1230*** (−3.11)	−19.132*** (−3.12)
SUS_INV	−2.354** (−2.14)	−11.465** (−2.18)	−12.154** (−2.17)	−21.129*** (−2.41)	-	-	-
LEV	−17.268*** (−2.65)	−9.134 (−1.32)	−22.114* (−1.96)	4.455 (1.34)	−1.019 (−1.34)	−18.536* (−1.92)	−25.253** (2.14)
ROA	−0.331** (−2.15)	7.126 (1.18)	1.341 (1.14)	−7.113** (−2.18)	1.341 (1.21)	1.431 (1.32)	−8.243*** (−4.12)
MTB	−0.019 (−1.42)	−0.133 (−1.14)	−0.013 (−1.24)	0.016 (1.14)	4.123 (1.45)	5.171 (1.42)	3.124** (2.14)
GFCD	10.384 (1.47)	19.223** (2.12)	12.126* (1.95)	17.067** (2.14)	−20.123 (−1.35)	−20.102 (−1.15)	13.134 (1.02)
LN_MKP	−7.434** (−2.18)	−87.237 (−1.17)	11.744* (1.94)	−14.132 (−1.33)	0.013 (1.13)	10.113 (1.11)	−1.136 (−1.23)
IO	12.342** (2.10)	−44.023 (−1.29)	0.031* (1.94)	0.023** (2.15)	0.034** (2.17)	0.153* (1.89)	0.016** (2.14)
CAP_INT	0.001 (1.45)	1.324** (2.18)	4.114 (1.55)	4.224** (2.17)	7.232 (1.23)	11.433 (1.31)	−1.434 (−1.23)
BSIZE	−0.342 (−1.33)	34.232** (2.15)	−1.042 (−1.11)	12.340** (2.09)	9.132** (2.11)	7.113* (1.98)	6.232** (2.16)
CEOD	4.111 (1.45)	−1.845** (−2.19)	5.226 (1.23)	−2.647** (−2.11)	−1.117** (−2.20)	−1.123** (−2.09)	−1.342** (−2.18)
BIND	−1.174** (−2.13)	1.112 (1.13)	−1.188** (−2.14)	1.283 (1.60)	1.133 (1.43)	1.232 (1.44)	1.121 (1.12)
FEMB	−0.331** (−2.12)	−3.092 (−1.23)	−0.212** (−2.16)	−2.083 (−1.22)	−1.001 (−1.13)	−2.843 (−1.34)	−1.231 (−1.22)
LN_GDP	139.022** (2.11)	−14.122 (−1.13)	-	-	-	-	-
GEFF	−134.341*** (−3.22)	22.128 (1.56)	-	-	-	-	-
CCON	109.115** (2.18)	76.283* (1.89)	-	-	-	-	-
CONSTANT	89.225*** (2.36)	−72.198* (−1.96)	27.129*** (2.44)	−141.176** (−2.16)	−32.133** (−2.10)	57.123*** (2.45)	−61.172** (−2.13)
Industry effect	Y	Y	Y	Y	N	Y	Y
Year effect	Y	Y	Y	Y	Y	Y	Y
F-statistic	-	-	-	-	17.221*** [0.001]	-	-
Cragg–Donald	-	-	-	-	201.142	-	-
N	23,501	23,501	3712	3678	23,501	23,501	23,501
Adj. R^2	.155	.212	.134	.221			

Note: Table 7 shows endogeneity results. Columns 1 and 2 present the impact of sustainable investment on energy intensity and carbon intensity, respectively, after including country-level variables. Columns 3 and 4 report the impact of sustainable investment on energy intensity and carbon intensity, respectively, using PSM estimators. Column 5 shows the first stage, and Columns 6 and 7 display the second-stage regression results of 2SLS. The industry and year effects are controlled. The robust *t*-statistics of each coefficient are shown in parentheses. All variables are defined in Table 1.

*Significance level at the 10% level.

**Significance level at the 5% level.

***Significance level at the 1% level.

energy and carbon intensities may be accredited to differences in sustainable investment rather than to any other factors. We present findings based on paired firm-year observations in Table 7 (Columns 3 and 4). We document that sustainable investment has negatively affected energy and carbon emission intensities (significant at the 5% or better level). These results indicate that the better performance of energy and carbon is due to the systematic variation in sustainable investment.

Third, to address the concern of endogeneity, we used the IV approach using 2SLS regressions to obtain the exogenous component from sustainable investment. We then used the latter to explain energy and carbon emission intensities. The IV approach requires an instrument that is correlated with the endogenous variable (i.e., *SUS_INV*) but that does not have a direct influence on the dependent variable (i.e., *ENE_INT* and *CO_INT*), except through the endogenous variable. We used industry median sustainable investment (*SUS_INV_MED*) as our IV following prior studies (e.g., Atif & Ali, 2021; Jiraporn et al., 2011). The IV is computed as the average sustainable investment of all the firms in a particular year, excluding firm i's sustainable investment in that year. The intuition behind using this IV

TABLE 8 Additional analysis

Variable	Excluding Japan, UK, and USA (1) ENE_INT	(2) CO_INT	Excluding financial and real estate (3) ENE_INT	(4) CO_INT	Probit (5) REND
SUS_INV	−1.401*** (−3.55)	−1.140*** (−3.19)	−1.217** (−2.15)	−8.142** (−2.16)	0.057*** (13.81)
LEV	7.943 (0.86)	−0.023 (−0.08)	−29.134*** (−3.18)	−9.220 (−0.07)	0.248*** (3.73)
ROA	0.102 (0.59)	0.004 (0.68)	−0.232** (−2.18)	3.116 (0.47)	−0.009*** (−5.48)
MTB	−0.018 (−0.21)	−0.000 (−0.05)	−0.023 (−0.60)	−0.133 (−0.17)	0.000 (0.01)
GFCD	−5.636 (−0.62)	0.468 (1.61)	10.133 (1.15)	17.121*** (3.14)	0.374*** (3.89)
LN_MKP	−5.425* (−1.82)	−0.088 (−0.93)	−9.040*** (−2.56)	−110.128 (−1.33)	0.388*** (9.19)
IO	16.352*** (2.82)	0.307* (1.86)	12.123 (1.43)	−65.134 (−1.15)	−0.688*** (−4.12)
CAP_INT	0.232*** (14.61)	0.014*** (17.34)	0.012 (0.12)	0.123* (1.92)	0.000 (1.02)
BSIZE	0.024 (0.06)	0.005 (0.40)	−0.127 (−0.57)	9.138** (2.10)	−0.009** (−2.10)
CEOD	4.032* (1.86)	0.125* (1.81)	2.119 (1.41)	−16.133** (−2.07)	−0.005 (−0.19)
BIND	0.166 (1.51)	0.004 (1.23)	−0.322*** (−3.19)	0.512 (1.20)	0.007*** (7.43)
FEMB	0.024 (0.23)	−0.002 (−0.63)	−0.440*** (−3.24)	−2.516 (−1.50)	0.004*** (3.12)
CONSTANT	28.928 (1.22)	−0.064 (−0.08)	78.131*** (4.41)	−34.341* (−1.96)	−3.152*** (−12.76)
Industry effect	Y	Y	Y	Y	Y
Year effect	Y	Y	Y	Y	Y
Country effect	Y	Y	Y	Y	Y
N	3165	3165	13,424	13,424	23,501
Adj. R^2/Pseudo	.223	.620	.111	.172	.146

Note: Table 8 shows the results of additional analysis. Columns 1 and 2 report the regression results of sustainable investment on energy intensity and carbon emissions intensity in a sub-sample of countries (excluding Japan, the United Kingdom, and the United States). Columns 3 and 4 present the regression results of sustainable investment on energy intensity and carbon emissions intensity in a sub-sample excluding financial and real estate sector firms. Column 5 shows the results with an alternative dependent variable (*REND*) while using the Probit regression technique. The robust *t*-statistics of each coefficient are shown in parentheses. All variables are defined in Table 1.

*Significance level at the 10% level.

**Significance level at the 5% level.

***Significance level at the 1% level.

is that a firm's sustainable investment might be highly related to industry peers due to their similar business mix and investment opportunities, but such an industry average is unlikely to directly affect a firm's energy and carbon performance. Although firm-level energy and carbon performance may affect firm-level sustainable investment, they are less likely to affect industry-level sustainable investment. Given these arguments, we consider industry median sustainable investment to be a valid IV since it is related to firm-level sustainable investment but unrelated to firm-level energy and carbon performance. Hence, we expect the IV to be negatively correlated with *SUS_INV*.

Column 5 of Table 7 reports findings of the first-stage regression with sustainable investment (*SUS_INV*) as the dependent variable. The regression used control variables as specified in Model 1. According to the prerequisites of the IV, *SUS_INV* is negatively associated (significant at the 1% level) in Column 5, implying the authenticity of

TABLE 9 Additional analysis with alternative variables

Variable	(1) ENE_INT	(2) CO_INT	(3) ENE_INT	(4) CO_INT	(5) ENE_INT	(6) CO_INT
SUS_INV/TA	−0.101*** (−5.61)	−1.091** (−2.14)	-	-	-	-
SUS_INV/SALES	-	-	−0.143*** (−4.99)	−1.034* (−1.91)	-	-
ENV_RD	-	-	-	-	−0.011** (−2.13)	−0.015*** (−4.04)
LEV	−29.246*** (−4.90)	−2.451 (−0.01)	−24.147*** (−4.12)	−2.498 (−0.01)	−0.116 (−0.02)	−0.825*** (−5.37)
ROA	−0.511*** (−3.46)	5.301 (0.99)	−0.480*** (−3.25)	5.272 (0.99)	0.143 (0.81)	0.000 (0.09)
MTB	−0.026 (−0.69)	−0.150 (−0.11)	−0.025 (−0.67)	−0.151 (−0.11)	0.853 (1.12)	0.009 (0.51)
GFCD	9.791 (1.11)	17.357*** (3.44)	10.186 (1.16)	16.950*** (3.44)	18.344*** (9.58)	0.341 (1.24)
LN_MKP	−7.377*** (−3.28)	−16.224 (−1.31)	−7.491*** (−3.33)	−15.091 (−1.39)	1.037 (0.49)	−0.401*** (−7.75)
IO	13.412* (1.94)	−9.832 (−0.32)	12.569* (1.87)	−7.962 (−1.42)	5.148 (0.48)	1.326*** (5.08)
CAP_INT	0.000 (0.11)	0.134** (2.15)	0.000 (0.10)	0.152*** (6.58)	−0.000 (−0.33)	0.027*** (15.54)
BSIZE	−0.254 (−0.67)	28.933** (2.10)	−0.275 (−0.72)	28.953** (2.10)	−0.021 (−0.11)	0.000 (0.09)
CEOD	3.579 (1.56)	−14.442* (−1.98)	3.636 (1.58)	−16.129** (−2.09)	−0.655 (−0.47)	−0.028 (−0.84)
BIND	−0.475*** (−5.43)	0.781 (0.25)	−0.469*** (−5.36)	0.776 (1.21)	−0.001 (−0.03)	−0.002** (−2.13)
FEMB	−0.519*** (−4.36)	−3.480 (−0.81)	−0.520*** (−4.38)	−3.479 (−1.11)	−0.141 (−1.11)	0.030*** (9.71)
CONSTANT	89.396*** (4.04)	−61.386 (−1.21)	89.903*** (4.06)	−52.003 (−0.81)	−22.565 (−0.96)	7.069*** (12.36)
Industry effect	Y	Y	Y	Y	Y	Y
Year effect	Y	Y	Y	Y	Y	Y
Country effect	Y	Y	Y	Y	Y	Y
N	23,501	23,501	23,501	23,501	1705	1705
Adj. R^2	.082	.193	.081	.193	.151	.199

Note: Table 9 shows the results of the additional analysis with alternative variables for sustainable investment. Column 1 presents the impact of *SUS_INV/TA* on energy intensity, and Column 2 reports the impact on carbon emission intensity. Columns 3–6 show the effect of *SUS_INV/SALES* and *ENV_RD* on energy intensity and carbon emissions intensity, respectively. The robust *t*-statistics of each coefficient are shown in parentheses. All variables are defined in Table 1.

*Significance level at the 10% level.

**Significance level at the 5% level.

***Significance level at the 1% level.

the IV. Furthermore, the *F-statistic* shows a higher value, and the *p value* of the Cragg–Donald *F* weak-instrument test is 0.001, rejecting the null hypothesis that the instrument is weak (Cragg & Donald, 1993; Stock & Yogo, 2005). Columns 6 and 7 report the results for the second-stage regressions, which used the predicted sustainable investment from the first-stage regression (*SUS_INV-fitted*) to estimate energy and carbon emission intensities. The results are similar to those from our main regression analysis, which suggests a negative relationship between sustainable investment and energy and carbon emission intensities. The coefficients on the predicted sustainable investment are significant at the 1% level in Columns 6 and 7.[10] Therefore, after addressing endogeneity bias, we can conclude that sustainable investment decreases both energy intensity and carbon emission intensity.

4.4 | Additional analysis

We report our results in Sections 4.1 and 4.2 based on the full sample. However, a large number of firm years in our sample are from three countries, Japan, the United Kingdom, and the United States, which may raise concerns about our findings. To avoid this issue, we re-estimated the model on the basis of a narrow sample while excluding the main contributing countries and reported our findings in Columns 1 and 2 of Table 8. The results are significant and consistent with the earlier findings. Moreover, our sample comprises all sectors of industry, but one may raise concern that firms in the *Real Estate* and *Financial* sectors are not harmful to the environment, compared to other industry sectors. To address this issue, we re-estimated the model by eliminating these industry sectors from the sample. We find consistent results in Columns 3 and 4. Furthermore, we examined the impact of sustainable investment on an alternative measure of environmental performance, that is, renewable energy consumption (*REND*), which is measured as a dummy variable equaling 1 if a firm uses renewable energy and 0 otherwise. We estimated the Probit regression based on Model 1, along with the control variables specified in the model. We found that sustainable investment has a significant positive relationship with renewable energy consumption (Column 5 in Table 8). These findings further support our results that sustainable investment fosters the environmental performance of firms.

Moreover, we used alternative measurements for sustainable investment in the regression specification. First, we specified sustainable investment as being sustainable investment scaled by total assets (*SUS_INV/TA*). Second, we used sustainable investment scaled by sales (*SUS_INV/SALES*). Third, we used firms' environmental research and development (R&D) expenditure (*ENV_RD*) to replace sustainable investment. We present our results in Table 9 in Columns 1–6. Our results are consistent with our main findings across all the regressions.

TABLE 10 The effect of sustainable investment on firm financial performance

Variables	TQ	ROS
SUS_INV	0.148** (2.10)	0.145** (2.14)
LEV	−4.534 (−1.12)	−1.122* (−1.93)
ROA	4.226 (1.46)	3.112* (1.96)
MTB	0.123 (0.19)	0.123 (1.18)
GFCD	−10.128*** (−3.14)	−2.312** (−2.13)
LN_MKP	−42.114 (−1.17)	−11.134 (−1.43)
IO	−19.023 (−1.21)	−12.226 (−1.45)
CAP_INT	1.122** (2.12)	1.129** (2.19)
BSIZE	3.123** (2.09)	3.171*** (3.12)
CEOD	−14.402** (−2.14)	−0.123* (−1.92)
BIND	1.234* (1.89)	1.134** (2.15)
FEMB	1.326* (1.97)	1.111** (2.11)
CONSTANT	7.135*** (2.76)	6.123** (2.10)
Industry effect	Y	Y
Year effect	Y	Y
Country effect	Y	Y
N	23,501	23,501
Adj. R^2	.171	.188

Table 10 includes the results of the association between sustainable investment and firm financial performance. Column 1 reports the impact of *SUS_INV/TA* on Tobin's *q* and Column 2 presents the effect on return on sales. The robust *t*-statistics of each coefficient are shown in parentheses. All variables are defined in Table 1.
*Significance level at the 10% level.
**Significance level at the 5% level.
***Significance level at the 1% level.

These findings in turn suggest that our results are not driven by any specific measurement.

Additionally, the sample covers six developed economies, which may indicate the likelihood of higher disparity in sustainable investment and environmental policies among these nations.[11] This may lead to the heteroscedasticity problem. We used the weighted least squares (WLS) specification (following, e.g., Chen, Podolski, & Veeraraghavan, 2015) to address this issue. The weights are converse

[10] We further conduct "system GMM" following Gull et al. (2021) where the system automatically creates an instrument; we find similar results (un-tabulated) to those reported in our 2SLS estimation.

[11] We ran an analysis based on individual countries and found similar results (un-tabulated).

within the country variation of energy intensity (*ENE_INT*) and CO_2 emission intensity (*CO_INT*). We then controlled the model variables as specified earlier. The regression coefficients (Table A2) are qualitatively similar to those in Tables 5 and 6, signifying the robustness of our key results to the potential heteroscedasticity problem. Moreover, we collected the data for sustainable investment from Bloomberg and re-estimated our main model to avoid the bias of any data source. The results (un-tabulated) are similar to our main analysis.

Finally, we investigated whether firms investing in sustainability have better financial performance. One may expect that sustainable investment may affect a firm's financial performance, given the funds used for environmentally friendly initiatives. We estimated the following regression model to examine the impact of *SUS_INV* on firm performance.

$$\begin{aligned} FP_{it} = {} & \alpha + \beta_1 (SUS\_INV)_{it} + \beta_2 (\text{firm characteristics})_{it} \\ & + \beta_3 (\text{governance characteristics})_{it} + \beta_4 \sum (\text{Industry effects})_i \\ & + \beta_5 \sum (\text{Year effects})_t + \varepsilon_{it}, \end{aligned} \tag{2}$$

We measured firm financial performance (*FP*) using Tobin's *q* (*TQ*, Market value of equity scaled by the book value) and return on sales (*ROS*, net income scaled by sales), based on prior studies (e.g., Hossain et al., 2020; Liu et al., 2014). The independent and control variables are the same as specified in Model 1 and previously discussed. Table 10 reports the results using OLS for *TQ* and *ROS*, respectively. The regression analysis shows a positive effect on firm performance, consistent with prior literature, that concludes a positive relationship between a firm's environmental and financial performance (Atif et al., 2020; Busch & Lewandowski, 2018; Endrikat et al., 2014; Gull, Atif, Ahsan, & Derouiche, 2022). Overall, we conclude that firms investing in sustainability enjoy a better financial performance.

5 | CONCLUSION

With its damaging impact on society, climate change has been forcing the corporate sector to strategically rethink conventional business practices. In response to such pressure, firms endeavor to embrace green business policies that promote energy efficiency and lower their carbon footprint. However, the implementation of these policies is largely related to a firm's sustainable investment. This study, investigating the relationship between a firm's sustainable investment and its environmental performance, empirically shows that sustainable investment has a significantly negative effect on a firm's energy intensity. Moreover, the study reports a negative relationship between sustainable investment and a firm's carbon emissions. These findings are robust to the alternative variables of sustainable investment, energy, and carbon emission intensities. In our array of robustness checks, including alternative econometric estimation and sub-sample analysis, we further confirm that our findings are upheld. Our additional analysis indicates that a firm's sustainable investment has a positive impact on its financial performance. Our findings are also robust across different endogeneity strategies, including additional country-level variables, PSM, and 2SLS. Overall, our results suggest that sustainable investment improves both the environmental and financial performances of firms.

This study provides imperative policy implications for firms' investors, managers, regulators, and policymakers. First, we provide evidence suggesting that a firm's sustainable investment improves its environmental and financial performance benefitting its shareholders and stakeholders. These benefits lead to a deeper relationship between the business and its society, creating a long-term commitment to each other—stakeholder capitalism—which positions businesses as the trustees of the society. Hence, investors and managers, who may consider mitigating the negative impacts of their business activities on the environment without compromising financial profit, may emphasize sustainable investment in their decision-making. Second, our study is beneficial for helping regulators and policymakers to understand the importance of sustainable investment to combat climate change and formulate sustainable development policies for businesses. Thus, our findings further motivate policymakers of the largest economies to accelerate and scale up actions to invest significantly in sustainable activities to achieve the goals of the Paris Agreement.

Although this study provides important policy implications, readers should be aware of a few limitations. These limitations should be a guide to future research. While energy consumption and carbon emissions are two important environmental indicators, the findings of this study cannot be generalized when referring to other indicators of sustainability (such as recycling, treatment, and sulfur dioxide emissions). Future research may focus on other indicators of pollutants and biodiversity once the data becomes available. Moreover, the scope of this study is limited to G-6 countries with advanced economies. Further research may be conducted comparing the developing and developed countries by employing a cross-sectional dependence analysis to extend this research stream.

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CONFLICT OF INTEREST

The authors, Atif, Alam, and Islam, declare that they have no conflict of interest.

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APPENDIX A

TABLE A1 Sample selection

	Full sample	Canada (TSX)	France (CAC40)	Germany (DAX 30)	Japan (Nikki 500)	UK (FTSE 350)	USA (S&P 1500)
All firms (2002–2018)	45,118	3978	680	510	8517	5967	25,466
Less: Missing values in variables	21,617	1803	100	100	3820	2521	13,273
Final observations	23,501	2175	580	410	4697	3446	12,193

TABLE A2 Weighted least squares regression

	ENE_INT	CO_INT
SUS_INV	−2.094**	−6.142***
	(−2.19)	(−3.12)
LEV	−15.158**	−4.123*
	(−2.12)	(−1.92)
ROA	−1.121***	3.123**
	(−3.12)	(2.09)
MTB	−1.231	−0.123
	(−1.17)	(−1.22)
GFCD	5.113	12.123**
	(1.23)	(2.11)
LN_MKP	−4.122*	−9.126
	(−1.88)	(−1.43)
IO	8.123**	−12.198
	(2.17)	(−1.22)
CAP_INT	0.012	1.032*
	(1.23)	(1.88)
BSIZE	−1.143	5.123**
	(−1.32)	(2.18)
CEOD	4.123	−12.123*
	(1.09)	(−1.93)
BIND	−1.238**	0.323*
	(−2.12)	(1.87)
FEMB	−0.113**	−2.126
	(−2.19)	(−1.02)
CONSTANT	32.112***	−12.245**
	(5.19)	(−2.16)
Industry effect	Y	Y
Year effect	Y	Y
N	23,501	23,501
Adj. R^2	.152	.146

Note: Table A2 presents the results of weighted least squares regression in two columns. The robust *t*-statistics of each coefficient are shown in parentheses. All variables are defined in Table 1.
*Significance level at the 10% level.
**Significance level at the 5% level.
***Significance level at the 1% level.

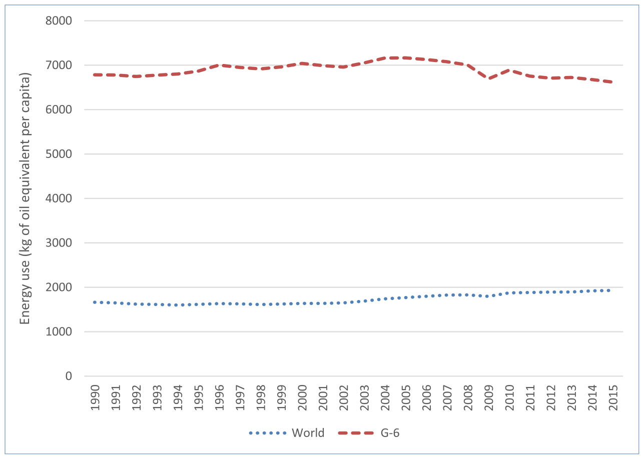

FIGURE A1 Per capita energy consumption (kilogram of oil equivalent per capita) in G-6 countries and the world. *Source*: World Development Indicators

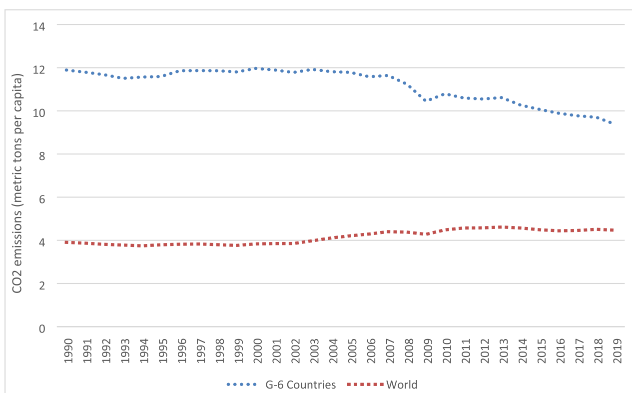

FIGURE A2 Per capita carbon emissions (metric tons) in G-6 countries and the world. *Source*: World Development Indicators