

Article

Perception of Economic Policy Uncertainty and Energy Consumption Intensity: Evidence from Construction Companies

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Abstract: Using 2010–2019 data from 404 listed construction companies in China, we explore the relationship between perception of economic policy uncertainty (PEPU) and energy consumption intensity (ECI) based on a fixed effects model controlling for company, year, and city fixed effects, with standard errors clustered at the industry level. The results show that the perception of economic policy uncertainty reduces construction enterprise energy consumption intensity, and this result holds after a series of robustness and endogeneity tests. Further, this effect is stronger in firms with more green shareholders, environmental information disclosure, and external attention. Moreover, mechanism analysis indicates that internal control enhancement and green innovation improvement, including quantity and quality, are the underlying channels through which the perception of economic policy uncertainty influences energy consumption intensity.

Keywords: perception of economic policy uncertainty; energy consumption intensity; construction company; internal control; green innovation; China



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1. Introduction

Perception of economic policy uncertainty (PEPU) refers to the subjective intensity with which enterprises perceive policy changes, reflecting the uncertainty of the policy environment and its impact on corporate decision-making [1,2]. Perception of economic policy uncertainty (PEPU) arises not only from the ambiguity of policy texts, such as frequent revisions of environmental regulations, but also from enterprises' expectations regarding policy enforcement and regulatory direction [3]. Studies have shown that perception of economic policy uncertainty (PEPU) increases operating costs, exacerbates financing constraints, and thereby inhibits long-term investment and innovation activities [4,5]. In the construction industry, due to its energy-intensive nature and high sensitivity to policy changes, the impact of the perception of economic policy uncertainty may be particularly significant [6]. However, while the negative economic effects of perception of economic policy uncertainty have been extensively studied, its specific impact mechanisms on corporate environmental performance remain underexplored, particularly regarding energy consumption intensity (ECI).

The existing literature suggests that perception of economic policy uncertainty may influence investment decisions and weaken investments in green technology, thereby increasing corporate energy consumption intensity [7,8]. For instance, policy uncertainty

may lead construction enterprises to reduce investments in low-carbon building materials and energy-saving technologies, ultimately increasing energy consumption. However, some studies have also found that firms may respond to policy uncertainty by strengthening internal controls or increasing green innovation investment, thereby reducing energy consumption [9]. These conflicting findings indicate that the impact direction of PEPU on ECI is theoretically ambiguous, necessitating empirical testing to distinguish between opposing effects.

The reasons why we focus on the construction industry are as follows: First, the construction industry has high energy-consuming characteristics compared with other industries [10]. Therefore, exploring the energy efficiency of the construction industry has great significance for green economy development, and we try to explore the influencing factors on the perception of economic policy uncertainty. Second, the perception of economic policy uncertainty displays features of dynamism and sectoral diversity, especially in energy-intensive fields like construction, where the gap between the frequency of policy adjustments and the industry's capacity to adapt can exacerbate the influence of the perception of economic policy uncertainty on corporate decision-making [6,11]. Despite this importance, few empirical studies have directly examined the interaction between PEPU and ECI in construction firms, leaving a critical gap in the literature.

To address this gap, we use the panel data of 404 listed construction companies in China from 2010 to 2019 and employ a fixed effects model to identify the impact of PEPU on ECI. Combined with previous studies, we explicitly propose two competing hypotheses: PEPU increases (H1a) or decreases (H1b) the energy consumption intensity of construction firms. In addition, we conduct mechanism analysis, robustness checks, and a Difference-in-Differences (DID) test to address endogeneity concerns. The results show that PEPU will reduce construction enterprise ECI, and this result holds after a series of robustness and endogeneity tests. Notably, this effect is more pronounced among firms with stronger green governance, higher environmental disclosure, and greater external scrutiny. Mechanism analysis indicates that internal control enhancement and green innovation improvement, including both quantity and quality, are the channels through which PEPU influences ECI.

This study makes several contributions. First, it expands the literature on the perception of economic policy uncertainty by addressing the research gap regarding its impact on the environmental performance of construction enterprises, particularly its direct effect on energy consumption intensity. Previous studies have widely explored the factors influencing corporate energy consumption intensity, such as CEO gender [8], corporate ESG [12], corporate greenwashing [13], and artificial intelligence technology [14,15] at a micro level, and green credit policy [16], climate policy uncertainty [17], and various other policies [18,19] at a macro level. However, considering the uncertain effect of macro policies on corporations, we shed new light on the relationship between the perception of economic policy uncertainty and corporate energy consumption intensity, especially in construction enterprises, focusing on the industry differences and the perception of economic policy uncertainty at a micro research level. Therefore, this study bridges the gap between macro-level policy uncertainty and micro-level environmental outcomes in the construction industry, with two competing hypotheses.

Second, it identifies the key mechanisms through which the perception of economic policy uncertainty influences energy consumption intensity, highlighting the roles of internal control and green innovation in helping construction enterprises respond to policy uncertainty. Corporations will strengthen internal control and increase green innovation by reducing energy consumption intensity [20,21]; they will then be better equipped to face economic policy uncertainty, providing novel insights into how internal and external governance mechanisms moderate the relationship between PEPU and ECI. More-

over, this study further examines the moderating roles of corporate governance and external supervision in this process, providing valuable empirical insights for policymakers and corporate managers to promote greener and low-carbon transformation in the construction industry.

Third, this study contributes to the literature on construction enterprises. Previous studies based on the construction enterprise have explored enterprise innovation [22–24], subcontracting decisions [25], energy consumption [26], environmental sustainability performance [27], public participation awareness [28], and contractual mechanisms [29]. This paper constructs the perception of economic policy uncertainty from a construction enterprise micro level to explore its effect on energy consumption intensity, stressing the importance of energy saving in construction enterprises and the measures taken by construction enterprises in response to economic policy uncertainty. It enriches the understanding of firm behavior under uncertainty by highlighting the dual role of risk aversion and green strategy in shaping energy outcomes.

The remainder of this paper is organized as follows: Section 2 reviews the literature. Section 3 presents the data and model construction, with Section 4 reporting the empirical results. Moreover, Section 5 presents further analysis. Lastly, Section 6 concludes this paper.

2. Literature Review

Research indicates that the perception of economic policy uncertainty exhibits characteristics of dynamism and industry heterogeneity, particularly in energy-intensive industries such as construction, where the mismatch between policy adjustment frequency and industry adaptability may amplify the perception of economic policy uncertainty's impact on corporate decision-making [6,11].

Previous studies have widely explored the effect of the perception of economic policy uncertainty from macro and micro levels. At the macroeconomic level, an increase in the perception of economic policy uncertainty may intensify fluctuations in GDP growth and inflation rates while amplifying economic cycle volatility [30,31]. Refs. [32,33] found that rising policy uncertainty leads firms to postpone long-term investment plans, thereby slowing economic growth and, in extreme cases, potentially triggering financial crises or debt default risks [2]. Additionally, the impact of the perception of economic policy uncertainty on capital markets cannot be ignored. Research suggests that heightened policy uncertainty typically leads to increased stock market volatility, exposing firms to greater financial challenges [31].

Considering the microeconomic effect, the perception of economic policy uncertainty can largely influence corporations, including inhibiting corporate investment activities by exacerbating financial constraints and increasing operating costs [1,4]. This effect is particularly pronounced in industries with high proportions of irreversible investment and intense competition, such as the construction sector, where policy fluctuations can lead to prolonged project approval cycles, thereby increasing investment risks [5]. Furthermore, [3] noted that the perception of economic policy uncertainty's impact on corporate research and development (R&D) activities may exhibit a "risk–reward trade-off" characteristic, prompting some firms to increase R&D investment to enhance market competitiveness. This phenomenon is particularly evident in industries with high policy sensitivity and complex innovation challenges, such as green building technology, where firms must weigh the potential risks and benefits of innovation [34].

Despite extensive research on the perception of economic policy uncertainty's effects on macroeconomics and corporate investment behavior, studies specifically examining its impact on energy consumption intensity (ECI) in the construction industry remain limited. Given its energy-intensive nature, the construction sector is highly sensitive to policy uncertainty,

which may lead firms to adopt short-term conservative strategies in energy-saving technology investments, thereby increasing energy consumption intensity [7,8]. Specifically, the perception of economic policy uncertainty may increase corporate energy consumption by influencing investment decisions and weakening green technology R&D investment [6].

On the one hand, policy uncertainty may lead construction firms to reduce investments in low-carbon building materials and energy-saving technologies, thereby increasing energy consumption. Research has found that in highly volatile policy environments, construction enterprises tend to adopt short-term conservative strategies, such as reducing green building technology R&D, which subsequently drives up energy consumption intensity [8]. For example, under China's "housing is for living, not for speculation" policy, some real estate firms, facing financial constraints, suspended investments in green building technology, leading to an overall increase in industry-wide energy consumption levels. Additionally, the mismatch between fixed-asset investment cycles and policy adjustment cycles may further exacerbate energy consumption. For instance, frequent adjustments in local government environmental policies can result in construction project suspensions or rework, leading to significant energy waste [11].

On the other hand, technological innovation in the construction industry presents a positive effect on energy consumption reduction. Some enterprises will increase investments in green technologies (such as prefabricated building technology) due to policy pressure, benefiting energy consumption reduction [6]. The number of green patent applications in the construction industry accounts for only 12% of that in the manufacturing sector, highlighting the industry's lagging green technology advancements [35]. Moreover, firms can also choose to mitigate the impact of policy uncertainty by enhancing internal management efficiency and optimizing production processes to reduce energy consumption [9].

In conclusion, facing policy uncertainty and the mismatch between fixed-asset investment cycles and policy adjustment cycles, firms will adopt short-term conservative strategies and promote energy consumption. Firms may also choose higher green technology investment, promote internal management efficiency, and improve production processes to reduce energy consumption. Therefore, the direction of the perception of economic policy uncertainty's impact on energy consumption intensity in construction firms remains uncertain.

However, the current literature lacks empirical studies that directly examine the dual pathways through which PEPU may influence ECI, either by inhibiting green investment or enhancing risk management capacity. This paper seeks to fill this gap by focusing on construction firms, which are particularly sensitive to policy shifts and energy demands.

To clarify the empirical objective, this study aims to identify whether PEPU leads to higher or lower ECI in construction firms, and through what mechanisms. We build on two opposing theoretical arguments: one suggests PEPU leads to energy inefficiency due to delayed green investments (risk-avoidance logic), and the other proposes that PEPU triggers managerial caution and control enhancement, improving energy efficiency (strategic adjustment logic).

H1a. *Perception of economic policy uncertainty will increase the energy consumption intensity of construction firms.*

H1b. *Perception of economic policy uncertainty will reduce the energy consumption intensity of construction firms.*

The empirical analysis will not only test these competing hypotheses, but also explore internal control and green innovation as mediating mechanisms and assess heterogene-

ity across external governance dimensions, such as environmental disclosure and media attention. In doing so, this study contributes to both the policy uncertainty and energy consumption literature by establishing a nuanced, context-specific framework in the under-explored construction sector.

3. Data and Model

3.1. Sample Construction

This study constructs a multidimensional data system for A-share listed companies in China's construction industry from 2010 to 2019, finally obtaining 404 listed construction companies. The primary data sources include two authoritative databases: the China Stock Market & Accounting Research (CSMAR) database and the China Research Data Service (CNRDS) platform. The construction industry and related sectors primarily utilize non-metallic mineral products (e.g., cement, glass, and other building materials) and metal products (e.g., metal structures for construction), undertaking specialized equipment manufacturing (e.g., construction engineering machinery), electrical machinery and equipment manufacturing (e.g., electrical equipment for construction), wholesale trade (e.g., wholesale of construction materials), and retail trade (e.g., retail of building materials).

The energy consumption intensity indicator is collected from annual report disclosure statements. A three-step filtering mechanism is applied to ensure the completeness and validity of the research sample: (1) removing firms with delisting risk warnings (ST/*ST); (2) excluding listed companies in the financial sector; and (3) filtering out observations with missing values in key variables.

3.2. Model Construction

This study explores the impact of the perception of economic policy uncertainty (PEPU) on energy consumption intensity (ECI) by constructing a fixed effects model. The specific model specification is as follows:

$$ECI_{i,t} = \alpha_0 + \beta PEPU_{i,t} + \sum \text{Controls} + \text{Firm} + \text{Year} + \text{City} + \varepsilon_{i,t} \quad (1)$$

$ECI_{i,t}$ is the energy consumption intensity of firm i at year t and $PEPU_{i,t}$ is the perception of economic policy uncertainty of firm i at year t . Controls is a series of control variables defined in Table 1. Considering the impact of unobservable factors at the company, year, and city level, we employ a three-way fixed effects model that includes a company effect, time fixed effect, and city fixed effect. On this basis, to solve the problem of autocorrelation between the perturbation terms in different periods, industry-level clustered standard error estimation is used in our model. β is our main focus, with a positive coefficient indicating that the perception of economic policy uncertainty will enhance energy consumption intensity, supporting H1a, and a negative coefficient indicating that the perception of economic policy uncertainty will reduce energy consumption intensity, supporting H1b.

This model is also used in robustness analysis and further analysis. In Section 4.2, we exclude the samples from the 2015 stock market crash and 2019 pandemic from this model and further apply winsorization to the continuous variables. In Section 5.1, Mechanism Analysis, only ECI is replaced as the internal control measurement variable and green innovation measurement variable to explore the underlying mechanism. In Section 5.2, we only add the environmental information variable and external attention variable, and the interaction between PEPU and these variables in a model is investigated to explore the heterogeneity.

To identify causal relationships more rigorously, we incorporate a Difference-in-Differences (DID) approach using the 2016 US–China trade war as an exogenous shock. Firms with higher export dependency are treated as more exposed to rising policy uncer-

tainty. This quasi-natural experiment enhances identification by mitigating endogeneity concerns, such as reverse causality and omitted variable bias. Parallel trend tests (see Section 4.3) confirm the method’s validity, indicating that no parallel trend exists between the treatment group and the control group before this shock.

3.3. Variable Definition

In terms of the dependent variable, following the measurement methods of [8,9], energy input–output efficiency is used as a proxy for energy consumption intensity (ECI). The calculation formula for this indicator has been standardized to ensure international comparability. It reflects the firm’s energy consumption per unit of revenue or output, capturing operational energy efficiency.

$$ECI_{it} = \frac{\text{energy consumption}_{it}}{\text{total output}_{it}}$$

In the design of the explanatory variable (perception of economic policy uncertainty), based on the text analysis frameworks of [36,37], the proportion of “uncertainty-related vocabulary” in the annual reports of listed companies is extracted to quantify the characteristics, thus constructing the perception of economic policy uncertainty index. This index effectively captures the policy expectation fluctuations at the enterprise level. This subjective measure reflects firm-level policy sentiment, rather than macro-level EPU indexes, making it especially suitable for micro-level analysis.

Regarding the selection of control variables, this study strictly follows the variable screening system of [9,38] and establishes a multidimensional control variable set that includes *Ins*, *Top10*, *ROA*, *Employ*, *Income*, *Lev*, *CEO*, and *Execu* (see Table 1 for definitions). These are selected based on their documented influence on energy efficiency, corporate governance, and environmental behavior [8,20]. For instance, *ROA* and *Employ* are used as a proxy for firm scale and resource availability; gender-related variables capture executive risk preferences.

Table 1. Variable names.

Category	Variable Symbol	Variable Name
Dependent Variable	<i>ECI</i>	Energy consumption intensity
Explanatory Variable	<i>PEPU</i>	Perception of economic policy uncertainty
	<i>Ins</i>	Institutional shareholding ratio
	<i>Top10</i>	Shareholding ratio of top ten shareholders
	<i>ROA</i>	Return on assets
Control Variable	<i>Employ</i>	The logarithm of the number of employees plus one
	<i>Income</i>	The logarithm of the amount of corporate income plus one
	<i>Lev</i>	Total liabilities to total assets
	<i>CEO</i>	Taking value of 1 if CEO is female and 0 otherwise
	<i>Execu</i>	Proportion of female executives

The descriptive statistics in Table 2 show that the mean of the perception of economic policy uncertainty (PEPU) is 0.084 (standard deviation = 0.098), with a right-skewed distribution, indicating that construction enterprises generally exhibit sensitivity to the policy environment. The mean of energy consumption intensity (ECI) is 0.842 (standard deviation = 1.958), with a maximum value of 8.008, showing significant internal industry variation and reflecting a clear differentiation in corporate energy efficiency.

Table 2. Descriptive statistics.

Variable	Num	Mean	Std	Min	Max
<i>ECI</i>	3266	0.842	1.958	0.000	8.008
<i>PEPU</i>	3266	0.084	0.098	0.000	0.867
<i>Ins</i>	3266	0.393	0.227	0.001	1.407
<i>Top10</i>	3266	55.57	15.36	12.72	95.38
<i>ROA</i>	3266	0.052	0.143	−1.353	7.091
<i>Employ</i>	3266	8.001	1.319	2.079	12.62
<i>Income</i>	3266	21.67	1.596	15.24	27.81
<i>Lev</i>	3266	0.479	0.312	−0.195	8.256
<i>CEO</i>	3266	0.051	0.218	0.000	1.000
<i>Execu</i>	3266	0.131	0.152	0.000	0.875

In terms of moderating variables, the mean proportion of shares held by green shareholders is 39.3%, and the mean proportion of shares held by the top ten shareholders (Top10) is 55.57%, significantly higher than the industry average, indicating a more concentrated shareholder structure. Additionally, corporate profitability (ROA), size (Employ), and income (Income) all exhibit considerable variation, suggesting significant differences among enterprises in terms of resource allocation, market competitiveness, and operational stability.

4. Empirical Results

4.1. Baseline Regression Result

Table 3 reports the baseline regression results, where Column (1) does not include control variables, Column (2) adds control variables, and Column (3) further includes city fixed effect. The regression results in Table 3 show a significant negative relationship between the perception of economic policy uncertainty and energy consumption intensity. In Column 1, the coefficient of the perception of economic policy uncertainty is -0.829 ($p < 0.01$), and in Columns 2 and 3, the coefficients are -0.885 ($p < 0.01$) and -0.852 ($p < 0.01$), respectively. This indicates that the perception of economic policy uncertainty consistently exerts a suppressive effect on energy consumption intensity, confirming Hypothesis H1b. This result implies that when firms perceive economic policy uncertainty, their energy consumption intensity significantly decreases in order to reduce operational risks and improve resource utilization efficiency.

Beyond mere statistical significance, this finding also demonstrates clear economic relevance. The negative effect of PEPU on energy consumption intensity suggests that firms internalize policy signals when allocating resources and respond by improving operational efficiency. This behavioral shift, driven by a precautionary or adaptive motive under uncertainty, indicates that even non-incentivized environmental outcomes, such as energy savings, can emerge from firm strategic adjustments. Specifically, a one-standard-deviation increase in PEPU is associated with an approximate 9.9% reduction in energy consumption intensity relative to its sample mean. This suggests that PEPU is not merely a background condition but a substantive driver of firm green transformation, with material implications for environmental efficiency and cost management. Therefore, PEPU serves not only as a constraint, but also as a governance-enhancing signal that aligns corporate behavior with long-term environmental goals.

In addition, we control for a series of variables that may influence energy consumption intensity, such as return on assets (ROA), firm size (Employ), leverage level (Lev), and CEO characteristics (CEO). The results show that these control variables have significant impacts on energy consumption intensity in all columns. For instance, ROA and firm size (Employ) are negatively correlated with energy consumption, meaning that construction firms with lower profitability and a larger size tend to consume more energy. Leverage (Lev) also shows a negative relationship, indicating that higher leverage encourages firms

to adopt more energy-saving and emission-reduction measures. Shareholder concentration (Top10) is significantly negatively correlated with energy consumption intensity, suggesting that construction firms with more concentrated ownership are more efficient in decision-making, leading to optimized energy management and lower energy consumption. Overall, the findings suggest that the perception of economic policy uncertainty reduces energy consumption intensity in construction firms.

Table 3. Baseline results.

	(1)	(2)	(3)
Var	ECI	ECI	ECI
<i>PEPU</i>	−0.829 *** (−2.775)	−0.885 *** (−3.095)	−0.852 *** (−2.961)
<i>Ins</i>		0.244 (1.402)	0.249 (1.429)
<i>Top10</i>		−0.011 *** (−3.127)	−0.012 *** (−3.305)
<i>ROA</i>		−0.432 ** (−2.440)	−0.467 *** (−2.600)
<i>Employ</i>		−0.618 *** (−7.592)	−0.623 *** (−7.580)
<i>Income</i>		−0.219 *** (−2.853)	−0.229 *** (−2.943)
<i>Lev</i>		−0.520 *** (−2.695)	−0.552 *** (−2.846)
<i>CEO</i>		−0.691 *** (−3.261)	−0.744 *** (−3.469)
<i>Execu</i>		0.753 ** (2.175)	0.755 ** (2.164)
<i>Cons</i>	0.911 *** (25.812)	11.335 *** (8.378)	11.664 *** (8.472)
<i>N</i>	3266	3266	266
<i>R²</i>	0.572	0.613	0.616
<i>Company FE</i>	YES	YES	YES
<i>Year FE</i>	YES	YES	YES
<i>City FE</i>	NO	NO	YES

Note: *** $p < 0.01$, ** $p < 0.05$.

In conclusion, our main regression results show that the perception of economic policy uncertainty reduces energy consumption intensity in construction firms. By further introducing control variables, we find that energy consumption decisions in construction firms are influenced not only by economic policy uncertainty, but also by governance structure, profitability, and resource allocation constraints.

This finding provides important empirical evidence for understanding how economic policy uncertainty affects corporate decision-making and, in turn, alters energy consumption behavior.

4.2. Robustness Results

In the robustness test, we further consider the potential market fluctuations caused by event-driven factors, such as the 2015 stock market crash and the 2019 pandemic, to examine whether our research conclusions are robust. First, we excluded the impact of the 2015 stock market crash and the 2019 pandemic from the baseline regression and applied winsorization to the continuous variables.

The results in Table 4 show that the negative impact of the perception of economic policy uncertainty on the energy consumption intensity (ECI) of construction companies remains significant after excluding these extreme events, and the coefficient values are similar to those in the main regression results. For instance, in Column 1, the coefficient of the perception of economic policy uncertainty is −0.989, slightly higher than the −0.829 in the main regression, indicating that the direction and intensity of the effect remain

consistent. Further analysis reveals that the significance of the coefficients for control variables (such as ROA, income, leverage, and CEO characteristics) is consistent with the baseline regression results, proving that these variables' impact on energy consumption intensity remains stable across different scenarios.

Table 4. Robustness results.

	(1)	(2)	(3)
Var	ECI	ECI	ECI
<i>PEPU</i>	−0.989 *** (−2.970)	−0.855 ** (−2.514)	−0.855 *** (−2.974)
<i>Ins</i>	0.575 *** (2.632)	0.271 (1.498)	0.203 (1.143)
<i>Top10</i>	−0.014 *** (−3.298)	−0.012 *** (−3.079)	−0.011 *** (−2.713)
<i>ROA</i>	−0.582 *** (−2.739)	−0.523 *** (−2.968)	−0.364 (−0.538)
<i>Employ</i>	−0.637 *** (−6.931)	−0.648 *** (−7.608)	−0.627 *** (−7.358)
<i>Income</i>	−0.341 *** (−3.771)	−0.176 ** (−2.200)	−0.261 *** (−2.985)
<i>Lev</i>	−0.679 *** (−3.103)	−0.613 *** (−3.327)	−0.314 (−0.967)
<i>CEO</i>	−1.184 *** (−4.935)	−0.759 *** (−3.404)	−0.718 *** (−3.382)
<i>Execu</i>	0.945 ** (2.437)	0.648 * (1.658)	0.718 ** (2.046)
<i>Cons</i>	14.506 *** (9.185)	10.616 *** (7.436)	12.190 *** (7.788)
<i>N</i>	2937	2959	3266
<i>R²</i>	0.682	0.596	0.616
<i>Company FE</i>	YES	YES	YES
<i>Year FE</i>	YES	YES	YES
<i>City FE</i>	YES	YES	YES

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

The testing results further confirm the robustness of the negative impact of the perception of economic policy uncertainty on energy consumption intensity in construction firms. Even after considering the potential impact of market anomalies, the research conclusion remains reliable. Therefore, we can confirm that the influence of the perception of economic policy uncertainty on energy consumption intensity is not driven by specific market events, but is universally applicable and stable.

And this conclusion is of great significance. First, policymakers should recognize that the perception of economic policy uncertainty has a substantial impact on corporate energy consumption behavior, particularly in energy-intensive industries such as construction. Therefore, improving the predictability and stability of policies can help drive firms to reduce energy consumption intensity, thus promoting a green and low-carbon transition. Moreover, companies should pay more attention to the long-term strategic and resource allocation effects of economic policy uncertainty, especially when setting green development goals. They should focus on how to mitigate the risks brought about by policy uncertainty by strengthening internal controls and increasing investments in green innovation. This provides policymakers and businesses with more forward-looking and practical decision-making guidance.

4.3. Endogeneity Test

To address potential endogeneity concern, we employ the Difference-in-Differences (DID) method to examine the causal relationship between the perception of economic policy uncertainty (PEPU) and energy consumption intensity (ECI) in construction firms. Given that the trade war following President Trump's inauguration might have impacted companies heavily reliant on overseas trade, following the approach of [8], we use this shock to carry out DID analysis. During the 2016 campaign, Trump promised to impose high tariffs on imports from China. Therefore, we set 2016 as the starting point for policy changes, and POST takes a value of 1 after 2016 (including the year of 2016) and 0 otherwise. Treat is a dummy variable indicating firms that rely heavily on export business, which equals 1 if a firm's average export dependence level ranked in the top 50% prior to the outbreak of the trade war (2010–2015) and 0 otherwise. The export dependence level equals export business revenue divided by total revenue. If a firm has a higher export dependence level, it is more likely to be affected by the US–China trade war and perceive a higher level of uncertainty. The variable DID is our focus, measured as $POST \times Treat$.

The regression results in Table 5 show that in Columns 1 and 2, the coefficient of the DID variable is significantly negative, with values of -0.485 and -0.433 , respectively, both passing the 1% significance level. This result indicates that after the policy change, the effect of the perception of economic policy uncertainty is amplified, further supporting the negative relationship between the perception of economic policy uncertainty and energy consumption intensity. Notably, this result is not significantly influenced by other control variables (such as ROA, income, leverage, etc.), which validates the robustness of our model specification.

Table 5. Endogeneity test.

	(1)	(2)
Var	ECI	ECI
DID	-0.485^{***} (-2.895)	-0.433^{***} (-2.637)
Ins		-0.007 (-0.038)
Top10		-0.006^* (-1.686)
ROA		-0.333^* (-1.819)
Employ		-0.529^{***} (-5.533)
Income		-0.255^{***} (-3.006)
Lev		-0.439^{**} (-2.414)
CEO		-0.385 (-1.467)
Execu		0.460 (1.225)
Cons	0.821^{***} (17.443)	11.130^{***} (7.253)
N	3266	3266
R ²	0.548	0.574
Company FE	YES	YES
Year FE	YES	YES
City FE	YES	YES

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Additionally, to ensure the validity of the DID model, we performed a parallel trends test (see Figure 1). The results show that, prior to 2016, there was no significant difference

in the trend changes between the treatment group and the control group, supporting the parallel trends assumption of the DID model; namely, in the absence of policy changes, the energy consumption intensity trends of the treatment and control groups are consistent. This result confirms that our DID method is valid.

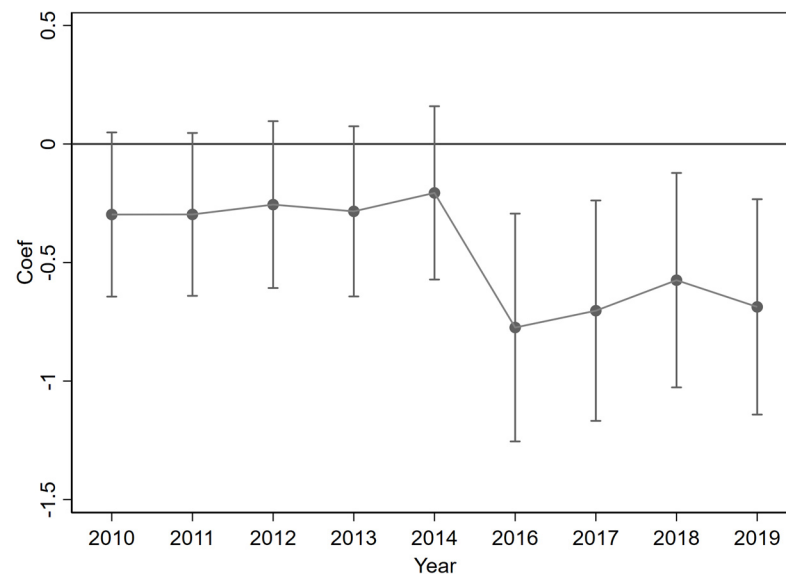


Figure 1. Parallel trend. Note: This figure is generated from Stata17 through programming.

5. Further Analysis

5.1. Mechanism Analysis

5.1.1. Internal Control

In the mechanism analysis, we explore the potential mechanisms through which the perception of economic policy uncertainty (PEPU) influences energy consumption intensity (ECI) in construction firms. We focused on two possible channels: (1) the enhancement of internal control and (2) the increase in green innovation, including both quantity (total number of patent applications) and quality (total number of granted patents).

First, we examined the role of internal control (see Table 6). Following the approaches of [39–41], we classified internal control as “effective” vs. “ineffective” and “defective” vs. “non-defective” to investigate its moderating effect on the relationship between the perception of economic policy uncertainty and energy consumption intensity. Valid takes a value of 0 if the internal control is effective and 1 otherwise, and Deficiency takes a value of 0 if the internal control is defective and 1 otherwise.

In Column 1 of Table 6, when the internal control is considered effective or not, the coefficient of perception of economic policy uncertainty is -0.032 , and it is significant ($p < 0.05$), indicating that a high perception of economic policy uncertainty will promote the construction enterprise to enhance internal control. Moreover, in Column 2, when internal control is deemed defective, the coefficient of perception of economic policy uncertainty is 0.189 and is significantly positive ($p < 0.05$), suggesting that a high perception of economic policy uncertainty will make the construction enterprise more non-defective in internal control.

This result implies that firms will take various measures to make the internal control more effective with less defectiveness, thus putting them in a better position to improve economic policies and effectively reduce energy consumption intensity.

Table 6. Mechanism analysis: internal control.

	(1)	(2)
Var	Valid	Deficiency
PEPU	−0.032 ** (−2.205)	0.189 ** (2.024)
Ins	−0.019 (−1.636)	0.183 *** (3.356)
Top10	−0.000 (−1.439)	−0.001 (−1.297)
ROA	−0.015 (−0.781)	−0.016 (−0.327)
Employ	0.002 (0.441)	0.015 (0.645)
Income	−0.009 (−1.430)	0.004 (0.178)
Lev	0.008 (1.034)	−0.077 (−1.408)
CEO	−0.001 (−0.676)	−0.017 (−0.272)
Execu	0.003 (0.389)	0.116 (1.464)
Cons	1.201 *** (10.537)	1.521 *** (4.019)
N	3036	3036
R ²	0.173	0.509
Company FE	YES	YES
Year FE	YES	YES
City FE	YES	YES

Note: *** $p < 0.01$, ** $p < 0.05$.

5.1.2. Green Innovation

We further explored the role of green innovation in the impact of the perception of economic policy uncertainty (PEPU) on energy consumption intensity (ECI) in construction firms. We specifically analyzed how the quantity (total number of patent applications) and quality (total number of granted patents) of green innovation serve as potential channels through which the perception of economic policy uncertainty affects energy consumption intensity.

The results in Table 7 indicate that the perception of economic policy uncertainty can enhance both the quantity and quality of green innovation significantly. In Column 4 (green innovation quantity), the coefficient of perception of economic policy uncertainty on the total number of patent applications is 0.385 ($p < 0.01$), suggesting that an increase in the perception of economic policy uncertainty promotes the number of patent applications in green technologies, thereby reducing energy consumption intensity. Similarly, in Column 5 (green innovation quality), the coefficient of perception of economic policy uncertainty on the total number of granted patents is 0.436 ($p < 0.01$), demonstrating the perception of economic policy uncertainty's positive effect on improving the quality of green technologies, and this improvement helps reduce energy consumption intensity. This indicates that green innovation, including not only the quantity of patents but also the quality of patents, becomes an important pathway through which the perception of economic policy uncertainty influences corporate energy behavior.

In summary, the mechanism analysis indicates that the strengthening of internal control and the enhancement of green innovation, including both quantity and quality, are potential channels through which the perception of economic policy uncertainty (PEPU) influences energy consumption intensity.

Table 7. Mechanism analysis: green innovation.

	(4)	(5)
Var	GIQuantity	GIQuality
PEPU	0.385 *** (2.646)	0.436 *** (3.158)
Ins	−0.103 (−1.492)	−0.088 (−1.375)
Top10	0.001 (1.076)	0.001 (0.727)
ROA	−0.062 (−0.845)	−0.070 (−1.046)
Employ	0.102 *** (4.493)	0.084 *** (3.997)
Income	−0.005 (−0.229)	−0.001 (−0.050)
Lev	0.020 (0.397)	0.011 (0.236)
CEO	0.154 * (1.922)	0.115 (1.563)
Execu	−0.181 * (−1.817)	−0.130 (−1.363)
Cons	−0.269 (−0.635)	−0.255 (−0.648)
N	3266	3266
R ²	0.720	0.708
Company FE	YES	YES
Year FE	YES	YES
City FE	YES	YES

Note: *** $p < 0.01$, * $p < 0.1$.

5.2. Heterogeneity Analysis

Corporate governance and external supervision also play crucial moderating roles in the relationship between the perception of economic policy uncertainty and energy consumption intensity in construction enterprises. First, studies have shown that firms with a high degree of green shareholder concentration can mitigate the negative impact of the perception of economic policy uncertainty on energy consumption intensity by optimizing decision-making mechanisms [35]. However, under high policy uncertainty, information asymmetry may weaken this governance advantage. Moreover, the involvement of green investors can reinforce the negative effect of the perception of economic policy uncertainty on energy consumption intensity, incentivizing firms to adopt more environmentally friendly production methods under policy uncertainty [42]. Second, external supervision, such as environmental information disclosure and media attention, can enhance corporate transparency, encouraging firms to adopt more proactive energy consumption strategies during periods of policy volatility [43].

Therefore, we explore the heterogeneity of the impact of the perception of economic policy uncertainty (PEPU) on energy consumption intensity (ECI) in construction firms from three different perspectives. First, we examine the role of green investors, specifically analyzing how the net value of shares held by green investors and the number of green investors moderate the relationship between the perception of economic policy uncertainty and energy consumption intensity. Second, we analyze the impact of environmental information disclosure, utilizing scores from 27 indicators such as environmental management, regulation, certification, and environmental performance to further investigate the moderating effect of environmental disclosure scores and their logarithmic transformation in the context of the perception of economic policy uncertainty. Lastly, we consider the influence of external attention, measuring the degree of external attention through the frequency of media coverage topics and total mentions, and explore its role in the relationship between the perception of economic policy uncertainty and energy consumption intensity.

Through these three analyses, we further reveal how various external factors affect corporate energy consumption behavior when responding to economic policy uncertainty.

5.2.1. Green Investor

At the corporate level, China's green credit policies are strongly related to energy consumption intensity [16], and green investors are increasingly focused on ESG-related green investment performance [42,44]. Therefore, we first explore the role of green investors in moderating the impact of the perception of economic policy uncertainty (PEPU) on energy consumption intensity (ECI) in construction firms, particularly focusing on the moderating effect of green investors' equity holdings and the number of green investors on the relationship between the perception of economic policy uncertainty and energy consumption intensity.

The regression results in Table 8 show that the presence of green investors and their interaction with the perception of economic policy uncertainty significantly affect energy consumption intensity. In Column 1, the interaction term between the perception of economic policy uncertainty and the net value of green investors' equity holdings (GreenIV) has a coefficient of -0.019 ($p < 0.05$), indicating that when the equity share of green investors is higher, the negative impact of the perception of economic policy uncertainty on energy consumption intensity becomes more pronounced. Similarly, in Column 2, the interaction term between the perception of economic policy uncertainty and the number of green investors (GreenIN) has a coefficient of -0.136 ($p < 0.01$), further demonstrating that an increase in the number of green investors enhances the negative effect of the perception of economic policy uncertainty on corporate energy consumption intensity.

Table 8. Green investors.

	(1)	(2)
Var	ECI	ECI
$PEPU \times GreenIV$	-0.019^{**} (-2.573)	
GreenIV	-0.005^{***} (-3.247)	
$PEPU \times GreenIN$		-0.136^{***} (-3.293)
GreenIN		-0.043^{***} (-4.765)
PEPU	-0.687^{**} (-2.245)	-0.524 (-1.626)
Ins	0.315^{*} (1.790)	0.377^{**} (2.139)
Top10	-0.013^{***} (-3.525)	-0.013^{***} (-3.521)
ROA	-0.446^{***} (-2.578)	-0.437^{***} (-2.586)
Employ	-0.616^{***} (-7.538)	-0.612^{***} (-7.521)
Income	-0.204^{***} (-2.613)	-0.184^{**} (-2.378)
Lev	-0.551^{***} (-2.908)	-0.553^{***} (-2.991)
CEO	-0.710^{***} (-3.303)	-0.694^{***} (-3.221)
Execu	0.754^{**} (2.168)	0.747^{**} (2.158)
Cons	11.109^{***} (8.018)	10.667^{***} (7.746)
N	3266	3266
R ²	0.619	0.621
Company FE	YES	YES
Year FE	YES	YES
City FE	YES	YES

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Additionally, when examining the direct effect of the perception of economic policy uncertainty on energy consumption intensity alone, the results show that the perception of economic policy uncertainty has a significant negative impact on energy consumption intensity (with coefficients of -0.687 in Column 1 and -0.524 in Column 2, both at $p < 0.05$). This suggests that the perception of economic policy uncertainty generally promotes efforts by firms to reduce energy consumption. The involvement of green investors amplifies this effect, highlighting their crucial role in driving corporate green transformation.

In conclusion, the participation of green investors, particularly through increased equity holdings and total numbers, significantly amplifies the negative impact of the perception of economic policy uncertainty on energy consumption intensity in construction firms, encouraging firms to adopt more energy-saving measures. This finding provides new insights for policymakers and investors, suggesting that encouraging the participation of green investors can strengthen the role of policy uncertainty in driving corporate green transformation, thereby providing strong support for reducing energy consumption intensity and promoting corporate sustainability.

5.2.2. Environmental Information

We further examine the moderating role of environmental information disclosure in the impact of the perception of economic policy uncertainty (PEPU) on energy consumption intensity (ECI) in construction firms. Specifically, we focused on the impact of environmental information disclosure scores, which are calculated based on 27 indicators across seven aspects: environmental management, environmental regulation and certification, environmental performance, and governance, with the final score also being log-transformed.

The regression results in Table 9 show that environmental information disclosure plays a significant moderating role in the relationship between the perception of economic policy uncertainty and corporate energy consumption intensity. In Column 1, the interaction term between the perception of economic policy uncertainty and environmental information disclosure score (EIS) has a coefficient of -0.162 ($p < 0.01$), meaning that when the environmental information disclosure score is higher, the negative impact of the perception of economic policy uncertainty on energy consumption intensity becomes more pronounced. Similarly, in Column 2, the interaction term between the perception of economic policy uncertainty and the log-transformed environmental information disclosure score (LNEIS) has a coefficient of -0.879 ($p < 0.01$), indicating that an increase in the environmental information disclosure score further strengthens the negative impact of the perception of economic policy uncertainty on energy consumption intensity. This suggests that a higher environmental information disclosure score not only increases corporate transparency, but also, by enhancing external public and investor attention, encourages firms to adopt more energy-saving measures in response to economic policy uncertainty.

Therefore, environmental information disclosure plays a key role in helping firms respond to economic policy uncertainty. By providing more transparent environmental information, it enhances the negative impact of policy uncertainty on corporate energy behavior. Policymakers should encourage companies to improve their environmental information disclosure, thus promoting more transparent practices and social supervision, which in turn drives companies to implement greener and more low-carbon operational strategies.

Table 9. Environmental information.

	(1)	(2)
Var	ECI	ECI
<i>PEPU × EIS</i>	−0.162 *** (−3.340)	
<i>EIS</i>	−0.008 (−0.738)	
<i>PEPU × LNEIS</i>		−0.879 *** (−3.660)
<i>LNEIS</i>		0.011 (0.257)
<i>PEPU</i>	−0.244 (−0.657)	0.075 (0.180)
<i>Ins</i>	0.252 (1.450)	0.251 (1.446)
<i>Top10</i>	−0.012 *** (−3.282)	−0.012 *** (−3.242)
<i>ROA</i>	−0.470 *** (−2.619)	−0.470 *** (−2.608)
<i>Employ</i>	−0.619 *** (−7.540)	−0.617 *** (−7.504)
<i>Income</i>	−0.226 *** (−2.917)	−0.229 *** (−2.951)
<i>Lev</i>	−0.555 *** (−2.885)	−0.553 *** (−2.862)
<i>CEO</i>	−0.739 *** (−3.452)	−0.748 *** (−3.499)
<i>Execu</i>	0.763 ** (2.196)	0.758 ** (2.183)
<i>Cons</i>	11.585 *** (8.444)	11.588 *** (8.434)
<i>N</i>	3266	3266
<i>R²</i>	0.618	0.618
<i>Company FE</i>	YES	YES
<i>Year FE</i>	YES	YES
<i>City FE</i>	YES	YES

Note: *** $p < 0.01$, ** $p < 0.05$.

5.2.3. External Attention

Finally, we examine the moderating role of external attention in the relationship between the perception of economic policy uncertainty (PEPU) and energy consumption intensity (ECI) in construction firms, specifically measuring external attention through the number of topic mentions (EETitle) and total mentions (EETotal) in external media reports.

The results in Table 10 show that external attention plays a significant moderating role in the relationship between the perception of economic policy uncertainty and energy consumption intensity. In Column 1, the interaction term between the perception of economic policy uncertainty and the number of external media report topic mentions (EETitle) has a coefficient of -0.003 ($p < 0.01$), indicating that external media attention enhances the negative effect of the perception of economic policy uncertainty on corporate energy consumption intensity. Specifically, when firms receive more media attention, the negative impact of the perception of economic policy uncertainty on energy consumption intensity becomes more significant. In Column 2, the interaction term between the perception of economic policy uncertainty and the total number of external media report mentions (EETotal) has a coefficient of -0.001 ($p < 0.01$), further confirming that increased external attention strengthens the negative impact of the perception of economic policy uncertainty on energy consumption intensity. This suggests that sustained external media attention, especially with increased reporting frequency and quantity, encourages firms to

place greater emphasis on energy-saving, emission reduction, and green transformation when facing economic policy uncertainty.

Table 10. External attention.

	(1)	(2)
Var	ECI	ECI
<i>PEPU × EATitle</i>	−0.003 *** (−3.686)	
<i>EETitle</i>	0.001 *** (2.601)	
<i>PEPU × EATotal</i>		−0.001 *** (−5.663)
<i>EETotal</i>		0.001 *** (4.039)
<i>PEPU</i>	−0.416 (−1.296)	−0.264 (−0.856)
<i>Ins</i>	0.228 (1.316)	0.232 (1.336)
<i>Top10</i>	−0.012 *** (−3.174)	−0.012 *** (−3.181)
<i>ROA</i>	−0.477 *** (−2.605)	−0.480 *** (−2.617)
<i>Employ</i>	−0.618 *** (−7.512)	−0.623 *** (−7.571)
<i>Income</i>	−0.251 *** (−3.171)	−0.246 *** (−3.145)
<i>Lev</i>	−0.555 *** (−2.860)	−0.559 *** (−2.865)
<i>CEO</i>	−0.737 *** (−3.449)	−0.747 *** (−3.498)
<i>Execu</i>	0.771 ** (2.210)	0.826 ** (2.373)
<i>Cons</i>	11.967 *** (8.581)	11.885 *** (8.615)
<i>N</i>	3266	3266
<i>R²</i>	0.618	0.620
<i>Company FE</i>	YES	YES
<i>Year FE</i>	YES	YES
<i>City FE</i>	YES	YES

Note: *** $p < 0.01$, ** $p < 0.05$.

Thus, external attention not only increases corporate responsiveness to external policies, but also, through heightened social pressure and public scrutiny, encourages firms to adopt greener and more low-carbon measures when responding to economic policy uncertainty. Therefore, policymakers should consider strengthening media attention on corporate green behavior to promote greater environmental responsibility as firms navigate policy uncertainty.

In summary, the participation of green investors, the transparency of environmental information disclosure, and the level of external media attention all significantly enhance the negative impact of the perception of economic policy uncertainty on energy consumption intensity. Specifically, the net value of shares held by green investors and the number of green investors, the environmental information disclosure scores of firms, and the frequency of media coverage all effectively amplify the role of the perception of economic policy uncertainty in driving corporate green transformation and energy-saving measures. These findings highlight that external factors such as green investors, environmental information disclosure, and external attention play key roles in helping firms respond to policy

uncertainty. They further emphasize the importance of transparency and social oversight in promoting corporate green behavior.

6. Conclusions

6.1. Conclusions and Discussion

This study investigates the relationship between the perception of economic policy uncertainty (PEPU) and energy consumption intensity (ECI) within construction companies in China. Our findings reveal a significant negative relationship between the perception of economic policy uncertainty and energy consumption intensity, indicating that heightened perceptions of economic policy uncertainty lead to a reduction in energy consumption intensity. This result remains robust across various tests, underscoring its reliability and consistency. The extant literature presents two contrasting views regarding the impact of policy uncertainty on corporate environmental performance, particularly energy use. The first is the inhibitory view. Studies such as [7,8,11] argue that economic policy uncertainty weakens corporate investment in green technology, especially in industries with long capital cycles like construction. Under this view, firms delay investment in energy-saving technologies and adopt short-term cost-cutting strategies, which ultimately increases energy consumption intensity. Another view is the adaptive view. The research by [9,21] suggests that policy uncertainty may stimulate firms to enhance internal controls, boost green innovation, and improve organizational resilience. These responses lead to improved energy efficiency despite the surrounding uncertainty.

Our findings support the adaptive view, thereby complementing and extending the latter stream of research in four important ways:

First, by focusing specifically on listed construction enterprises in China, our results provide industry-specific evidence that the perception of policy uncertainty does not always result in hesitation or inefficiency. Instead, firms may actively transform uncertainty into a driver of green transformation when supported by institutional governance and stakeholder scrutiny.

Second, while prior studies mainly explore macro-level uncertainty (e.g., GDP shocks, trade policy shocks), this study leverages a firm-level textual analysis of annual reports to construct a micro-level perception index (perception of economic policy uncertainty), offering a more granular perspective on how uncertainty is internalized by managers.

Third, our mechanism analysis reveals that both internal control effectiveness and green innovation (quantity and quality) serve as crucial mediators in the link between the perception of economic policy uncertainty and energy consumption intensity. This dual-pathway mechanism has received limited attention in previous studies and constitutes a theoretical advancement, compared with [9,21].

Last, the heterogeneity analysis underscores the importance of external moderators, such as green shareholders, environmental information disclosure, and media attention, which amplify the perception of economic policy uncertainty–energy consumption intensity relationship. These findings align with [35,43], emphasizing that information transparency and stakeholder pressure are critical levers in shaping corporate sustainability behavior under uncertainty.

In summary, this study diverges from the conventional “policy uncertainty harms green investment” view and instead provides empirical support for the transformative potential of uncertainty under the right corporate governance and institutional conditions.

6.2. Implications

The implications of these findings are as follows. First, policy makers should recognize the significant role that economic policy uncertainty plays in influencing corporate

behavior, especially in energy-intensive sectors such as construction. By enhancing the predictability and stability of policy environments, governments can encourage firms to reduce energy consumption and embrace sustainable practices, thus achieving high-quality economic development.

Second, companies should acknowledge the critical role of internal control systems and green innovation in responding to policy uncertainty. Enhancement in corporate internal governance and investment in green technologies not only help reduce energy consumption intensity, but also contribute to the overall sustainability of the firm, further highlighting the importance of internal governance and proactive green strategies in helping firms manage the adverse impacts of policy uncertainty.

Third, external attention has great significance for corporate sustainable development. Specifically, the presence of green shareholders, higher levels of environmental information disclosure, and greater external media attention amplify the negative effect of the perception of economic policy uncertainty on energy consumption intensity. This suggests that improving transparency, encouraging stakeholder engagement, and enhancing public scrutiny will play vital roles in driving companies to adopt more sustainable practices.

In conclusion, this study provides valuable insights into how economic policy uncertainty interacts with corporate strategies to influence energy consumption. It offers practical recommendations for both policy makers and businesses seeking to foster a greener, more resilient economy, emphasizing the need for transparent, forward-looking policies and sustainable business practices.

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