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-RESEARCH ARTICLE-

THE IMPACT OF ECONOMIC POLICY UNCERTAINTY ON CORPORATE GREEN INNOVATION: EVIDENCE FROM CHINA

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─Abstract─

Ensuring green innovation is essential for companies striving to maintain competitiveness in the global market. This study examines the influence of Economic Policy Uncertainty (EPU) on green innovation activities among China's A-share listed firms, with particular attention to the moderating effects of financial constraints, government subsidies, and central state ownership. Utilising data from 2007 to 2022, the research incorporates firm-level measures of the China Economic Policy Uncertainty Index alongside green innovation data. A quantitative methodology is employed, applying Ordinary Least Squares (OLS) regression to panel data analysis. Contrary to previous studies suggesting that EPU inhibits green innovation, the findings indicate that EPU exerts a positive and significant impact on firms' green innovation efforts. However, financial constraints diminish this effect, whereas government subsidies enhance it. Furthermore, central state-owned enterprises (SOEs) demonstrate a higher propensity to invest in green innovation compared to their non-central counterparts. These findings have significant policy implications, providing insights for refining innovation policies. This study not only establishes a framework for fostering corporate green innovation but also offers practical recommendations to support sustainable development amid economic uncertainty.

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INTRODUCTION

China has played a pivotal role in the global economy in recent decades. However, its early developmental strategies have intensified tensions between economic growth and environmental conservation (Khanra et al., 2022). Given the escalating risks associated with environmental pollution and climate change, achieving a delicate balance between economic expansion and ecological sustainability has become increasingly urgent. As Marshall notes, fostering green innovation within businesses is essential for achieving both economic and environmental benefits. Moreover, green innovation extends beyond reactive governance, supporting resource recycling and advancing the circular economy (Khanra et al., 2022).

To address these challenges, the Chinese government has implemented a series of policies aimed at encouraging corporate green innovation. However, the fluctuating and unpredictable nature of the global economy has created a volatile policy-making environment in China, frequently leading to heightened EPU (Cui et al., 2023; Peng et al., 2023; Ren et al., 2023; Zhou et al., 2024). The EPU index developed by Baker et al. has been widely adopted in research. While the measurement of EPU has become increasingly precise since its popularisation by (Bloom, 2014), accurately capturing the underlying concept remains challenging (Knight Frank, 1921). As noted above, Liu Guanchun (2022) highlight that EPU assessments typically incorporate both risk and uncertainty measures, thereby introducing model risk. Furthermore, the EPU index proposed by (Baker et al., 2016) presents certain limitations. Firstly, it provides a single national-level measure for all firms, aggregating data across time and diverse individual experiences, which may vary in duration. Secondly, assuming homogeneity in uncertainty exposure is problematic, as firms encounter multiple dimensions of uncertainty based on their unique circumstances.

Given these concerns, the present study employs the EPU index developed by (Huihua Nie, 2020) to capture firm-level economic policy uncertainty perceptions in a heterogeneous manner, utilising a novel dataset of individual Chinese firms. In related research, this model has been applied to examine corporate perceptions of social responsibility (Li et al., 2024), digital transformation (Fang et al., 2017), as well as investment decisions and financial asset allocation (Huihua Nie, 2020). While uncertainty models have been widely recognised across various fields, limited research has investigated their impact on corporate green innovation (Cui et al., 2023). At present, only indirect evidence exists regarding the effect of EPU on corporate green innovation. Although previous studies suggest that changes in uncertainty influence economic variables such as investment and corporate cash holdings (Baker et al., 2016; Huihua Nie, 2020; Su et al., 2020), the role of EPU in corporate investment and liquidity

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management remains critical for fostering green innovation (Cui et al., 2023).

Building on this discussion, the present study formulates several key research questions: How does firm-level perception of EPU influence corporate investment in green innovation? Does it act as a catalyst or a deterrent? To what extent do financing constraints moderate the relationship between EPU and green innovation? How do government subsidies enhance the impact of EPU on green innovation? Furthermore, how do central and non-central enterprises in China differ in their green innovation investment behaviours under economic policy uncertainty? A deeper understanding of these questions offers valuable insights for shaping innovation policies, equipping policymakers with strategies that effectively align with stakeholder expectations. Ultimately, this can stimulate corporate investment in green innovation through the circular economy, strengthening firms' ability to sustain their competitive position in the global market.

This research investigates the influence of EPU on corporate GI in China. The results indicate that a rise in EPU substantially promotes corporate green innovation, contradicting the prevailing belief that EPU hinders companies' innovation initiatives. The results demonstrate that the favourable impact of EPU on GI is especially significant for central companies, firms with reduced financial constraints, and large-scale sectors. This research makes three key contributions. First, it extends the literature by focusing on a firm-level EPU index (Huihua Nie, 2020) rather than the widely used national-level index (Baker et al., 2016). This approach advances research on Chinese corporate green innovation by demonstrating that heightened EPU fosters GI. Second, the study explores the moderating roles of financing constraints and government subsidies in the relationship between EPU and GI, thereby bridging macroeconomic uncertainty perceptions with firm-level innovation dynamics. Finally, it accounts for the heterogeneity in EPU's effects on GI based on ownership structure (central vs. non-central enterprises), aligning more closely with China's economic landscape and addressing gaps in the existing literature.

LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

Theoretical Foundation

Drawing on (Bachmann et al., 2013; Baker et al., 2016; Gulen & Ion, 2015; Huihua Nie, 2020), this research defines EPU as firms' difficulty in predicting new policy issuance, changes to existing policies, and their impacts. EPU has two aspects: firms cannot accurately foresee policy changes or their direction, content, and extent. Real options theory suggests uncertainty can drive investment. Some firms invest to capitalise on opportunities despite uncertainty. With time-lagged investments, returns and costs materialise later. If investment lags are short, uncertainty may delay investment, but longer lags can stimulate it. In real estate, developers may invest despite poor conditions to secure future opportunities.

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Moreover, research and development (R&D) investments are characterised by long cycles and significant uncertainty; however, successful innovation can generate substantial monopoly profits. As Schumpeter observed, economic development is driven by innovation. For firms, innovation serves as a strategic tool to expand market share and achieve above-average returns. Watkins (1922) argued that the decision to engage in or invest in innovation is primarily determined by the entrepreneur, with firm profits constrained by the uncertainty inherent in entrepreneurial innovation. If future changes were entirely predictable, firms would be unlikely to generate substantial profits; however, uncertainty can incentivise entrepreneurs to increase investments in innovation. By intensifying market risks, EPU may compel firms to invest further in innovation to sustain or regain market dominance. While the adjustment cost for physical investments corresponds to the direct expenses associated with altering inventory levels, knowledge stock—being intangible and generally non-tradable—can only be modified by adjusting R&D investment levels, thereby influencing the rate of knowledge accumulation.

Empirical Studies and Hypothesis Development EPU and GI

Economic policy uncertainty (EPU) broadens the scope of corporate profit volatility. According to real options theory, uncertainty is a fundamental driver of corporate profitability (Watkins, 1922). When firms encounter market competition and risk, EPU may incentivise them to accelerate innovation as a strategy to sustain or regain market power (Bloom, 2014). This occurs because EPU heightens market risk, thereby increasing the potential returns from green innovation and making firms more likely to engage in such activities. Prospect theory's reflection effect further supports this argument. It posits that when firms face potential losses due to uncertainty, they exhibit loss aversion, prompting them to pursue high-return innovation strategies to compensate for previous setbacks. Consequently, firms internalise loss aversion into their innovation behaviour, aligning their green innovation decisions with the pursuit of high returns (Kahneman & Tversky, 2013; Tversky & Kahneman, 1992).

From a theoretical perspective, EPU influences managerial opportunity assessment and enhances firms' willingness to undertake risks (Giat et al., 2009; Segal et al., 2015). This leads firms to focus more on the anticipated benefits of successful green innovation—such as pollution reduction, environmental protection, meeting green consumer demand, and improving financial performance—while placing less emphasis on the potential costs of failure (Fraj-Andrés et al., 2009; Hart, 1995). EPU may accelerate investment when pre-emptive strategies outweigh waiting or abandonment (Weeds, 2002). Green innovation drives corporate sustainability, enabling firms to secure monopoly profits, maintain competitiveness, and align with ecological civilisation. EPU may encourage green innovation by increasing managers' risk tolerance, widening profit volatility, and enhancing market competitiveness. Hence, this study proposes Hypothesis 1.

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H1: *EPU promotes corporate green innovation activities, indicating that EPU has a positive impact on such activities.*

Financial Constraints Moderating Role

Previous research indicates that firms experience financing constraints at various stages of their operations, which can be further intensified by difficulties in accessing external capital. These constraints present significant challenges for green innovation, as such activities require substantial and sustained financial investment. When firms face financial difficulties and lack continuous funding, they are more likely to forgo optimal decisions, particularly in green innovation. This issue is further exacerbated by agency costs, as highlighted by Xiaming et al., (2018) and Li Huiyun (2020). Firms with constrained resources are less likely to engage in green innovation and are more susceptible to financial limitations (Hart & Ahuja, 1996). Consequently, it is expected that firms facing financing constraints will respond differently to EPU compared to those with greater financial flexibility.

H2: *Financing constraints weaken the positive impact of economic policy uncertainty on corporate green innovation activities.*

Government Subsidies Moderating Role

Government subsidies influence corporate green innovation. (Hall et al., 2016) find a positive link between R&D spending and subsidies, while Fang et al. (2017) show that government funding fosters green innovation. Financial frictions restrict market transactions Brunnermeier et al. (2012) and are exacerbated by EPU, potentially reducing firms' green innovation efforts (Caselli & Gennaioli, 2013). However, government support—through tax breaks, research grants, and other financial aid—helps mitigate these frictions, encouraging investment in green innovation. Defined as firms' ability to adopt sustainable practices for growth and investor returns green innovation may respond differently to EPU depending on government support.

H3: *Government subsidies exacerbate the positive impact of EPU about how green innovation in businesses will be prosecuted.*

Central enterprises, positioned within regional industrial chains, benefit from market advantages, resource integration, and state policy support, rather than competitive market forces. In contrast, non-central enterprises, including privately controlled firms, are more responsive to market dynamics and strategic optimisation. Central enterprises can restructure production chains to adapt to EPU expansion, while non-central firms adjust their resource base more dynamically. Consequently, their approaches to integrating production in response to EPU, particularly in ecological innovation, will differ.

H4: *Central enterprises, compared to non-central enterprises, enhance the positive impact of Economic Policy Uncertainty (EPU) on corporate green innovation activities.*

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RESEARCH METHODS

This study examines the impact of EPU on corporate green innovation, focusing on A-share listed firms on the Shanghai and Shenzhen stock exchanges. It utilises patent application data from 2007 to 2023, aligning the annual EPU index with financial data from these companies. The sample period begins in 2007, as this marks the implementation of new accounting standards for Chinese A-share companies, which redefined certain accounting items. To ensure consistency in variable measurement, the study adopts 2007 as its starting point. For data processing and analysis, EXCEL and STATA software were employed. The methodological approach includes descriptive statistics, correlation analysis, multiple linear regression, and robustness tests.

Variable Measurement and Econometric Models

Data for the moderating variables (government subsidies and financing constraints) and control variables (firm age, CEO compensation, largest shareholder ownership, net profit margin, tangible asset ratio, Tobin's Q, and cash-to-assets ratio) were obtained from the CSMAR, WIND, and CNRDS databases. Patent data, representing the dependent variable of green innovation, were sourced from the China National Intellectual Property Administration's patent query system. The independent variable, EPU, was measured using the EPU index constructed through the annual report text analysis method developed by Huihua Nie, Rui Ruan, and Jisan Shen (Huihua Nie, 2020). Details of these variables are provided in Table 1. The data underwent the following processing steps to ensure reliability and consistency:

1. Firms classified as ST (Special Treatment) or PT (Particular Transfer) during the sample period were excluded.
2. Financial companies were removed from the dataset.
3. Observations with missing variables were eliminated.
4. To mitigate the influence of outliers, all continuous variables were winsorised at the 1% level at both extremes.

This study aims to investigate the impact of perceived EPU on corporate green innovation investment behaviour. The study also explores differences in green innovation investment between central and non-central enterprises. To address these research objectives, four models were employed.

Model-1 $GI_{i,t} = \beta 0 + \beta 1 EPUI_{i,t-2} + \alpha CV_{i,t-2} + \eta t + \eta ind + \eta area + \varepsilon i,t$

Model-2 $GI_{i,t} = \beta 0 + \beta 1 EPUI_{i,t-2} + \beta 2 FS_{i,t} + \beta 3 EPUI_{i,t-2} \times FS_{i,t-2} + \alpha CV_{i,t-2} + \eta t + \eta ind + \eta area + \varepsilon i,t$

Model-3 $GI_{i,t} = \beta 0 + \beta 1 EPUI_{i,t-2} + \beta 2 GS_{i,t} + \beta 3 EPUI_{i,t-2} \times GS_{i,t-2} + \alpha CV_{i,t-2} + \eta t + \eta ind + \eta area + \varepsilon i,t$

Model-4 $GI_{i,t} = \beta 0 + \beta 1 EPUI_{i,t-2} + \beta 2 CE_{i,t} + \beta 3 EPUI_{i,t-2} \times CE_{i,t-2} + \alpha CV_{i,t-2} + \eta t + \eta ind + \eta area + \varepsilon i,t$

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Table 1: Variables Measurements

Constructs	Acronyms	Measurements	References
Dependent Variable			
Green Innovation	GI	"Green invention patent applications+ Green utility model patent applications"	(Zhou et al., 2024)
Independent Variable			
Economic Policy Uncertainty	EPU	"Economic policy uncertainty index"	(Huihua Nie, 2020)
Moderating Variable			
Financial Constraints	FC	"SA index"	(Liu et al., 2017)
Government Subsidies	GS	"Subsidies for bonuses and rewards, Tax incentives, Industrial support, Technological upgrades, Research funding, and Talent acquisition."	(Xiaming et al., 2018)
Central Enterprise	CE	"If a company is classified as a central enterprise, it is assigned a value of 1; if it is not a central enterprise, it is assigned a value of 0."	(Xiaming et al., 2018)
Control Variable			
Firm Age	FA	"Number of years from the company's registration date to the current date"	(Xiaming et al., 2018)
CEO Compensation	CC	"Base salary, Bonuses, Stock options, and Benefits"	(Hall et al., 2016)
Largest Shareholder's Ownership Proportion	LSOP	"Proportion of shares held by the largest shareholder"	(Hall et al., 2016)
Return on Total Assets	RTA	"Net profit/Total Assets"	(Liu Guanchun, 2020)
Tangible Asset Ratio	TAR	"Tangible Asset/Total Assets"	(Liu Guanchun, 2022)
Tobin's Q	TQ	"Market value/Total Assets"	(Liu Guanchun, 2020)
Cash Assets	RCA	"Cash Assets/total assets"	(Liu Guanchun, 2022)

In the four multiple regression models, innovation activities are not immediate, and to address endogeneity, explanatory and control variables are lagged by two periods relative to the dependent variable. Enterprises are i and time is t. GI is measured by the number of GIPA and GUMPA filed by firms. Economic policy uncertainty index is independent. Financial limitations, government subsidies, and central enterprise status moderate. CV include supervisory board shareholding, business age, CEO salary, largest shareholder ownership, return on total assets, tangible asset ratio, Tobin's Q, and cash asset-to-total asset ratio. $\beta 0$ represents constant, $\beta 1$ represents EPU's impact on green innovation, α represents control variable coefficients, ϵ represents random error, and ηt, ηind, and $\eta area$ indicate year, industry, and region fixed effects.

DATA ANALYSIS AND RESULTS Descriptive Statistics

Table 2 shows the key study variables' descriptive statistics. The mean, standard deviation, and median of GI are 0.16, 0.68, and 0, respectively, indicating that Chinese listed companies' green innovation performance is poor with significant variation. EPU ranges from 0 to 6.94444, with a standard deviation of 1.53. These findings show that EPU changed dramatically over 2007–2023, affecting firms. Even with equal macroeconomic conditions, economic policy uncertainty affected enterprises differently. Most control variable estimates match previous studies (Hall et al., 2016;

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Liu Guanchun, 2022; Xiaming et al., 2018). Table 2 summarises these observations.

Table 2: Descriptive Statistics

Variables	OBS	Mean	Minimum	Median	Maximum	Std. Deviation
GI	31073	0.16	0	0	5	0.68
EPU	31073	1.52	0	0	6.94444	1.53
FA	31073	10.05	0	10	23	6.32
CC	31073	999716.19	55000	640000	6075300	1070000
LSOP	31073	0.37	0.0905	0.3662	0.7496	0.15
RTA	31073	0.03	-0.250304	0.024704	0.214821	0.06
TAR	31073	0.97	0.794426	0.982164	1	0.03
TQ	31073	1.74	0.888936	1.430178	6.292739	0.9
RCA	31073	0.15	0.0147619	0.1179487	0.6153846	0.11

Correlation Matrix

Table 3 shows the study variables' correlation matrix. GI and EPU are positively correlated, implying that enterprises spend more in green innovation in response to economic policy uncertainties. This supports the study's hypothesis. No substantial multicollinearity exists because the variables' absolute correlation coefficients are all below 0.5.

Table 3: Correlation Matrix

	GI	EPU	FA	CC	LSOP	RTA	TAR	TQ	RCA
GI	1								
EPU	0.033*	1							
FA	0.021*	0.145*	1						
CC	0.095*	0.101*	0.095*	1					
LSOP	0.047*	0.004	-0.083*	-0.028*	1				
RTA	0.025*	-0.023*	-0.159*	0.180*	0.135*	1			
TAR	0.035*	0.030*	0.034*	0.112*	0.027*	-0.001	1		
TQ	-0.065*	-0.069*	0.007	-0.064*	-0.131*	0.094*	-0.061*	1	
RCA	-0.037*	-0.094*	-0.249*	0.030*	0.035*	0.235*	0.059*	0.106*	1

Note: Values in parentheses indicate t-statistics. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. The values below the main diagonal represent Pearson correlation coefficients.

Hypothesis Testing

To test the research hypotheses, this study employed STATA 17 software to conduct a linear regression analysis between GI and EPU using the OLS method. Industries were classified according to the 2012 standards set by the China Securities Regulatory Commission. To address heteroscedasticity and time-series correlation in the error terms, robust standard errors were applied and clustered at the firm level. Given that economic policies operate at a macro level, individual firms are unlikely to influence these policies directly, thereby reducing the risk of reverse causality between corporate green innovation and economic policy uncertainty. To further mitigate this concern, all explanatory and control variables were lagged by two periods.

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Additionally, fixed effects at the year, industry, and region levels were incorporated to control for potential endogeneity arising from omitted variables. To examine how financial constraints, government subsidies, and central enterprise status influence the relationship between EPU and GI, this study followed the methodologies of Xiaming et al. (2018) and (Liu Guanchun, 2022). Interaction terms were introduced to assess the combined effects of EPU with these moderating variables. Consistent with the recommendations of Hall et al. (2016) and Liu Guanchun (2022), control variables were systematically included in four models to monitor changes in the significance levels of key research variables.

Table 4: Hypothesis Results

Variables	**Model 1 (GI)**	**Variables**	**Model 2 (GI)**	**Variables**	**Model 3 (GI)**	**Variables**	**Model 4 (GI)**
EPU	0.005*** (3.534)	EPU	0.005*** (3.164)	EPU	0.003** (2.109)	EPU	0.004*** (2.637)
		EPU*FC	0.025*** (3.590)	EPU*GS	0.000** (2.011)	EPU*CE	0.019*** (3.192)
		FC	0.147*** (10.045)	GS	0.000*** (14.323)	CE	0.103*** (11.459)
FA	0.005*** (6.839)	FA	0.004*** (9.720)	FA	0.004 (1.405)	FA	0.004 (1.438)
CC	0.018*** (4.770)	CC	0.044*** (12.879)	CC	0.002*** (4.804)	CC	0.002*** (5.359)
LSOP	0.005 (0.160)	LSOP	0.085*** (5.025)	LSOP	0.029*** (8.569)	LSOP	0.040*** (11.717)
RTA	0.050* (1.734)	RTA	0.190*** (6.358)	RTA	0.069*** (3.972)	RTA	0.075*** (4.473)
TAR	0.079* (1.672)	TAR	0.139*** (3.518)	TAR	0.200*** (6.046)	TAR	0.211*** (7.063)
TQ	-0.009*** (-5.750)	TQ	-0.019*** (-12.754)	TQ	0.113*** (2.669)	TQ	0.117*** (2.982)
RCA	-0.045*** (-2.787)	RCA	-0.077*** (-5.192)	RCA	-0.013*** (-7.828)	RCA	-0.016*** (-11.429)
Variables	**Model 1 (GI)**	**Variables**	**Model 2 (GI)**	**Variables**	**Model 3 (GI)**	**Variables**	**Model 4 (GI)**
Province	Yes	Province	Yes	Province	Yes	Province	Yes
Year	Yes	Year	Yes	Year	Yes	Year	Yes
Industry	Yes	Industry	Yes	Industry	Yes	Industry	Yes
Constant	0.228*** (-3.336)	Constant	-0.032 (-0.409)	Constant	-0.310*** (-4.451)	Constant	-0.478*** (-7.015)
N	31073	N	31070	N	29943	N	31072
$\mathbf{R^2}$	0.105	$\mathbf{R^2}$	0.090	$\mathbf{R^2}$	0.108	$\mathbf{R^2}$	0.091

Notes: Values in parentheses indicate t-statistics. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

The analysis reveals that EPU has a significant and positive effect on corporate green innovation investment, supporting the proposed hypothesis. Financial constraints were found to weaken this relationship, whereas government subsidies were shown to enhance green innovation investment in response to economic policy uncertainty. Furthermore, central enterprises were more inclined to engage in green innovation

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under conditions of economic policy uncertainty compared to non-central enterprises. As state-owned1 entities operating in strategic sectors, central enterprises play a crucial role in regional industrial chains, possess substantial market power, and exhibit strong resource integration capabilities, including a responsibility to drive technological innovation. These findings are summarised in Table 4.

Robustness Test

In this study, a two-period lag was applied to all explanatory and control variables to reduce the risk of reverse causality. While reverse causality between macroeconomic policies and corporate innovation activities is unlikely, we further validated our results by using the EPU Index from (Baker et al., 2016) as an instrumental variable for China's EPU Index. The empirical results indicate that the impact of EPU on innovation activities remains significant. It is important to note that the EPU Index from (Baker et al., 2016) is based on monthly data, while our dependent variable—green patent data from listed companies—is annual. Therefore, we converted the monthly EPU Index into an annual measure to align with our analysis. These outcomes are summarised in Table 5.

Table 5: Robustness Results

Variables	GI
EPU(SCMP）	0.000***(6.790)
FA	0.000(0.109)
CC	0.012***(2.844)
LSOP	0.011(0.391)
RTA	0.070**(2.430)
TAR	0.049(1.021)
TQ	-0.008***(-4.432)
RCA	-0.034**(-2.125)
Province	Yes
Year	Yes
Industry	Yes
Constant	-0.033(-0.350)
N	31073
R^2	0.012

DISCUSSION

This paper analyses the influence of EPU on green innovation investments in publicly traded enterprises, while accounting for the moderating effects of financial restrictions, government subsidies, and central SOE status. Analysis of a sample of A-share listed businesses from Shanghai and Shenzhen indicates that firm-level Economic Policy Uncertainty (EPU) positively affects investments in green innovation, aligning with Knightian Uncertainty Theory and Real Options Theory (Watkins, 1922). These findings are consistent with the research of (Bloom, 2007; Peng et al., 2023; Xiaming et al., 2018; Yang et al., 2022), yet contrast with the conclusions of (Cui et al., 2023;

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Ren et al., 2023), and (Zhou et al., 2024), which propose that elevated EPU obstructs investment in green innovation. The differences may stem from variations in EPU measurement, sample range, and control variables used.

Among studies reaching similar conclusions, significant variations exist in participant characteristics, primarily due to differences in EPU measurement techniques. This study employs the Economic Policy Uncertainty Index developed by Nie Huihua and colleagues, which utilises text mining to extract EPU indicators from the annual reports of A-share listed companies. By capturing firms' perceptions of EPU, this approach contributes to the literature on green innovation investment while offering practical insights for future research. Specifically, it provides guidance on adjusting green innovation policies within the Chinese context and sheds light on how different policy frameworks and interacting factors either hinder or facilitate the national transition to a low-carbon economy.

This study underscores the critical role of financial constraints, government subsidies, and central SOE status in shaping the impact of firm-level EPU on green innovation investment. These factors highlight the importance of business conditions and the broader economic environment in influencing corporate innovation commitments. Increased government subsidies significantly support green innovation investments, enabling firms to maintain their competitive advantage while advancing sustainable development objectives. As economic policies operate at a national and macro level, individual firms are unlikely to exert significant influence over them. Consequently, the risk of reverse causality between corporate green innovation (CIT) and EPU is minimal (Xiaming et al., 2018). Nevertheless, robustness tests were conducted to ensure the reliability of the findings. The results confirm that all primary conclusions remain consistent (Model 1), with coefficient signs aligning with those observed in the baseline model. Across various verification methods, the results demonstrate stability. Additionally, Xiaming et al. (2018) provide further validation using alternative indicators.

Overall, the robustness of these results across multiple dimensions highlights the significance of EPU in corporate sustainability, particularly regarding perceived macroeconomic policy uncertainty, financial constraints, public subsidies, and green innovation practices. The findings suggest that a systematic and holistic framework integrating these four factors is essential for informing policy and managerial decisions with sustainability in mind, particularly in the transition towards a circular economy. Policymakers can leverage these insights to refine green innovation policies, thereby enhancing firms' competitive positioning while fostering sustainable economic development.

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IMPLICATIONS

Theoretical Implications:

This study presents a new model exploring the interplay between macroeconomic policy uncertainty, financial constraints, government subsidies, and green innovation practices. It highlights why some firms fail to develop essential green innovations for sustainability and shows that government funding can encourage green innovation during economic policy uncertainty. Central enterprises, with access to government support, are better positioned to fast-track green innovation and integrate into regional industrial chains.

Practical Implications:

The findings provide key policy recommendations for enhancing the sustainability of listed companies in China. As the country shifts towards a circular economy, it is crucial for government agencies to foster a supportive economic environment. Policymakers should increase subsidies for green innovation, reduce financing costs, and alleviate financial constraints to encourage innovation. These measures will stimulate green innovation when firms anticipate increased economic policy uncertainty. Additionally, government reforms that improve operational conditions can support green innovation and lead to industry restructuring, boosting the sector's overall green innovation capacity.

LIMITATIONS AND FUTURE DIRECTIONS

This study acknowledges certain limitations and proposes directions for future research. Firstly, subsequent studies could specifically examine heavily polluting enterprises, where resource recycling plays a crucial role, to provide more nuanced insights into green innovation dynamics. Additionally, while this research focuses on moderating effects, future investigations could explore potential mediating effects, such as those related to corporate social responsibility, financial performance, or risk-taking behaviours, to further deepen the understanding of the mechanisms underlying the relationship between economic policy uncertainty and green innovation. Moreover, as this study is confined to China—a developing economy—future research could extend the analysis to developed countries.

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