

Political uncertainty and corporate green investment: Evidence from European firms

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ABSTRACT

Political uncertainty is a primary source of friction hindering firm-level decarbonization efforts toward Europe's 2050 climate neutrality target. This study provides a quantitative investigation of this issue by analyzing the impact of political uncertainty on green investment using a comprehensive panel dataset of European firms from 2016 to 2021. We employ a novel keyword-based proxy extracted from annual reports to measure green investment and utilize an instrumental variable (IV) approach as a supplementary strategy to mitigate potential endogeneity concerns. Our findings reveal that heightened political uncertainty, particularly at the national level, significantly discourages green investment. This effect is heterogeneous: it is more pronounced for financially constrained firms that are less equipped to withstand policy shocks. Conversely, firms with established political connections exhibit greater resilience, effectively mitigating the negative impacts of uncertainty. Furthermore, the analysis highlights regional heterogeneity, with firms in the EU and the UK demonstrating higher sensitivity to continental-level uncertainty. Overall, these results underscore the critical role of policy stability in mobilizing the private capital essential for a low-carbon transition, offering vital insights for both policymakers and firm managers.

KEYWORDS

Political uncertainty, corporate decarbonization, EU climate policy, multilevel governance, political connections, financial constraints.

1 Introduction

Achieving Europe's 2050 climate neutrality goal requires firms to make significant decarbonization investments. However, political uncertainty may constrain these investments, possibly by leading to unpredictable policy environments. While uncertainty is known to affect global economic activity^[1], its specific impact on firm green investment in Europe remains under-explored. This study addresses that gap by analyzing how political uncertainty affects green investment decisions of European firms.

It is contended that in today's world, all industries are increasingly prioritizing green investment as awareness of the gravity of climate change grows. Since most European countries are part of the European Union, the supranational organization has an outsized impact on the continent. The European Union's objective of achieving climate neutrality by 2050^a is encouraging companies in Europe to increase their investments in environmentally sustainable initiatives. However, in the presence of elevated economic policy uncertainty, companies are reluctant to make investment decisions, including those that involve green investments. According to Hou et al.^[2], companies tend to defer their actions until they have obtained further information.

Most of the continent is heavily affected by EU laws and policies. EU directives are characterized by structured discretion, allowing member states to adapt rules to domestic contexts and

producing differentiated implementation^[3,4]. Firms, therefore, face structured but varied signals across the European Union. Moreover, as the public administration literature has demonstrated, policy processes are complex and messy. They are incremental rather than linear, shaped by fleeting policy windows and political struggles^[5]. Moreover, various actors attempt to shape policy goals, from the design phase to the implementation phase, within shifting coalitions^[6,7]. Rather than being neutral, policymaking involves political struggles over agenda setting and implementation^[8–10]. Taken together, firms operate in a double uncertainty: structured variation across member states and messy political realities that destabilize climate neutrality goals. However, some firms are better positioned to weather political uncertainty. Research on EU policy processes shows that policymaking is highly open to interest intermediation, where firms and business associations mobilize expertise, networks, and lobbying to influence both the design and implementation of policies^[11]. The EU's reliance on directives creates multiple entry points for such influence^[3]. Politically connected firms can exploit this discretion by lobbying national authorities for favorable transposition and by leveraging their ties to EU institutions to shape interpretation and enforcement.

Although Europe is heavily influenced by EU policies, not all the countries in Europe are EU members. Therefore, we compare the relationship between climate policies and laws and green

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^a See European Commission, The European Green Deal. Available at: https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en (accessed 26 July 2025).

investments among firms from EU and non-EU countries. This comparison highlights the broader claim of the article: climate neutrality requires not only ambitious goals but also stability in fulfilling them.

Grounded in this complex European context, our study makes several contributions. First, by using a novel keyword-based proxy for green investment derived from corporate disclosures, we provide robust empirical evidence that political uncertainty discourages firms' long-term decarbonization. This fundamental finding persists across different specifications, alternative uncertainty metrics and an instrumental variable (IV) approach to mitigate endogeneity. Our results also show that national-level political instability is a more potent deterrent than broader continental uncertainty. Second, we argue that politically connected firms can better navigate this instability, effectively avoiding the negative effects of uncertainty. Third, we find that financial constraints exacerbate the negative impact, particularly for firms with limited access to capital. The analysis also reveals significant regional disparities, with firms in the EU and the UK being especially vulnerable.

2 Political uncertainty and green investment: theories and hypotheses

2.1 Conceptualizing political uncertainty: measurement and multi-level dynamics

Political uncertainty is defined as uncertainty of government decisions, policy shifts or system stability. Political uncertainty can include electoral or leadership transitions, geopolitical shocks, socioeconomic crises^[12]. Global events such as the COVID-19 pandemic, the UK's European Union (EU) referendum, and the 2024 U.S. presidential election further exacerbate concerns about the unpredictability of the political landscape. However, political uncertainty is not confined to electoral or leadership cycles; it is also embedded in the ambiguity of policymaking and implementation. Policy processes are often polarised and open to interpretations^[15,13].

Scholars have developed diverse approaches to operationalize this construct. Bollerslev^[14] pioneered the use of stock market volatility as an indirect proxy of political risk to capture investor expectations. In parallel, Baker et al.^[12] introduced the Economic Policy Uncertainty (EPU) Index as a direct metric of political uncertainty derived from computational text analysis of news articles for determining media-driven claims about policy unpredictability. Beyond financial and text proxy effects, political events such as national elections, especially in developing economies, can also increase political uncertainty^[15]. Political events such as leadership changes or shifting political coalitions can similarly increase decision unpredictability, making it difficult for firms to plan their investments^[16–18].

Recent research also separates national and local political uncertainty, where national political uncertainty tends to lead to broader macroeconomic consequences, but local political uncertainty, provincial leadership changes and local elections, can be more targeted. Kong et al.^[19] argue that local political uncertainty may increase investment at the regional level, as local officials may take action to encourage economic growth in their region, thereby potentially minimizing the wider impacts of national uncertainty.

2.2 Green investment: definitions, drivers, and divergent outcomes

Green investment refers to capital that contributes to projects in the advancement of environmental sustainability, including climate change mitigation, renewable energy deployment, energy efficiency improvements, and green technology development. Its growing prominence is consistent with global commitments to the United Nations Sustainable Development Goals (SDGs), evidenced by a 70% surge in SDG-related international investments in 2021, predominantly in developing countries. During the same year, sustainability-themed financial products reached \$5.2 trillion in value, marking a 63% increase from 2020.

Despite this growth, green investments face the risk of exogenous shocks. The COVID-19 pandemic, geopolitical conflicts and carbon price fluctuation have heightened market uncertainty around long-term environmental policy promises and economic and political uncertainties^[20]. Such risks bring investor hesitancy and tension between short-term financial inflow and long-term sustainability objectives.

Paradoxically, uncertainties and growing demand for adaptation and mitigation on climate change also stimulate clean energy and green innovation^[2]. Regulatory restrictions and stakeholder demand for corporate social responsibility (CSR) also drive firms to adopt green strategies. As a result, firms are prioritising sustainability efforts to satisfy regulatory requirements and societal needs^[21,22].

2.3 Core mechanism: uncertainty as catalyst or constraint

Political uncertainty creates an unpredictable environment and makes it difficult for businesses to predict future policy directions. This increases investment risk and leads to delays in decision-making, including those related to green technologies^[2], and this can reduce the willingness of firms to make sustainable investments. Therefore, we propose:

Hypothesis 1a. Political uncertainty will decrease a firm's green investment.

Conversely, green investments (e.g., in renewable technologies) can increase productivity, reduce operating costs, and provide a competitive advantage^[19]. With heightened economic and political uncertainty, firms may be driven to innovate, including by adopting green technologies, to maintain their competitive advantage. Therefore, we propose:

Hypothesis 1b. Political uncertainty will increase a firm's green investment.

2.4 Contextual boundary: national policy shocks in Europe

In the EU, national governments have significant autonomy in policy design and resource allocation. These disparities, coupled with leadership turnover, often lead to instability in policy implementation. New governments may change policies due to a new political alignment, which creates fragmented implementation processes and increases uncertainty over the expected costs and benefits of long-term green investment. Moreover, non-EU countries such as Norway and Switzerland closely follow EU regulations, while the UK forges its own path, and Russian policies differ significantly from those of the EU. Based on this, we propose:

Hypothesis 2. National political uncertainty will reduce firms' scale of green investment.

2.5 Moderating role of political connections

Firms with strong political connections are better positioned to cope with political uncertainty. These connections provide access to information about policy changes, allowing for timely responses and insulating firms from the adverse effects of political uncertainty^[23]. This builds on foundational work demonstrating that politically connected firms enjoy preferential access to financing and government support worldwide^[24,25]. Firms and business associations partake in interest intermediation, both at the EU and national levels^[3,11]. Political ties also confer greater legitimacy and social capital to firms, maintaining stakeholder trust in times of uncertainty. Therefore, we propose:

Hypothesis 3. Firms that have deep political connections experience a weaker decline in green investment compared to firms that do not have political connections.

2.6 Moderating role of financial constraints

Political uncertainty exacerbates financial market volatility and increases the cost and difficulty of financing investments. Firms facing fewer financial constraints are more likely to maintain or expand their investments, while constrained firms are likely to reduce their investment commitments in times of uncertainty^[26]. Therefore, we propose:

Hypothesis 4. Political uncertainty would increase financial constraints and further decrease firms' green investments.

3 Data and methodology

3.1 Data selection

The research sample for this study consists of companies listed in the Euro STOXX 50, Euro STOXX 600, and the 2022 EU Industrial R&D Investment Scoreboard^b. These firms represent 20 European countries, including Germany, France, Denmark, Norway, Italy, Ireland, the Netherlands, Spain, the United Kingdom, Finland, Belgium, Slovenia, Austria, Malta, Switzerland, Russia, the Czech Republic, Luxembourg, Cyprus, and Hungary.

The sample period spans from 2016 to 2021 and was chosen based on the availability of archived annual reports and financial data. This period includes 2,358 firm-year observations. To enhance the robustness of the analysis, the study compares two distinct timeframes: the relatively stable period from 2016 to 2018 and the more turbulent years from 2019 to 2021. This comparison provides a unique opportunity to evaluate the effects of political uncertainty on green investment across varying levels of volatility.

3.2 Major variable definition: Political, NPU, and Green

Throughout this paper, we use political uncertainty to refer to the broader theoretical construct and Economic Policy Uncertainty (EPU) to denote the specific empirical proxy used to operationalize it. The Economic Policy Uncertainty (EPU) index used in this study is derived from a newspaper-based index measuring the relative frequency of news articles jointly mentioning terms related to the economy, policy, and uncertainty^[12]. Although EPU is narrower than the full theoretical construct of political uncertainty, it captures a substantial subset of it as the index rises sharply around elections, government-

formation crises, and political shocks such as Brexit. We complement this measure with the World Uncertainty Index^c (WUI) as a politics-oriented robustness check.

As the index is calculated monthly, we computed the geometric average of the 12 monthly values for each year between 2016 and 2021 to align with the annual financial data of firms. To capture varying effects, our research employs both a continental-level (European) EPU and country-level EPU (NPU). Full construction details are provided in Appendix 1.

Given the lack of precise disclosure regarding direct green investments in firms' annual reports, this study employs a disclosure-based proxy for green investment. Using Python, we calculated the frequency of nine keywords within firms' annual reports, which is consistent with established green dictionaries in the prior literature and the textual-analysis tradition in finance and accounting research^[27–29]. The selected keywords cover three main dimensions of corporate green investment disclosure: climate and carbon mitigation ("climate change," "carbon," "emission"), renewable energy and energy transition ("renewable," "energy transition," "solar"), and broader environmental sustainability ("sustainability," "environment," "green"). These keywords were selected based on the environmental objectives defined in the EU Taxonomy Regulation (Regulation (EU) 2020/852) and the European Green Deal^[30]. Keyword counts were divided by the report's total word count, and scaled by 10,000 to yield a measure of green keyword density per 10,000 words. This scaling by report length mitigates bias arising from differences in firm size and report verbosity. This indicator should therefore be interpreted as capturing the intensity of firms' disclosed orientation toward green investment, rather than the absolute monetary volume of such investment.

The use of annual report text is based on the assumption that firms engaging in significant green investments are more likely to highlight related terms in their annual reports to demonstrate environmental stewardship and attract stakeholders^[31–33]. Firms with minimal or no green investments are less likely to use these terms consistently. Hence, an increase in the frequency of these keywords reflects higher green investment levels, while a decrease suggests reduced green investment activity. This method provides a reliable and scalable measure of firms' green investment behaviors over time.

To assess the validity of the text-based indicators, we collected directly reported green investment amounts for the subset of firms for which such information was available. The direct financial indicator was calculated by dividing the reported amount of green investment by the total investment for the corresponding fiscal year and expressed as a percentage. This validation sample, based on data availability, included 62 firm-year observations. As shown in Table A1 in Appendix 2, the text-based and financial measures are strongly positively correlated (Spearman's $\rho = 0.768$, $p < 0.001$), indicating that firms with higher directly reported green investment shares generally exhibit greater green investment disclosure intensity. Moreover, when the direct financial measure is used as an alternative dependent variable, the coefficient on political uncertainty remains negative and statistically significant at the 5% level, consistent with the baseline findings (Table A2 in Appendix 2).

^b Available at: <https://iri.jrc.ec.europa.eu/scoreboard/2022-eu-industrial-rd-investment-scoreboard>.

^c <https://worlduncertaintyindex.com/>.

3.3 Other variables

Country-level election data (*Election*) are utilized as an instrumental variable for political uncertainty (source: International Foundation for Electoral Systems^d). *WUI* is employed for robustness checks. Financial constraints are calculated using the Kaplan-Zingales (1997) model, which combines cash flow, leverage, and dividend ratios. Political connections are coded as a binary variable (1/0) based on executives' government affiliations or firms' participation in state-funded projects, with data sourced from the EU Transparency Register^e. Table A3 in Appendix 2 provides a transparent overview of our variable operationalization and summarizes the definitions and constructions of all dependent, independent, and control variables employed in the empirical analysis.

3.4 Descriptive statistics of main variables

Table A4 in Appendix 2 provides descriptive statistics for all variables. Notably, the positive skewness of *Green* and *Political* suggests significant variation in green investment across firms and in political uncertainty over time. The Pearson correlation coefficients are presented in Table A5 in Appendix 2. As a preliminary check, *Green* is significantly and negatively correlated with *Political*, offering initial support for Hypothesis 1a.

3.5 Methodology

We specify the following multiple regression equation to investigate the impact of political uncertainty on firms' green investment

$$Green_{it} = \alpha_1 Political_{it} + \alpha_2 Controls_{it} + \lambda_i + \varepsilon_{it} \quad (1)$$

where the subscript i denotes the firm and t denotes the year. The dependent variable, $Green_{it}$, represents the disclosure-based green-investment measure defined above. The explanatory variable, $Political_{it}$, denotes European political uncertainty. $Controls_{it}$ represents the set of all control variables mentioned above. λ_i represents firm fixed effects, and α coefficients represent the estimated effects of each independent variable on green investment. The error term is denoted by ε_{it} .

Since all firms are located in Europe, the annual continental *EPU* measure takes the same value for every firm in a given year. It is therefore not possible to estimate its coefficient jointly with year fixed effects. We confirmed this by estimating a two-way fixed-effects specification, in which the *EPU* variable was automatically dropped owing to perfect collinearity with the year dummies. We nonetheless recognize that common time-varying macroeconomic shocks may affect both political uncertainty and firms' green investment decisions. We therefore interpret the continental-level estimates cautiously and complement the analysis with instrumental-variable estimations and robustness checks using an alternative uncertainty measure.

Second, to further understand the impact of national policy uncertainty on firms' green investment, we take a closer look at country-level election data from a specific perspective. The specific model is as Eq. (2):

$$Green_{it} = \beta_1 NPU_{it} + \beta_2 Controls_{it} + \lambda_i + \varepsilon_{it} \quad (2)$$

where NPU_{it} denotes national political uncertainty. β coefficients represent the estimated effects of each independent variable on green investment, and all other variables remain consistent with the descriptions above.

Third, we specify the following multiple regression equation to investigate whether political connections would mitigate the impact of political uncertainty on firm green investment. The specific model is as Eq. (3):

$$Green_{it} = \beta_1 Political_{it} + \beta_2 Connection_{it} + \beta_3 Controls_{it} + \beta_4 Political_{it} \times Connection_{it} + \lambda_i + \varepsilon_{it} \quad (3)$$

where $Connection_{it}$ denotes whether a firm has political connections, and all other variables remain consistent with the descriptions above.

To examine industry-level heterogeneity, we interact *NPU* with 11 GICS sector indicators in a specification including firm and year fixed effects. As reported in Table A6 in Appendix 2, the joint Wald test indicates significant cross-industry variation ($F(10, 1100) = 2.623, p = 0.0037$).

4 Empirical results and analysis

This section presents the main empirical findings on how political uncertainty affects corporate green investment. We begin with the baseline estimations and then examine the mechanisms through which the effect operates. Next, we explore two key channels that moderate this relationship: financial constraints and political connections. Finally, we analyze the heterogeneity of this effect by distinguishing between national and continental uncertainty and by examining regional sub-samples, followed by a series of robustness checks to verify the stability of our results.

4.1 Baseline effect of political uncertainty on green investment

In line with real options theory, which suggests that uncertainty incentivizes investment delays^[34,35], we test the relationship between political uncertainty and green investment. Our primary specification is a firm fixed-effects model, chosen based on a significant Hausman test ($p = 0.037$), and we confirm our results using ordinary least squares (OLS) and Tobit regressions for robustness (Table 1).

The baseline outcomes presented in Table 1 show a negative and statistically considerable correlation between firm green investment and political uncertainty. This observation is consistently revealed across the models; for instance, the variable representing political uncertainty is negative and statistically considerable at the 1% level for the fixed-effect as well as Tobit models. The results are consistent with H1a.

Several firm-level controls are also significant. Notably, firms with higher debt-to-capital ratios (*TDC*), recent income growth (*OIG*), and independent policy boards (*PBI*) tend to invest more in green initiatives, while higher return on assets is associated with less green investment (*ROA*).

4.2 Channels and mechanisms: moderating relationships and boundary conditions

Having established the baseline relationship, this section examines whether firms' responses to political uncertainty vary with their

^d <https://www.electionguide.org/>.

^e <https://ec.europa.eu/transparencyregister/public/homePage.do>.

Table 1 Results of different regression methods.

Variables	(1) <i>Green</i>	(2) <i>Green</i>	(3) <i>Green</i>	(4) <i>Green</i>	(5) <i>Green</i>
<i>Political</i>	-1.550e-08*** [-5.6897]	-6.169e-10*** [-6.2301]	-1.573e-05* [-4.3304]	-9.154e-10*** [-6.1235]	-2.31e-09*** [-5.975]
<i>MV</i>	0.425839 [0.7966]	0.3459853 [0.9427]	0.261448 [1.1233]	0.2659253 [1.1125]	-0.71619 [-0.364]
<i>ROA</i>	-0.002843** [-2.9896]	-0.0021785** [-3.0705]	-0.003505* [-2.9236]	-0.0008265*** [-3.3438]	-1.22e-10 [-6.437]
<i>TD</i>	0.8090722 [0.2417]	-0.6897393 [-0.3993]	-0.257503 [-1.1327]	-0.5448551 [-0.6055]	0.91372 [0.108]
<i>TDC</i>	0.003003** [2.9727]	0.0003516*** [3.5829]	0.017132* [2.3862]	0.0006968*** [3.3908]	0.01594* [2.410]
<i>OIG</i>	0.001970** [3.1007]	0.0028014** [2.9941]	0.027895* [2.2006]	0.0007652*** [3.3651]	0.00189** [3.108]
<i>O5G</i>	-0.352389 [-0.9303]	-0.3695448 [-0.8976]	-0.060828 [-1.8760]	-0.1084721 [-1.6051]	-0.1173 [-1.566]
<i>MVTB</i>	-0.586475 [-0.5441]	-0.5376811 [-0.6165]	0.268956 [1.2997]	0.7585268 [0.3074]	0.99533 [0.006]
<i>PBI</i>	2.226e-07*** [5.2055]			0.0005218*** [3.4693]	0.000722 [3.255]
Obs	2,358	2,358	2,358	2,358	2,358
Firm fixed effects	Y	Y	N	N	Y
<i>R</i> ²	0.16308	0.18565	0.030497	0.063219	0.2837

Notes: Table 1 presents the baseline results of several different regression models. Column (1) and column (2) use firm fixed effects models. There are no firm fixed effects in column (3) and column (4). For column (5), a Tobit model is used. ***, **, and * represent the significance at the 1%, 5%, and 10% respectively. *PBI* refers to a dummy variable that captures whether a firm's policy board is independent from external influences, such as political pressure, corporate interests, or personal biases. The variable takes a value of 1 if the policy board is independent, and 0, otherwise.

political connections and financial constraints, which are interpreted as moderators or boundary conditions rather than as causally identified mechanisms.

4.2.1 The mitigating role of political connections

We also investigate whether political connections can alleviate the negative influence of political uncertainty on firm green investments. Our empirical analysis results are presented in Table 2, which displays the impact of political connections. Firstly, we regress political uncertainty, political connection, and their interactions on green investment, as illustrated in column (1) in Table 2. The results show that the coefficient of the interaction term, *Political* × *Connection*, is positive and significant at the 10% level. This indicates that the impact of political uncertainty on green investment differs between politically connected and non-connected firms. Since the coefficient of *Political* is negative, the positive coefficient of the interaction term suggests that political connections help mitigate the adverse effect of political uncertainty on firms' green investment. In other words, the negative influence of political uncertainty on green investment is less severe for politically connected firms than for firms without such connections.

Column 3 further shows that the coefficient of *Connection* is positive and significant when the interaction term and firm fixed effects are excluded. The coefficient of *Connection* is significant and positive at the 1% level, implying that firms with political connections have an important positive effect on the influence of political uncertainty on green investments. This finding suggests that political connections have a catalytic effect on firms' green investment performance. This may be because politically connected companies are generally better equipped to leverage political resources to support their green initiatives and

environmental measures, resulting in more investment in green activities. Building on this, we further incorporate the interaction term into our regression. The coefficient of the interaction term is significant and positive, providing support for our Hypothesis 3.

As an additional robustness check, Table A7 in Appendix 2 introduces both firm and year fixed effects; the interaction between political uncertainty and political connections remains positive and statistically significant ($\beta = 0.2079$, $p = 0.0447$).

4.2.2 The impact of financial constraints

We also investigate whether the negative effects of political uncertainty on green investment can be alleviated in the presence of lower financial constraints. Specifically, our Hypothesis 4 posits that increasing political uncertainty leads to higher levels of financial constraints, making it more difficult for firms to finance their green investments, and ultimately decreasing their overall investment in green investment. Our results confirm this hypothesis. Table 3 shows the results of our regression analysis, which reveals a positive and significant relationship between *Political* and *Constraints*. The coefficient of *Political* is 2.062e-05 (t -statistic of 4.2752), which is statistically significant at the 1% level.

We also hypothesize that firms with more severe financial constraints would experience a sharper decrease in their green investment compared to firms with fewer financial constraints. To ensure the accuracy of our analysis, we deleted financial firms and firms with incomplete data from our sample, as the financing behavior of financial firms is different from other firms, and their financial constraints are lower than those of others. We divided the remaining firms into three groups based on the level of financial constraints, with the cut-off points set at the 33rd and 67th percentiles of the *Constraints* variable. After classifying the

Table 2 Political connection.

Variables	(1) <i>Green</i>	(2) <i>Green</i>	(3) <i>Green</i>
<i>Political</i>	−2.204e−06*** [−4.7479]	−2.595e−05*** [−4.2172]	−1.131e−05*** [−4.4034]
<i>MV</i>		0.14172 [1.4701]	0.71491 [0.3653]
<i>ROA</i>		−0.0014427** [−3.1925]	−0.796e−05*** [−3.9330]
<i>TD</i>		−0.7524311 [−0.3155]	−0.7604753 [−0.3049]
<i>TDC</i>		2.846e−05*** [4.1962]	0.03069* [2.1629]
<i>OIG</i>		0.0007431*** [3.3808]	0.01592* [2.4131]
<i>O5G</i>		−0.2715568 [−1.0999]	−0.10697 [−1.6128]
<i>MVTB</i>		0.88245 [0.1479]	0.58728 [0.5429]
<i>PBI</i>		2.176e−08** [5.6225]	−0.1611 [−1.4020]
<i>Connection</i>	0.46759 [0.7266]	0.35241 [0.9302]	4.272e−05*** [4.1027]
<i>Political</i> × <i>Connection</i>	0.04172* [2.0376]	0.04521* [2.0041]	
Obs	2,358	2,358	2,358
Firm fixed effects	N	Y	N
R ²	0.0364	0.0662	0.0387

Notes. Table 2 presents the moderating effect of political connections. There are no firm fixed effects in column (1). Column (2) uses firm fixed effects models. For column (1), the regression is conducted without control variables. The *t*-statistics are shown in square brackets. ***, **, and * represent the significance at the 1%, 5%, and 10%, respectively. *PBI* refers to a dummy variable that captures whether a firm's policy board is independent from external influences, such as political pressure, corporate interests, or personal biases. The variable takes a value of 1 if the policy board is independent and 0 otherwise. *Political* × *Connection* is an interaction variable.

Table 3 Financial constraints (1).

Variables	Constraints
<i>Political</i>	2.062e−05*** [4.2752]
<i>MV</i>	−0.33763 [−0.9593]
<i>ROA</i>	−1.2603*** [−54.9964]
<i>TD</i>	−0.81839 [−0.2297]
<i>TDC</i>	−0.87853 [−0.1529]
<i>OIG</i>	−0.42956 [−0.7902]
<i>O5G</i>	−0.03653* [−2.0934]
<i>MVTB</i>	−0.19783 [−1.2885]
<i>PBI</i>	0.07702 [1.7698]
Obs	1,883
Firm fixed effects	Y
R ²	0.7346

Notes. Table 3 presents the impact of political uncertainty on firm-level financial constraints. The regression uses firm fixed effects. The *t*-statistics are shown in square brackets. ***, **, and * represent the significance at the 1%, 5%, and 10%, respectively.

companies, we performed Pearson tests and found that the variables *MV* and *O5G* had collinearity with other variables in the three groups of samples (see Tables A8 and A9 in Appendix 2 for detailed data), so we deleted these two variables from the regressions.

The results are presented in Table 4. The coefficients of *Constraints* are all negative and significant, indicating that financial constraints and firm green investments are negatively related. However, in Column 2, which consists of low-constrained

Table 4 Financial constraints (2).

Variables	(1) All <i>Green</i>	(2) Low-constrained <i>Green</i>	(3) Mid-constrained <i>Green</i>	(4) High-constrained <i>Green</i>
<i>Constraints</i>	−0.0008822*** [−3.3334]	−0.0009186*** [−3.3388]	−0.005786** [−2.407]	−0.008402** [−2.197]
<i>Political</i>	−7.008e−09*** [−5.8296]	−1.484e−05*** [−4.3840]	−0.005093*** [−2.8148]	−0.01704** [−2.4003]
<i>TD</i>	−0.9797566 [−0.0254]	0.0714127 [1.8075]	−0.7592 [−0.3068]	0.966419 [0.0421]
<i>TDC</i>	0.008185** [2.6484]	0.0321362* [2.1501]	0.3821 [0.8750]	−0.869952 [−0.1638]
<i>OIG</i>	0.0918712 [1.6869]	0.0461408* [2.0002]	5.332e−06*** [4.6171]	−0.410592 [−0.8238]
<i>MVTB</i>	0.7184324 [0.3606]	−0.962254 [−0.0474]	−0.2381 [−1.1816]	−0.298936 [−1.0402]
Obs	1,883	627	628	628
Firm fixed effects	Y	Y	Y	Y
R ²	0.0424	0.10748	0.0662	0.0365

Notes. Table 4 presents the moderating effects of financial constraints. The first column displays the comprehensive outcome. The outcomes displayed in columns (2) to columns (4) are categorized based on the degree of financial constraints. Firm fixed effects are used in all regressions. The *t*-statistics are shown in square brackets. ***, ** and * represent the significance at the 1%, 5% and 10%, respectively.

firms, *Constraints* is significant at the 1% level. This significant relationship is also observed in Column 1. While in other two regressions with higher-constrained samples, the coefficients are significant at 5% level. We argue this pattern reflects a potential non-linear relationship. As the challenge of securing financing initially becomes more arduous, a company's investment in green projects may decline significantly, potentially to a minimal level. After this sharp reduction, further escalations of financial limitations (i.e., moving from the mid- to the high-constrained group) would naturally result in the investment remaining relatively stable, as it cannot be reduced much further. Since the regressions are estimated separately across financial-constraint groups, the coefficients should be interpreted as group-specific marginal effects.

Figure 1 illustrates the role of financial constraints further. The left panel represents the fitted response to political uncertainty for firms with different financial constraints, based on the estimates of Table 4. As shown, the slope goes upward from low to high-constrained firms, indicating that tighter financial constraints significantly increase the negative influence of political uncertainty on firms' green investment. The right panel displays the corresponding marginal effects (β), and their 95% confidence intervals, showing that all effects are negative and significant. This figure adds visual evidence that financial constraints not only restrict investment capacity directly, but also increase firms' sensitivity to policy and institutional uncertainty.

It is also noteworthy that in Column 2, the coefficient of *Political* is $-1.484e-05$ (t -statistic of -4.3840), which is significant

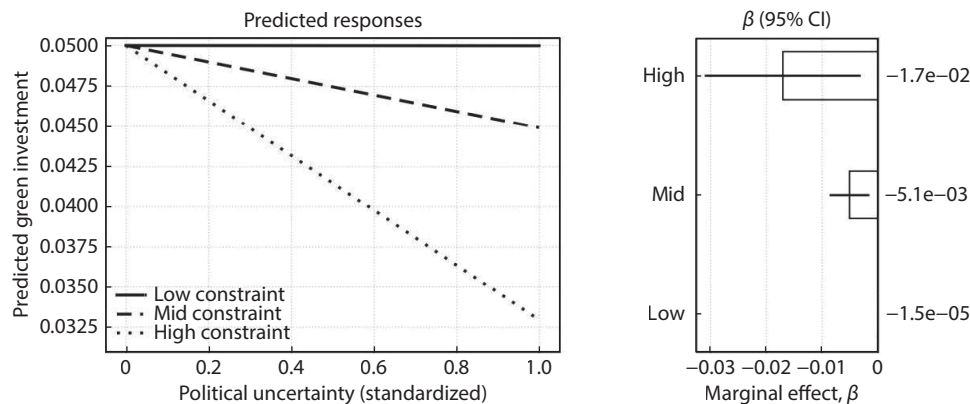


Fig. 1 Expected green investment in financial constraint groups according to political uncertainty. CI represents confidence intervals.

Table 5 National political uncertainty.

Variables	(1) <i>Green</i>	(2) <i>Green</i>	(3) <i>Green</i>	(4) <i>Green</i>
<i>Political</i>			$-3.281e-09^{***}$ [-5.9562]	-0.000240^{***} [-3.6727]
<i>NPU</i>	$-1.787e-09^{***}$ [-6.0567]	$-8.296e-12^{***}$ [-6.8333]	$-4.548e-07^{***}$ [-5.0654]	$-1.135e-14^{***}$ [-3.0453]
<i>MV</i>	0.0060661^{**} [2.7484]	0.027447 [2.2051]	0.009032^{*} [2.6140]	0.154442 [1.4240]
<i>ROA</i>	-0.0002129^{***} [-3.7130]	-0.001409^{**} [-3.1928]	-0.001486^{**} [-3.1830]	-0.004391^{**} [-2.8486]
<i>TD</i>	-0.2654126 [-1.1141]	-0.484824 [-0.6986]	-0.436227 [-0.7788]	-0.487092 [-0.6949]
<i>TDC</i>	0.0566033 [1.9080]	0.003331^{**} [2.9354]	0.005005^{**} [2.8106]	0.0031581 [2.9519]
<i>OIG</i>	0.0060423^{**} [2.7497]	$1.744e-05^{***}$ [4.2954]	0.0002595^{***} [3.6623]	0.0002623 [3.6499]
<i>O5G</i>	-0.0532296 [-1.9347]	-0.3485988 [-0.9373]	-0.2811893 [-1.0781]	-0.1112051 [-1.5928]
<i>MVTB</i>	0.698087 [0.3880]	0.939638 [0.0757]	0.924444 [0.0949]	0.97945 [0.0258]
<i>PBI</i>	$2.739e-07^{***}$ [5.1665]	0.0007381 [3.3750]	$5.982e-06^{***}$ [4.5449]	0.0039770^{**} [2.8800]
Obs	2,358	2,358	2,358	2,358
Firm fixed effects	Y	N	Y	N
Adjusted R^2	0.0499	0.063305	0.0446	0.0364

Notes. Table 5 presents the effect of national political uncertainty on green investment. Column (1) and column (3) use firm fixed effects models. There are no firm fixed effects in column (2) and column (4). The regressions in columns (3) and (4) are conducted simultaneously with *Political* and *NPU* which is an index for national political uncertainty. In columns (1) and (2), regression is performed without *Political* but with *NPU* instead. ***, **, and * represent the significance at the 1%, 5%, and 10%, respectively.

at the 1% level. However, as the level of financial constraints rises, as shown in Columns 3 and 4, the coefficients of *Political* become more negative, changing to -0.005093 (t -statistic of -2.8148) and -0.01704 (t -statistic of -2.4003), and are significant at the 1% and 5% levels, respectively. This is because firms with high constraints are not able to cushion the negative effects of political uncertainty. Therefore, a firm's green investment is restricted when it faces severe financial constraints under a high level of political uncertainty.

The left panel plots fitted values (for firm fixed effects models). The right panel shows estimated marginal effects (β) with 95% confidence intervals. Slopes become progressively steeper as financial constraints tighten, indicating amplified sensitivity to political uncertainty. All coefficients are negative and statistically significant at the 5% level.

4.2.3 National level uncertainty and regional heterogeneity

We next examine national level political uncertainty (NPU). As shown in Table 5, NPU is negative and statistically significant across all models, supporting Hypothesis 2. When continental (*Political*) and national (NPU) uncertainty are included jointly, both remain significant in the firm fixed effects specification (Column 3), indicating that national level uncertainty has an additional negative impact on green investment beyond broader continental uncertainty.

We then extend our analysis to examine the heterogeneous effects of political uncertainty at different geographical levels on corporate green investment. The empirical findings are presented in Table 6 and Table 7, which distinguish between continental-level and country-level political uncertainty. As illustrated in Table 6, we first regress continental-level political uncertainty

Political on green investment across European firms. The results indicate significant heterogeneity among enterprises in responding to political uncertainty at the continental European level. Both the coefficient of *Political* for the UK and the EU are statistically significant at the 1% level, with negative t -statistics, suggesting that political uncertainty on the European continent significantly inhibits green investment by UK and EU enterprises. This indicates that even after Brexit, UK enterprises remain closely integrated with European markets and thus retain high sensitivity to uncertainty across the continent. Conversely, for non-EU firms (Switzerland, Russia, Norway), the impact of continental political uncertainty is non-significant. This divergence may stem from differing political-economic ties between these three nations and the EU: Switzerland and Norway, despite their close economic links with Europe, may be insulated to a considerable extent from the direct impact of EU political turbulence due to their non-EU membership and relatively stable domestic environments. Russia, meanwhile, possesses an economic and political system relatively independent from Europe, so continental political uncertainty has minimal influence on its firms' investment decisions. However, the Russian sub-sample contains only 42 observations, which limits the statistical power of the estimates. The results for Russia should therefore be interpreted as suggestive rather than conclusive.

To further identify the impact of local institutional conditions, we examined the role of national political uncertainty (NPU) in Table 7. Here, the results show a marked shift. The coefficients of NPU were significantly negative in the United Kingdom, Switzerland, and Norway (at the 1%, 1%, and 10% significance levels, respectively), indicating that domestic political uncertainty significantly inhibits firm green investment. However, the Russian

Table 6 The effects of political uncertainty at the continental level in different regions.

Variables	(1) <i>Green</i>	(2) <i>Green</i>	(3) <i>Green</i>	(4) <i>Green</i>	(5) <i>Green</i>
<i>Political</i>	-0.0002722^{***} [-3.6404]	-0.087101 [-1.7109]	0.5177 [0.6870]	-0.4908 [-0.7271]	$-7.391 \times 10^{-10}^{***}$ [-6.1575]
<i>MV</i>	0.0383969^* [2.0706]	-0.149188 [-1.4424]	0.6690 [0.4493]	0.81 [0.2496]	0.2453281 [1.1618]
<i>ROA</i>	-0.3520677 [-0.9306]	-0.114926 [-1.5764]	-0.432 [-0.8421]	0.7114 [0.3854]	-0.0045416^{**} [-2.8379]
<i>TD</i>	0.565272 [0.5750]	0.001574^{**} [3.1607]	0.6637 [0.4570]	0.2916 [1.1404]	-0.4913457 [-0.6882]
<i>TDE</i>	0.2283303 [1.2047]	-0.008175^{**} [-2.6447]	0.9916 [0.0110]	0.5367 [0.6495]	0.3699448 [0.8966]
<i>TDC</i>	0.2175378 [1.2331]	0.004202^{**} [2.8626]	-0.8262 [-0.2293]	-0.64 [-0.4886]	0.0009177^{***} [3.3146]
<i>OIG</i>	0.0011183^{**} [3.2589]	-0.38227 [-0.8737]	-0.6346 [-0.5005]	-0.1652 [-1.5495]	0.0007184^{***} [3.3825]
<i>O5G</i>	0.5835874 [0.5482]	0.1643 [1.3908]	-0.6551 [-0.4697]	0.3605 [0.9783]	-0.1133297 [-1.5834]
<i>MVTB</i>	-0.259598 [-1.1273]	0.021799^* [2.2938]	0.928 [0.0942]	-0.5669 [-0.6008]	-0.4396038 [-0.7729]
<i>PBI</i>	$8.775 \times 10^{-5}^{***}$ [3.9222]	-0.253069 [-1.1429]	0.362 [0.7523]	-0.2403 [-1.2832]	-0.0005161 [-0.7729]
Obs	474	156	42	42	1,644
Firm fixed effects	N	N	Y	Y	N
R^2	0.15928	0.17114	0.62553	0.68537	0.275012

Notes. Table 6 presents the effects of political uncertainty at the continental level in the EU on green investments in different regions. (1) represents UK firms, (2) represents the Switzerland firms, (3) represents Russia firms, (4) represents Norway firms, and (5) represents EU firms. The t -statistics are reported in brackets $***$, $**$, and $*$ denote significance at the 1%, 5%, and 10% levels, respectively.

Table 7 The effects of political uncertainty at the national level on green investments in different regions.

Variables	(1) <i>Green</i>	(2) <i>Green</i>	(3) <i>Green</i>	(4) <i>Green</i>
<i>NPU</i>	-1.813926*** [-9.5800]	-2.773×10 ⁻⁵ *** [-4.1913]	-0.2011 [-1.4358]	-0.01402* [-1.8520]
<i>MV</i>	0.045842* [1.9968]	-0.162875 [-1.3955]	0.6109 [0.5365]	0.08628* [1.9948]
<i>ROA</i>	-0.443182 [-0.7668]	-0.298207 [-1.0403]	-0.4348 [-0.8368]	-0.30249 [-1.1129]
<i>TD</i>	0.970692 [0.0367]	0.001007** [3.2887]	0.7177 [0.3790]	-0.38512 [-0.9263]
<i>TDE</i>	0.159718 [1.4060]	-0.011124* [-2.5388]	-0.8949 [-0.1379]	0.65069 [0.4729]
<i>TDC</i>	0.12907 [1.5178]	0.016455* [2.3987]	-0.8611 [-0.1826]	0.35072 [0.9998]
<i>O1G</i>	0.005394** [2.7825]	-0.315898 [-1.0029]	-0.5069 [-0.7056]	-0.02628* [-2.8066]
<i>O5G</i>	0.784152 [0.2739]	0.175902 [1.3535]	-0.8800 [-0.1575]	0.04414* [2.4495]
<i>MVTB</i>	-0.174285 [-1.3586]	0.039794* [2.0559]	0.682 [0.4303]	-0.07817 [-2.0617]
<i>PBI</i>	0.002696** [3.0004]	-0.153039 [-1.4289]	-0.2652 [-1.3728]	1.070517 [0.04941]
Obs	474	156	42	42
Firm fixed effects	N	N	Y	Y
<i>R</i> ²	0.29288	0.24348	0.69937	0.86522

Notes. Table 7 presents the effects of political uncertainty at the national level on green investments in different regions. (1) represents UK firms, (2) represents the Switzerland firms, (3) represents Russia firms, and (4) represents Norway firms. The *t*-statistics are reported in brackets.

sample again presents an exception. Its coefficient is negative but statistically insignificant, suggesting insufficient evidence that domestic political uncertainty affects firms' green behavior. This outcome may stem partly from the relatively small sample size for Russia, which could inflate standard errors, but it may also reflect the country's distinct political-economic institutions. Russia's economy is dominated by large state-owned enterprises, whose green investment decisions are determined more by the Kremlin's long-term energy strategy, international commitments (such as carbon neutrality), or geopolitical considerations, rather than short-term domestic political fluctuations. Consequently, both continental and national political uncertainties are buffered by state-level priorities, exerting limited influence on corporate investment behavior in Russia.

4.3 Robustness tests

This section aims to validate the robustness of the baseline results, first by addressing potential endogeneity and then by testing with alternative uncertainty metrics.

4.3.1 Endogeneity mitigation by an instrumental variable (IV) method

To mitigate potential endogeneity, we employ two instrumental variables for political uncertainty. The first, the average price of gasoline in Europe (*APG*), is correlated with political uncertainty^[36] yet is plausibly exogenous to an individual firm's green investment decisions. *APG* measures the average gasoline price at the European level rather than firm-specific energy costs. Mature firms' green investment decisions usually involve long-term capital planning, technological adjustment, and partially irreversible expenditures. Thus, they are unlikely to immediately replace existing energy systems, production lines, vehicle fleets, or supply-chain arrangements in response to short-term gasoline

price fluctuations, because the adjustment costs may exceed the present value of temporary fuel-cost changes. In addition, gasoline prices are not the main energy-cost exposure for many firms in the sample: for service-oriented firms, fuel costs are not central to production, while energy-intensive firms are more directly exposed to electricity, natural gas, or coal rather than gasoline^[37]. Nevertheless, the exclusion restriction cannot be established conclusively. Gasoline prices may directly affect businesses in which fuel or transportation costs account for a significant proportion of total costs through factors such as operating costs, profitability, aggregate demand, or incentives to invest in energy-saving technologies. Therefore, we view the *APG* as an imperfect but economically motivated tool, and treat the corresponding IV estimates as supplementary evidence rather than definitive proof of causation.

The second, the occurrence of a national election (*Election*), serves as a common exogenous political shock that is independent of a firm's specific actions. Both instruments are expected to be correlated with political uncertainty and are unlikely to directly affect firm level green investment. Although the exclusion restriction cannot be tested directly, the aggregate nature of *APG* and the long-term, partially irreversible nature of green investment provide additional support for the identification strategy.

Our findings are presented in Table 8. The first stage of the regression results, as shown in Column 1, demonstrate the effectiveness of our IVs, with *t*-statistics of 13.685 and 5.271 for *APG* and *Election*, respectively, and significant coefficients at the 1% level. The results show that *APG* is negatively associated with political uncertainty, while national elections are positively associated with political uncertainty. Although the result may appear counter-intuitive at first, it can be explained by the macroeconomic and policy environment in which gasoline prices

Table 8 The impact of economic policy uncertainty on firm-level green investment: An instrumental variable approach.

Variables	(1) <i>Political</i>	(2) <i>Green</i>
<i>APG</i>	-2.933189 *** [-13.685]	
<i>Election</i>	3.526264 ** [5.271]	
<i>Pred_Uncertainty</i>		-8.366e-09 *** [-5.7974]
<i>MV</i>	-0.286 [-1.067]	0.4950092 [0.6825]
<i>ROA</i>	0.6 [0.524]	-0.0007041 [-3.3958]
<i>TD</i>	0.838 [0.205]	-0.7859698 [-0.2716]
<i>TDC</i>	0.802 [0.802]	0.0048091 ** [2.8242]
<i>O1G</i>	-0.0076 ** [-2.998]	0.0012323 ** [3.2381]
<i>O5G</i>	-0.236 [-1.85]	-0.3414713 [-0.9516]
<i>MVTB</i>	0.633 [1.478]	0.7813142 [0.2777]
<i>PBI</i>	0.686 [0.405]	3.499e-07 *** [5.1198]
<i>Obs</i>	2,358	2,358
<i>R</i> ²	0.8203	0.0767

Notes. Table 8 presents the impact of economic policy uncertainty on firm-level green investment using instrumental variable approach. *APG* refers to the average price of gasoline in Europe and *Election* refers to the national election data. *Pred_Uncertainty* is the predicted value of *Political*. The *t*-statistics are shown in square brackets. ***, **, and * represent the significance at the 1%, 5%, and 10%, respectively.

move. During periods of economic recovery or stronger aggregate demand, gasoline prices tend to rise, while crisis-driven policy debates and newspaper coverage of policy uncertainty may decline. Conversely, sharp declines in energy prices often occur during economic disruptions, when governments are more likely to introduce emergency fiscal, regulatory, or energy-policy responses, thereby increasing policy uncertainty. Within our 2016–2021 observation window, the major *EPU* peaks (Brexit, the aftermath of the migration crisis, and the COVID-19 pandemic) coincided with weakening aggregate demand and depressed energy prices, whereas periods of lower *EPU* (2017–2018 and 2021) were associated with stronger demand and higher prices. This interpretation is consistent with prior studies on the relationship between oil price movements and economic policy uncertainty^[38,39]. The positive coefficient on *Election* indicates that political uncertainty rises around national elections, as expected. Next, we replace *Political* in Eq. (1) with the predicted value of *Political* (*Pred_Uncertainty*) from the regression in Column 1. In Column 2, the coefficient of *Pred_Uncertainty* is negative and significant at the 1% level, suggesting that after controlling for endogeneity in our model, our conclusion that Hypothesis 1a is supported remains valid.

4.3.2 Alternative metrics of *EPU*

We use the *WUI* index as an alternative to the *EPU* index. The results, presented in Table A10 in Appendix 2, confirm that the negative and significant relationship between uncertainty and green investment holds across all specifications. This reinforces our main conclusion.

Our robustness tests provide additional evidence that higher political uncertainty is associated with lower firm green investment. The coefficients of *WUI* remain negative across all specifications and are statistically significant based on the reported *t*-statistics.

5 Discussion

This study provides empirical evidence for the proposition that political uncertainty is one key barrier to firm green investment in Europe. Our primary theoretical contribution goes, however, further than this baseline finding to emphasise the role of institutional levels. One of the most significant results of this paper is that national-level political uncertainty is a substantially more effective barrier to green investment than broader, continental-level uncertainty. This finding provides a crucial micro-foundation for theories of multi-level governance in the European context. While the EU sets ambitious supranational goals, its directives are characterized by structured discretion^[34]. Thus, the implementation of policies and the potential risks and rewards of green investing fall within the purview of national governments. For firm managers, abstract continental goals represent a weak signal compared to the immediate, material risk of a national government altering subsidies, permits, or regulatory frameworks. Our finding that firms react more strongly to NPU demonstrates that investment freezes are a direct response to institutional fragmentation and the “key bottleneck” of national-level policy implementation.

Additionally, the results further suggest that financial constraints may act as more than just a passive moderator for this uncertainty. In essence, this supports an institutional theory of finance, indicating that politics is priced into capital markets, and as such, banks and other investors view projects of this nature that entail large, irrecoverable costs and thereby impose a premium on capital through limited accessibility due to endogenously generated financial restrictions that, in turn, dampen investment.

Our result that politically connected firms can mitigate this detrimental effect is, however, more complex and nuanced as it suggests. While consistent with findings in other institutional contexts^[2], it is based on a different mechanism in Europe’s open, lobby-driven system. There, connections can be viewed as a means of implementing an interest intermediation role. Yet, this strategy presents a double-edged sword logic. That is, connections, while providing benefits (e.g., risk mitigation, access), also create significant, often hidden, costs, namely “agency costs,” as executives potentially act on behalf of their political principals, as opposed to shareholders, and “rent-seeking inefficiencies.” Furthermore, connections can become a liability if the political patron falls from favor. Thus, connected firms are not “immune” to uncertainty; they are strategically exchanging systemic political risk for firm-specific agency and reputational risks.

The results of our study have significant implications for both publicly traded and privately held companies. Firms must strategically evaluate the trade-offs involved in cultivating political connections. Although such connections can reduce perceived risks, they entail resource allocation that may divert attention from core business functions. For firms facing tighter financial constraints, robust financial planning is vital, as political uncertainty can directly tighten capital access.

For policymakers, the implications are twofold. First, low political uncertainty and high institutional predictability are needed to maintain firms’ continued participation in green

investments over time. Abrupt policy reversals can become a limiting factor in times of geopolitical and economic uncertainty. Without clear indicators of future regulatory and market conditions, firms might hesitate to invest in sustainability changes. The EU's evolving climate policy architecture, from emissions trading to the comprehensive European Green Deal, illustrates both the ambition and the implementation challenges that generate policy uncertainty^[40,41]. Second, targeted financial instruments are needed in order to shield financially constrained firms from uncertainty and maintain that decarbonization will not just be confined to well-capitalized or politically connected parties. Recognizing that policymaking and implementation are inherently messy does not mean accepting paralysis; instead, it calls for designing guardrails that can provide sustainable commitments in the face of turbulence. Without such guardrails, political uncertainty will prevent decarbonization and weaken Europe's climate neutrality trend.

To distill the most transferable insights from our analysis, we highlight three key conclusions for the broader policy community. (i) National implementation is the binding constraint: ambitious supranational climate targets are necessary but insufficient; investment decisions are governed by the predictability of national-level policy environments. (ii) Financial inclusion determines the breadth of the green transition: if counter-cyclical financing mechanisms are absent, political uncertainty will systematically exclude financially constrained firms from decarbonization, concentrating green investment among a narrow set of large, well-connected incumbents. (iii) Transparency can substitute for connections: rather than attempting to eliminate political connections, which constitute a rational firm response to uncertainty, policymakers should focus on making policy information universally accessible, thereby reducing the informational rents that currently accrue to connected firms. These three principles are not specific to Europe; they apply to any multi-level governance system pursuing long-term environmental transformation under conditions of political volatility.

While this study provides critical insights into the interplay between political uncertainty and green investment, certain constraints should be considered. The sample focuses on major European economies and may not generalize to other institutional settings. Moreover, political uncertainty may propagate through global supply chains, a channel not captured by our firm-country design. Furthermore, the operationalization of the main dependent variable, Green, via keyword extraction from annual reports, though methodologically rigorous, may underreport firms' actual sustainability commitments due to selective disclosure. Although the text-based indicators show a significant positive correlation with the proportion of green investments as directly reported, the validation sample contains only 62 firm-year observations and is limited to firms with identifiable green investment data. Therefore, these validation results should be viewed as supporting evidence rather than proof that the text-based indicators are fully equivalent to the financial indicators. As the Corporate Sustainability Reporting Directive (Directive (EU) 2022/2464) and its accompanying European Sustainability

Reporting Standards introduce granular reporting requirements for pollution, water, biodiversity, and circular-economy activities, future research can productively extend our proxy to track these dimensions with higher resolution. Further avenues include sector-specific analyses, cross-country comparisons, and the identification of policy designs that inadvertently exacerbate political uncertainty or disincentivize green investment. This would enable policymakers to craft adaptive frameworks for preserving decarbonization pathways in politically volatile environments.

Appendix 1. Construction of the political uncertainty measures

A1.1 Source

All *EPU* data are obtained from the Economic Policy Uncertainty database maintained by Baker, Bloom, and Davis (2016), available at Ref. [12]. Each country's *EPU* index is constructed by counting, for each month, the number of articles in a panel of major national newspapers that contain at least one term from each of three categories: (i) economy (e.g., "economic," "economy"), (ii) policy (e.g., "regulation", "deficit", "Congress/parliament", "legislation", "central bank"), and (iii) uncertainty (e.g., "uncertain", "uncertainty"). The raw counts are scaled by the total number of articles in the same newspapers and month to control for variation in newspaper volume, normalized to a mean of 100 over the index's base period, and aggregated across newspapers to produce a monthly country-level index.

A1.2 Continental measure (*Political*)

Our baseline measure of political uncertainty, denoted *Political*, is the Economic Policy Uncertainty Index for Europe from the Economic Policy Uncertainty database. This index is the standard cross-country *EPU* aggregate for Europe.

A1.3 National measure (*NPU*)

For the country-level analysis we use the country-specific monthly *EPU* index, denoted *NPU*, matched to each firm's headquarters country and year.

A1.4 Annual aggregation

Both indices are released at monthly frequency. To align with the annual frequency of our firm-level financial and disclosure variables, we compute, for each index and year t , the geometric mean of the twelve monthly values:

$$\begin{cases} \text{Political}_t = \left(\prod_{m=1}^{12} \text{EPU}_{t,m}^{\text{Europe}} \right)^{1/12} \\ \text{NPU}_{c,t} = \left(\prod_{m=1}^{12} \text{EPU}_{t,m}^c \right)^{1/12} \end{cases} \quad (\text{A1})$$

where c indexes the firm's headquarters country, $m \in \{1, 2, \dots, 12\}$ indexes the months within year t . The geometric mean dampens the influence of single-month outliers on the annual aggregate.

Appendix 2. Supplementary tables and results

Table A1 Spearman rank correlation coefficients between the textual and direct financial measures of green investment.

Variables	N	Spearman's ρ	p -value
Financial measure vs. <i>green</i>	62	0.768***	< 0.001

Notes. The direct financial measure is calculated as directly reported green investment divided by total investment for the corresponding firm-year and expressed as a percentage.

Table A2 Regression using the directly reported green investment share.

Variables	Financial measure
<i>Political</i>	−5.2369** [−2.2000]
<i>MV</i>	−55.9546* [−1.7610]
<i>ROA</i>	8076.945 [0.3948]
<i>TD</i>	56.2689 [1.3011]
<i>OIG</i>	−51184.324** [−2.1503]
<i>O5G</i>	−561.110 [−0.6494]
<i>MVTB</i>	54.7288* [1.9155]
Observations	62
Firm fixed effects	Y
R^2	0.5199

Notes. The dependent variable is directly reported green investment divided by total investment for the corresponding firm-year. The regression is estimated using the 62 firm-year observations for which the direct financial measure is available. The *t*-statistics are reported in square brackets. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Table A3 Variable definitions.

Type	Variable name	Symbol	Definition / measurement
Dependent	Green Investment	<i>Green</i>	The frequency of nine green-related keywords divided by the annual report's total word count, scaled by 10,000.
Independent	Continental Uncertainty	<i>Political</i>	The geometric mean of the monthly European Economic Policy Uncertainty (<i>EPU</i>) index.
	National Uncertainty	<i>NPU</i>	The geometric mean of the country-specific monthly <i>EPU</i> index.
Control	Market Value	<i>MV</i>	The natural logarithm of the firm's total market capitalization at year-end.
	Return on Assets	<i>ROA</i>	Net income divided by total assets.
	Total Debt	<i>TD</i>	The natural logarithm of the firm's total debt.
	Debt to Capital	<i>TDC</i>	Total debt divided by total capital.
	Revenue Growth 1-year	<i>OIG</i>	One-year revenue growth rate.
	Revenue Growth 5-year	<i>O5G</i>	Five-year annualized revenue growth rate.
	Market-to-Book	<i>MVTB</i>	Market value of equity divided by book value of equity.
	Board Independence	<i>PBI</i>	A dummy variable equaling 1 if the firm's policy board is independent, and 0 otherwise.

Table A4 Descriptive statistics of main variables.

	Obs	Mean	Std.dev	Median	Min	Max	1st.Qu	3rd.Qu
<i>Green</i>	2,358	0.0848	0.0982	0.0536	0.0000	1.0000	0.0229	0.1099
<i>Political</i>	2,358	0.4316	0.3860	0.3999	0.0000	1.0000	0.0065	0.8655
<i>MV</i>	2,358	0.0128	0.0620	0.0018	0.0000	1.0000	0.0008	0.0063
<i>ROA</i>	2,358	0.2590	0.0415	0.2551	0.0000	1.0000	0.2468	0.2657
<i>TD</i>	2,358	0.0096	0.0542	0.0006	0.0000	1.0000	0.0002	0.0026
<i>TDC</i>	2,358	0.1341	0.0832	0.1255	0.0000	1.0000	0.0811	0.1793
<i>OIG</i>	2,358	0.0193	0.0365	0.0147	0.0000	1.0000	0.0129	0.0172
<i>O5G</i>	2,358	0.1940	0.0505	0.1901	0.0000	1.0000	0.1727	0.2101
<i>MVTB</i>	2,358	0.6396	0.0175	0.6390	0.0000	1.0000	0.6384	0.6399
<i>PBI</i>	2,358	0.5715	0.4950	1.0000	0.0000	1.0000	0.0000	1.0000
<i>Election</i>	2,358	0.4146	0.4928	0.0000	0.0000	1.0000	0.0000	1.0000

Table A5 The Pearson correlation coefficients between variables.

	<i>Green</i>	<i>Political</i>	<i>MV</i>	<i>ROA</i>	<i>TD</i>	<i>TDC</i>	<i>OIG</i>	<i>O5G</i>	<i>MVTB</i>	<i>Election</i>
<i>Green</i>	1.000	−0.104***	0.012	−0.121**	0.018	0.079	0.063	−0.049*	−0.014	−0.111**
<i>Political</i>	−0.104***	1.000	−0.045	−0.003	−0.017	0.021	−0.108**	−0.097**	−0.016	−0.03
<i>MV</i>	0.012	−0.045	1.000	0.014***	0.655***	−0.039	0.024	0.033	−0.003	0.032
<i>ROA</i>	−0.121***	−0.003	0.014***	1.000	−0.091*	−0.145**	−0.044	0.108***	0.220***	−0.015
<i>TD</i>	0.018	−0.017	0.655***	−0.091*	1.000	0.183***	0.019	−0.014	−0.011	−0.002
<i>TDC</i>	0.079	0.021	−0.039	−0.145**	0.183***	1.000	−0.019	−0.114***	−0.029	−0.037
<i>OIG</i>	0.063	−0.108**	0.024	−0.044	0.019	−0.019	1.000	0.082***	−0.006	0.024
<i>O5G</i>	−0.049*	−0.097**	0.033	0.108***	−0.014	−0.114***	0.082***	1.000	0.018	−0.016
<i>MVTB</i>	−0.014	−0.016	−0.003	0.220***	−0.011	0.029	−0.006	0.018	1.000	−0.038
<i>Election</i>	−0.111**	−0.03	0.032	−0.015	−0.002	−0.037	0.024	−0.016	−0.038	1.000

Notes. Table A5 presents the Pearson correlation coefficients between variables. ***, **, and * represent the significance at the 1%, 5%, and 10%, respectively.

Table A6 Industry heterogeneity in the marginal effects of national political uncertainty on green investment.

Variables	<i>Green</i>
Industrials	−0.0433** [−2.5660]
Communication Services	−0.0300 [−1.3510]
Consumer Discretionary	−0.0587*** [−2.7700]
Consumer Staples	0.0121 [0.6990]
Energy	−0.2979*** [−2.6760]
Financials	−0.0416 [−1.3560]
Health Care	−0.0446* [−1.8370]
Information Technology	−0.0567 [−1.6390]
Materials	−0.1224** [−2.3660]
Real Estate	−0.0469** [−2.0240]
Utilities	−0.1857*** [−3.4030]
Joint Wald test	2.6232*** [<i>p</i> = 0.0037]
Observations	2,358
Firm fixed effects	Y
Year fixed effects	Y

Notes. This table reports the industry-specific marginal effects of national political uncertainty (*NPU*) on *Green*, estimated from a model that interacts *NPU* with 11 GICS sectors. Firm and year fixed effects are included, and standard errors are clustered at the firm level. The *t*-statistics are shown in brackets. The joint Wald test evaluates whether the ten industry interaction terms are jointly zero. ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively.

Table A7 Robustness test of the moderating effect of political connections.

Variables	<i>Green</i>
<i>Connection</i>	0.0457** [2.2497]
<i>MV</i>	−0.0406 [−0.7173]
<i>ROA</i>	0.2025 [1.0614]
<i>TD</i>	−0.1492** [−2.5232]
<i>TDE</i>	0.0220 [0.2396]
<i>TDC</i>	−0.0137 [−0.2358]
<i>OIG</i>	0.0402 [0.4607]
<i>O5G</i>	−0.0019 [−0.0417]
<i>MVTB</i>	−0.0362 [−0.3502]
<i>PBI</i>	0.0014 [0.1853]
<i>Political × Connection</i>	0.2079** [2.0144]
Observations	2,358
Firm fixed effects	Y
Year fixed effects	Y
Adjusted R^2	0.7569

Notes. The dependent variable is *Green*. Firm and year fixed effects are included. Standard errors are clustered at the firm level. The main effect of *Political* is absorbed by year fixed effects because the continental-level political uncertainty measure is identical across firms within each year. The *t*-statistics are reported in square brackets. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Table A8 Pearson correlation coefficients between variables (Set 1).

	<i>Green</i>	<i>Political</i>	<i>MV</i>	<i>ROA</i>	<i>TD</i>	<i>TDC</i>	<i>OIG</i>	<i>O5G</i>	<i>MVTB</i>	<i>PBI</i>
<i>Green</i>	1.0000	−0.1416	0.0440	−0.1033	0.0654	−0.0457	0.0808	0.0250	−0.0147	−0.0576
<i>Political</i>	−0.1416	1.0000	−0.0553	0.0128	−0.0345	0.0255	−0.1318	−0.1081	−0.0175	−0.0513
<i>MV</i>	0.0440	−0.0553	1.0000	0.0501	0.7496	−0.0473	0.0070	0.0326	0.0003	0.0796
<i>ROA</i>	−0.1033	0.0128	0.0501	1.0000	−0.0088	−0.0537	−0.0278	0.0503	0.2259	−0.0843
<i>TD</i>	0.0654	−0.0345	0.7496	−0.0088	1.0000	0.0868	−0.0039	0.0116	−0.0121	0.0959
<i>TDC</i>	−0.0457	0.0255	−0.0473	−0.0537	0.0868	1.0000	−0.0060	−0.0945	−0.0343	0.1327
<i>OIG</i>	0.0808	−0.1318	0.0070	−0.0278	−0.0039	−0.0060	1.0000	0.2109	−0.0049	0.0499
<i>O5G</i>	0.0250	−0.1081	0.0326	0.0503	0.0116	−0.0945	0.2109	1.0000	0.0154	−0.0135
<i>MVTB</i>	−0.0147	−0.0175	0.0003	0.2259	−0.0121	−0.0343	−0.0049	0.0154	1.0000	0.0272
<i>PBI</i>	−0.0576	−0.0513	0.0796	−0.0843	0.0959	0.1327	0.0499	−0.0135	0.0272	1.0000

Notes. Table A8 presents the Pearson correlation coefficients between variables.

Table A9 Pearson correlation coefficients between variables (Set 2).

	<i>Green</i>	<i>Political</i>	<i>MV</i>	<i>ROA</i>	<i>TD</i>	<i>TDC</i>	<i>OIG</i>	<i>O5G</i>	<i>MVTB</i>	<i>PBI</i>
<i>Green</i>	1.0000	−0.1031	0.0131	−0.7211	0.0179	0.0888	0.0494	−0.0504	−0.0141	0.0048
<i>Political</i>	−0.1031	1.0000	−0.0458	−0.0046	−0.0173	0.0176	−0.1114	−0.1003	−0.0160	−0.0312
<i>MV</i>	0.0131	−0.0458	1.0000	0.0126	0.6551	−0.0410	0.0243	0.0327	−0.0031	0.0227

Table A9 Pearson correlation coefficients between variables (Set 2). (Continued).

	<i>Green</i>	<i>Political</i>	<i>MV</i>	<i>ROA</i>	<i>TD</i>	<i>TDC</i>	<i>OIG</i>	<i>O5G</i>	<i>MVTB</i>	<i>PBI</i>
<i>ROA</i>	−0.7211	−0.0046	0.0126	1.0000	−0.0922	−0.1478	−0.0429	0.1078	0.2203	−0.0885
<i>TD</i>	0.0179	−0.0173	0.6551	−0.0922	1.0000	0.1830	0.0201	−0.0151	−0.0108	−0.0635
<i>TDC</i>	0.0888	0.0176	−0.0410	−0.1478	0.1830	1.0000	−0.0151	−0.1159	−0.0291	0.1103
<i>OIG</i>	0.0494	−0.1114	0.0243	−0.0429	0.0201	−0.0151	1.0000	0.0835	−0.0056	0.0511
<i>O5G</i>	−0.0504	−0.1003	0.0327	0.1078	−0.0151	−0.1159	0.0835	1.0000	0.0180	−0.0090
<i>MVTB</i>	−0.0141	−0.0160	−0.0031	0.2203	−0.0108	−0.0291	−0.0056	0.0180	1.0000	0.0153
<i>PBI</i>	0.0048	−0.0312	0.0227	−0.0885	−0.0635	0.1103	0.0511	−0.0090	0.0153	1.0000

Notes. Table A9 presents the Pearson correlation coefficients between variables.

Table A10 Alternative metrics of *EPU*.

Variables	(1) <i>Green</i>	(2) <i>Green</i>	(3) <i>Green</i>	(4) <i>Green</i>	(5) <i>Green</i>
<i>WUI</i>	−6.821e−08 [−5.4257]	−2.004e−07 *** [−5.2257]	−0.0003935 [−3.5515]	−1.401e−12 [−7.0840]	−8.18e−08 *** [−5.363]
<i>MV</i>	0.304036 [1.0282]	0.3578405 [0.9198]	0.312162 [1.0110]	0.4772512 [0.7107]	−0.658726 [−0.442]
<i>ROA</i>	−0.0031503 ** [−2.9579]	−0.0044805 ** [−2.8469]	−2.172e−05 *** [−4.2584]	−0.0064862 ** [−2.7221]	−3.49e−10 *** [−6.275]
<i>TD</i>	−0.7667587 [−0.2967]	−0.8010825 [−0.2520]	−0.3377993 [−0.9588]	−0.9209772 [−0.0992]	0.871594 [0.162]
<i>TDC</i>	0.0002589 *** [3.6629]	0.0023168 ** [3.0520]	0.0018545 ** [3.1175]	6.809e−07 *** [4.9667]	0.013807 * [2.462]
<i>OIG</i>	0.0012897 ** [3.2250]	0.0009362 *** [3.3163]	0.1101598 [1.5983]	0.1018288 [1.6369]	0.002273 ** [3.052]
<i>O5G</i>	−0.3994097 [−0.8429]	−0.3605956 [−0.9145]	−0.0958624 [−1.6662]	−0.0968739 [−1.6611]	−0.183881 [−1.329]
<i>MVTB</i>	0.730239 [0.3449]	0.7391364 [0.3331]	0.6227863 [0.4920]	0.7377078 [0.3349]	0.96307 [0.046]
<i>PBI</i>		3.314e−08 *** [5.5560]		0.0004362 *** [3.5172]	0.000931 *** [3.311]
Obs	2,358	2,358	2,358	2,358	2,358
Firm fixed effects	Y	Y	N	N	Y
<i>R</i> ²	0.051	0.072017	0.030945	0.050685	0.031321

Notes. Table A10 presents several robustness checks using alternative metrics of *EPU* and estimation methods. Column (1), column (2), and column (5) use firm fixed effects models. There are no firm fixed effects in column (3) and column (4). All the regressions use *WUI* as the alternative metrics of Political. The *t*-statistics are shown in parentheses. ***, **, and * represent the significance at the 1%, 5%, and 10%, respectively.

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Author contribution statement

Ruoyi Li is responsible for conceptualization, methodology, investigation, data curation, formal analysis, validation, writing the original draft, and reviewing and editing the manuscript. Everardus Wilhelmus Stapper is responsible for validation, writing the original draft, and reviewing and editing the manuscript. Anqi Zhu is responsible for validation, writing the original draft, and reviewing and editing the manuscript. Tianyi Sun is responsible for validation and reviewing and editing the manuscript. Lei Zhang is responsible for conceptualization, supervision, validation, and reviewing and editing the manuscript. All the authors have approved the final manuscript.

Data availability

Not applicable.

Use of AI statement

During the preparation of this work, the authors used ChatGPT (OpenAI) to improve the readability and language of the manuscript. The scientific content of the manuscript is the authors' original work. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

Declaration of competing interest

The authors have no competing interests to declare that are relevant to the content of this article.

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