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The Impact of Energy-Related Uncertainty on Corporate Investment Decisions in China

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Abstract: This study investigates the impact of the Energy-related Uncertainty Index (EUI) on corporate investment among Chinese non-financial listed companies, focusing on two aspects: the effect of EUI fluctuations on investment behavior, and its differential impact on energy versus non-energy sectors. Utilizing a dataset of 2487 firms from 2007 to 2022, encompassing 22,346 firm-year observations, our analysis reveals that a 1% increase in the EUI leads to a 0.045% decrease in overall corporate investment. Notably, this effect is more pronounced in energy-related firms, where a 1% increase in EUI leads to a 0.057% reduction in investment. In comparison, non-energy-related firms exhibit a milder response, with a 1% increase in EUI resulting in a 0.026% decrease in investment. Given the average annual change in EUI over the sample period [2007–2022] of 27.710%, a 0.045% decrease in investment implies a substantial 1.246% per annum change in investment. This highlights the economically significant impact of EUI fluctuations on corporate investment decisions, particularly during periods of heightened uncertainty. These findings, validated through alternative EUI measures and investment metrics, provide crucial insights for understanding investment behavior under energy uncertainty. Conclusively, our study contributes to the literature by highlighting how energy uncertainty uniquely impacts corporate investment, taking into account the specific financial and operational conditions within different sectors. The findings highlight the importance of incorporating energy policy considerations into corporate strategic planning, particularly for energy-intensive industries within transitional economies like China.

Keywords: energy uncertainty; corporate investment; China; energy sector

Citation: Xie, Z.; Ali, H.; Kumar, S.; Naz, S.; Ahmed, U. The Impact of Energy-Related Uncertainty on Corporate Investment Decisions in China. *Energies* **2024**, *17*, 2368. https://doi.org/10.3390/en17102368

Academic Editor: David Borge-Diez

Received: 4 April 2024
Revised: 8 May 2024
Accepted: 8 May 2024
Published: 14 May 2024

1. Introduction

Corporate investment decisions are important for shaping a firm's market value and, by extension, the wealth of its investors. Consistent evidence from both empirical studies and theoretical models highlights the negative effect of uncertainty on investment decisions. This uncertainty may originate from diverse sources, including fluctuations in input costs and output prices [1,2], macroeconomic instabilities [3], ambiguities in policy environments [4], political fluctuations [5], pandemic-related uncertainties [6,7], energy policy uncertainties [8–10], climate policy uncertainties [11], and environmental regulation uncertainties [12].

Over the past years, the energy sector has experienced notable fluctuations, primarily attributable to various uncertainties such as market dynamics, regulatory changes, and geopolitical factors, profoundly shaping corporate investment strategies. The introduction of the Energy-related Uncertainty Index (EUI) by [10] provides a novel metric to assess these uncertainties by encapsulating changes in energy prices, policy dynamics, and technological advancements. This comprehensive index is crucial for understanding the complex impacts of energy-related uncertainties on corporate decisions, especially within

the Chinese market. Despite existing studies [13–15] highlighting the influence of general uncertainties on investment behaviors, there is a distinct lack of research specifically addressing the implications of the EUI on Chinese firms' investment strategies, which this study aims to address. The Energy-related Uncertainty Index (EUI) is favored for its precise capture of the dynamics and specific uncertainties affecting energy markets, such as geopolitical risks, supply disruptions, and policy shifts. Unlike broader uncertainty measures, the EUI provides a detailed insight into energy market dynamics, enabling a direct assessment of energy-specific shocks. This makes it exceptionally useful for energy economics research, where immediate reactions to energy-related events are critical.

China is chosen for our study due to its significant role as a major global energy consumer and the world's top net energy importer, making it highly sensitive to international energy market fluctuations. In Figure 1, the divergence between energy consumption and production in China since the 2000s highlights a growing dependency on energy imports, driven by rapid industrialization and economic expansion. This trend, illustrating a consistent increase in energy consumption outpacing production, highlights China's escalating demand and its vulnerability to global energy market shifts. This increasing gap between energy consumption and production reflects China's intensive industrial activities and urbanization, pointing to the relevance of studying the impact of global energy uncertainties on China's corporate investment landscape [10].

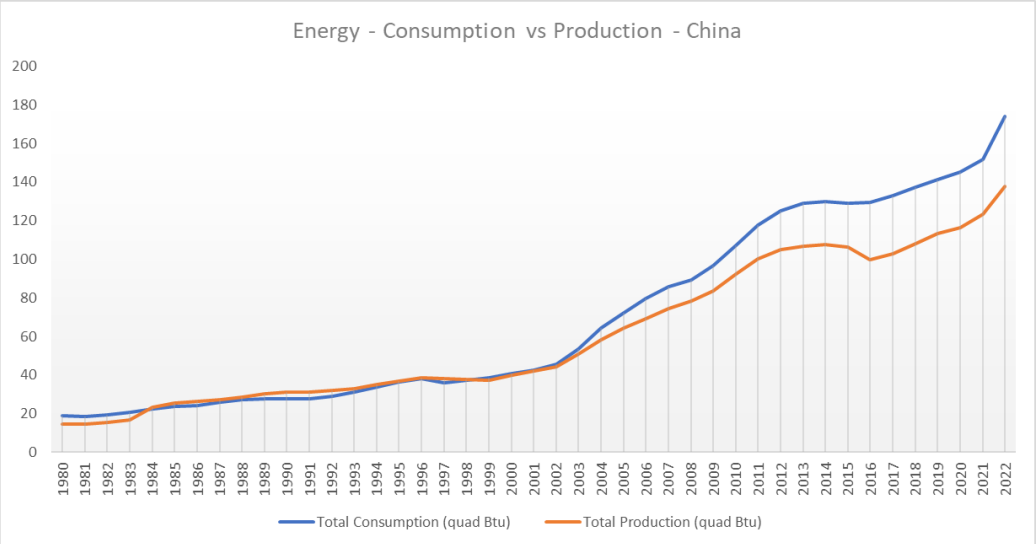

Figure 1. Trends in Energy Consumption vs. Production in China (1980–2022), measured in Quadrillion British Thermal Units (quad Btu). Sourced from https://www.eia.gov/international/data/country/chn (accessed on 3 July 2023).

This study is structured to achieve two primary research objectives: to meticulously evaluate how fluctuations in the Energy-related Uncertainty Index (EUI) impact the investment behaviors of firms and to explore the varying effects of this influence across firms within and outside energy-related sectors. A comprehensive panel dataset of 2487 Chinese non-financial listed companies from 2007 to 2022, including 22,346 firm-year observations (14,447 from energy-related and 7899 from non-energy sectors), forms the basis for this analysis. The results indicate a predominantly negative influence of the EUI on corporate investments, where a 1% increase in energy-related uncertainty leads to a significant 0.045% decrease in investment, keeping other factors constant. This negative impact is more pronounced in energy-related firms (a reduction of 0.057%), which could be attributed to their direct exposure to energy market fluctuations. Conversely, non-energy-related firms, while also negatively impacted, exhibit lower sensitivity to the EUI (a reduction of 0.026%), suggesting that their involvement in energy markets is indirect, primarily affecting them through increased costs and supply chain disruptions. The robustness of these findings is

further validated through alternative measures of EUI and corporate investment, enhancing the study's credibility and its relevance for policymakers and strategists in economies like China [10].

This study stands at the intersection of energy economics and corporate behavior, closely examining the pervasive influence of energy-related uncertainties on firm-level investment decisions. Through the careful utilization of the thoughtfully designed EUI, our analysis not only conforms to but also broadens the horizons of previous studies in energy economics which have typically centered on the effects of energy policies and market uncertainties. More precisely, our research enhances the current understanding of energy economics by employing the newly devised Energy-related Uncertainty Index (EUI) to evaluate the influence of uncertainty on corporate investment in China. This application of EUI distinguishes our work from other studies that have examined the effects of uncertainties like oil-price [15–17], energy policy [18], and climate policy [19] on economic outcomes. By utilizing the EUI, which consolidates different aspects of energy-related concerns, our research offers a more holistic context for comprehending the influence of energy-related uncertainties. It complements findings from [20] by focusing on firm-level impacts rather than broader economic indicators and extends the work of [14] by examining how marketization levels interact with policy uncertainty in the energy sector. Moreover, the EUI's comprehensive nature allows for a comprehensive analysis that can capture the complexity of energy dynamics, making it an invaluable tool for stakeholders to navigate the uncertain energy environment effectively [15,18,20].

Our second significant contribution lies in establishing the link between the Energy-related Uncertainty Index (EUI) and corporate investment within the Chinese context. While earlier studies such as those by [1] have emphasized the broader concept of investment under uncertainty, our research narrows the focus onto energy-specific uncertainties. This study resonates with the findings of [10], who highlight the relevance of energy uncertainty in corporate decision-making. By quantifying the negative impact of EUI on investment, our research provides empirical evidence to support the theoretical propositions of Real Option Theory, suggesting that firms indeed postpone investments given heightened energy uncertainty. This aligns with recent research by [6], who noted that market uncertainties during the pandemic led firms to reconsider their investment strategies, highlighting the timeliness of our results in a period marked by significant uncertainty in energy markets.

Thirdly, our study explores the differential impacts of EUI on energy-related versus non-energy-related firms. While the literature has documented the general effects of uncertainties on corporate investments, such as the works by [4], our research differentiates the degree of impact across sectors. Our contribution here lies in demonstrating how the sensitivity of sectors to energy markets can markedly influence corporate investment decisions, thereby enhancing our comprehension of sector-specific risk profiles. This contribution is significant as it adds depth to the understanding of sector-specific impacts of uncertainty indices, particularly in the energy sector, an important area of study highlighted in the studies by [21] on climate policy uncertainty in the Chinese energy industry.

Overall, these contributions not only enhance our understanding of the complexities involved in corporate investment decision-making in the face of energy uncertainty but also offer timely insights into the increasingly volatile global energy landscape. Such findings hold significant value for policymakers and corporate strategists alike, as they navigate the complex dynamics of energy reliance and economic growth within the rapidly evolving Chinese economy.

The subsequent sections of this paper are structured as follows: Section 2 offers a comprehensive review of essential literature. Section 3 presents an overview of the dataset used in this study, definitions of variables and econometric model. Section 4 discusses the empirical findings. Details regarding robustness tests can be found in Section 5. Finally, Section 6 concludes the study.

2. Literature Review, Goals and Research Hypotheses

2.1. Theoretical Background on Investment under Uncertainty

The literature on the interrelation between corporate investment and uncertainty has been marked by divergent outcomes. As posited in the seminal theory of [22], uncertainty is seen as a catalyst for entrepreneurs to discover and seize investment opportunities, culminating in profit generation through adept resource amalgamation. Thus, it is posited that uncertainty is a conduit for corporate profits. Moreover, economic theories given by [23,24], predicated on perfect competition, constant returns to scale, and symmetrical adjustment costs, postulate that heightened uncertainty may amplify the anticipated profit margin of capital, thereby fostering investment. Empirical backing for this view is found in the study by [25].

Conversely, ref. [26] argues that capital investments are inversely related to escalating uncertainty, particularly when certain economic assumptions are relaxed. This perspective gains further support from the principles of real options theory. This theory suggests that the irreversible nature of many investment projects, often coupled with sunk costs, requires firms to meticulously weigh the benefits of current versus future investments. In conditions of heightened uncertainty, the advantage of deferring investments gains prominence, leading to a reduction in current investment activities. This line of reasoning is corroborated by studies such as those by [27,28], which examine the effects of uncertainty on investment decisions. Adding to this discourse, recent studies have continued to explore this dynamic. For instance, ref. [1] explores the role of market volatility in shaping investment behaviors, arguing that uncertainty can often lead firms to adopt a wait-and-see approach. Moreover, ref. [2] offers insights into how increased uncertainty can act as a deterrent to corporate investments, echoing the sentiments of earlier researchers. These contemporary studies further solidify the argument that uncertainty, particularly in volatile economic environments, can significantly influence corporate investment decisions.

In a related context, ref. [29] employed real options analysis in Information Systems (IS) investments, demonstrating that decision-makers might gain from deferring investments amid uncertainty, echoing the industry's penchant for brief payback periods. Correspondingly, the research by [30] on U.S. manufacturing firms indicated that amplified uncertainty, particularly at the industry level, culminates in diminished firm investment, resonating with real options behavior. Ref. [31] observed a 'real options effect' in corporate investment, where firms encountering more uncertainty and possessing greater managerial agility typically curtailed their current investment outlays. Moreover, the study by [32] on corporate venture capital and acquisition investment approaches revealed that in situations of heightened market uncertainty, firms are more inclined towards venture capital investments over acquisitions, underscoring the sway of real options in uncertain circumstances.

Augmenting this body of literature, ref. [33] scrutinized the repercussions of oil price volatility on investment choices. This study inferred that increased oil price volatility bears a pronounced deterrent effect on the production of durable goods and the oil exploration sectors, vividly showcasing how elevated uncertainty can impede investment, a cornerstone of real options theory. In the context of policy uncertainty, ref. [34]'s examination of the influence of economic policy uncertainty on Australian firms' capital investment lent further credence to this viewpoint. Their investigation highlighted that such uncertainty imposes a protracted, detrimental impact on capital investment. The enduring negative consequence, particularly juxtaposed against more transient effects seen in other markets like the US, corroborates real options theory by exemplifying how investment irreversibility coupled with uncertainty can stifle investment prospects.

Collectively, these studies bolster the premise that escalating uncertainty significantly influences capital investment decisions, often leading firms to defer or diminish investments, a fundamental tenet of real options theory.

2.2. Investment Patterns in the Renewable Energy Sector

Over the years, the influence of uncertainties on corporate investment decisions in the energy sector has been extensively studied, revealing how different forms of uncertainty—from policy to market dynamics—shape these decisions. For example, ref. [35] focused on the power generation sector, where investments are deeply affected by uncertain future climate policies. They quantified these regulatory risks, showing that climate policy uncertainty creates a risk premium for investments, particularly in technologies like carbon capture and storage (CCS). This uncertainty can significantly alter the investment timing and technology choice in power generation. Ref. [19] used a real options approach to analyze how government climate policy uncertainty affects private investors' decision-making in the power sector. Their study revealed that different climate policy scenarios, particularly in terms of carbon pricing, significantly impact investment decisions, illustrating the crucial role of government policy in shaping investment landscapes in the energy sector.

Many studies have explored the impact of energy-price uncertainty, in particular, the oil-price uncertainty as the main proxy for energy-related uncertainty in evaluating its role in corporate investment. For example, ref. [9] examined the effects of energy price uncertainty on firm-level investment, focusing on U.S. manufacturing firms. They concluded that higher energy price uncertainty reduces the responsiveness of investment to sales growth, indicating that firms become more cautious in their investment strategies amid such uncertainty. This effect was more pronounced in high-growth firms, suggesting that energy price volatility can significantly alter the investment landscape for rapidly expanding companies. Ref. [13] discussed the complexities faced by energy managers in public agencies due to conflicting policy objectives and uncertainties in alternative energy technologies. This paper presented a stochastic multi-attribute analytic approach to assist in making informed infrastructure investment decisions under such uncertainties. Ref. [4] highlighted a strong negative relationship between firm-level capital investment and aggregate policy uncertainty, emphasizing that this relationship is more pronounced in firms with a higher degree of investment irreversibility and dependence on government spending. This research highlights the broad impact of policy uncertainty on investment behaviors across sectors, including energy.

In a similar context, ref. [36] examined how uncertainty regarding U.S. Presidential energy-related executive orders correlates with corporate investment and consumption growth. This study proposes a theory explaining that firms invest in energy-efficient capital when facing energy policy uncertainty, affecting both the stock market and the broader economy. A study by [14] examined the effect of economic policy uncertainty on inefficient investment in energy and power firms. They found a notable impact on firms in regions with a low level of marketization, indicating that uncertainty in economic policy could lead to less efficient investment decisions in the energy sector. Moreover, The relationship between oil price uncertainty and corporate investment has garnered significant interest, particularly in how it affects firms' strategic decision-making and investment behaviors. Additionally, ref. [37] conducted a comprehensive study involving over 33,000 firms from 54 countries, showing that crude oil price uncertainty negatively influences corporate investment. Notably, this effect varied based on market and stock characteristics of the firms and was stronger among crude oil producers than consumers, highlighting the global reach of oil price uncertainty and its differential impact across various firm categories.

Ref. [38] revealed that the detrimental impact of crude oil price return uncertainty on investment is asymmetric, with a greater reduction observed following the volatility in positive oil price changes. This impact was found to be more marked in smaller firms and those directly engaged in crude oil and gas production, illustrating the non-uniform response to oil price uncertainty across different sectors. Similarly, ref. [16] scrutinized the effects of three classical oil shocks on Chinese corporate investment using firm-level data. The study also assessed the influence of product market competition on the interplay between oil shocks and corporate investment. The findings underscored that aggregate

demand and specific demand oil shocks adversely affect corporate investment, while oil supply shocks tend to have a positive impact. Notably, corporate investments in energy-related industries showed greater sensitivity to these oil shocks when compared to non-energy sectors. Additionally, the study suggested that intensified competitive pressure might alleviate the effects of oil-specific demand shocks on corporate investment in energy-related fields, albeit with limited impact on other oil shock-investment relationships.

Ref. [39] explored the nonlinear association between oil price uncertainty and corporate leverage, particularly focusing on Chinese listed companies. The study identified a U-shaped relationship, with short-term debt financing being more profoundly influenced, highlighting the extensive financial ramifications of oil price uncertainty. More recently, ref. [17] investigated the link between oil price uncertainty and corporate inventory investments in U.S. manufacturing firms. The research concluded that heightened oil price uncertainty leads to a reduction in inventory investments, suggesting a more extensive influence of oil price fluctuations on various corporate operations and planning aspects. Ref. [15] delved into the impact of oil price uncertainty (OPU) on corporate inefficient investment, discovering a detrimental effect. This negative influence was consistent across both over-investment and under-investment subsets. Their insights align with the principles of real options theory and strategic growth option theory. Furthermore, they pinpointed a truncated debt maturity structure as a key factor in the reduced inefficient investment due to OPU. The study also highlighted that state-owned enterprises, firms with significant financing constraints, and those with lower ownership concentration are more susceptible to the adverse effects of OPU. Additionally, it was noted that OPU stemming from positive oil price shifts has a more pronounced negative impact on inefficient investment.

These studies collectively indicate that a wide range of uncertainties, from policy and economic upheavals to climate change initiatives and energy price variances, have substantial bearings on corporate investment decisions in the energy sector. These findings emphasize the criticality for firms to strategically adapt to these uncertainties and for policymakers to acknowledge their implications in policy formulation and execution.

2.3. Key Changes in Energy Sector of China (2007–2022)

The energy sector in China has undergone significant transformations between 2007 and 2022, marked by substantial policy shifts, rapid technological advancements, and increasing international engagement. These developments have profoundly influenced both domestic and international energy markets.

2.3.1. 2007–2009: Regulatory Foundations and Renewable Initiatives

The journey began in 2007 when China's National Development and Reform Commission released the Medium and Long-term Energy Conservation Plan, which set ambitious targets for reducing energy intensity and emphasized energy conservation as a national priority [40]. In 2009, the Chinese government enacted an enhanced version of the Renewable Energy Law, which introduced detailed measures such as feed-in tariffs and renewable portfolio standards to foster the growth of renewable energy [41]. This period laid the foundational policies that would guide much of the subsequent development in the sector.

2.3.2. 2010–2012: The 12th Five-Year Plan

The 12th Five-Year Plan (2011–2015), announced in 2010 and implemented starting in 2012, focused extensively on reducing carbon emissions, improving energy efficiency, and increasing the proportion of renewable energy in the total energy mix. This plan also introduced significant investments in clean energy, which led to a boom in the solar and wind sectors [42].

2.3.3. 2013–2016: Market Liberalization and Global Integration

In 2013, China began to liberalize its energy market, especially the electricity sector, by introducing reforms aimed at creating a more market-driven mechanism for price setting.

This shift was intended to increase the efficiency and competitiveness of Chinese energy companies [43]. The year 2015 saw the launch of the "Made in China 2025" initiative, which, among other goals, aimed to upgrade the technological capabilities of the renewable energy sector [44].

2.3.4. 2017–2018: Response to International Challenges

The U.S.–China trade tensions that began in 2018 introduced new challenges, including tariffs on imported energy resources and technologies. These tensions pressured the Chinese energy sector, leading to increased costs and disrupted supply chains, thereby injecting a significant degree of uncertainty into the market [45].

2.3.5. 2019–2022: Subsidy Adjustments and International Commitments

The period from 2019 to 2022 was marked by significant policy shifts and international commitments in China's energy sector, reflecting a strategic pivot towards sustainable energy practices and reduced carbon dependency.

In 2020, China revised its approach to renewable energy subsidies, reducing the level of state support to foster a more market-driven renewable energy industry. This move was designed to promote financial sustainability and market-driven competition within the sector.

This policy change introduced some market uncertainty, as stakeholders adjusted to the reduced predictability of government interventions. The reforms were part of broader efforts to stimulate innovation and cost-efficiency within the renewable sector, particularly in solar and wind energy, which continued to see investment and growth despite initial disruptions [46].

In addition to subsidy reforms, China made a landmark pledge in 2021 to achieve carbon neutrality by 2060. This commitment has catalyzed a comprehensive reevaluation of energy and industrial strategies across the board. By 2022, the effects of this pledge were evident as China aggressively expanded its renewable energy capacities, despite the challenges posed by reduced subsidies. The nation's focus on amplifying the role of renewables was part of a broader effort to align its development objectives with global climate change mitigation goals [47]. Furthermore, the year 2022 saw China navigating through the complexities of energy security and economic pressures exacerbated by global events such as Russia's invasion of Ukraine. Despite these challenges, China's energy-related carbon dioxide emissions remained relatively flat, as declines in industrial and transport emissions balanced out increases from other sectors. The stability of these emissions, against the backdrop of economic and geopolitical turmoil, underscored the effectiveness of China's ongoing transition to a cleaner energy matrix and its robust implementation of energy efficiency and renewable initiatives.

Together, these subsidy adjustments and international commitments reflect China's proactive approach to addressing global environmental challenges through national policy adjustments and international cooperation. By fostering a competitive renewable energy market and committing to long-term environmental goals, China is positioning itself as a leader in global efforts to transition to a sustainable energy future. These efforts are crucial not only for China's environmental and economic health but also for global sustainability.

2.4. Research Gap and Objectives

While the current literature regarding uncertainties in the energy sector and their effect on corporate investment decisions is extensive and diverse, as demonstrated by studies such as [9,13,35], and others, there is a notable research void concerning the specific impacts of the Energy-related Uncertainty Index (EUI) on corporate investment strategies, especially in the context of Chinese firms. Existing works like those of [14,37,38], though shedding light on various aspects of energy uncertainties, have yet to delve into the intricacies brought forth by the comprehensive EUI. This gap is increasingly significant given the evolving energy market dynamics, which have extended beyond mere oil price

fluctuations to encompass broader aspects such as energy prices, policies, and technological advancements. The absence of a detailed examination of the recently developed EUI by [10] and its role in the investment decisions within the rapidly transforming Chinese corporate sector underscores the necessity for a more in-depth investigation.

- **Objective 1—Analysis of EUI Impact on Corporate Investment:** This study aims to dissect the impact of the Energy-related Uncertainty Index (EUI), as proposed by [10], on the investment decisions of Chinese corporations.
- **Objective 2—Differential Impact Across Sectors:** The second objective is to assess the varying degrees of the EUI's influence across firms within the energy-related sector compared to those in non-energy sectors. This comparative analysis aims to unravel whether the effects of energy uncertainty, as encapsulated by the EUI, are more pronounced in energy-centric firms or extend significantly to companies in other sectors, thus uncovering the sector-specific nuances in response to energy uncertainties.

The objectives outlined here are designed to provide holistic insights into the ways energy uncertainty, quantified by the EUI [10], influences investment strategies across different sectors and corporate contexts. Ultimately, this study endeavors to deepen the understanding of how energy-related uncertainty shapes the corporate investment landscape, making a significant contribution to both academic research and strategic business planning.

2.5. Theoretical Model

Building upon the reviewed literature, the theoretical model depicted in Figure 2 elucidates the interplay between energy-related uncertainties, corporate investment decisions, and firm characteristics framed within the Real Option Theory. This model contends that the general Energy-related Uncertainty (EUI) significantly impacts Corporate Investment, serving as a critical variable in firm investment valuation and timing considerations. Below is an elaboration of the model and the formulated hypotheses addressing the research questions.

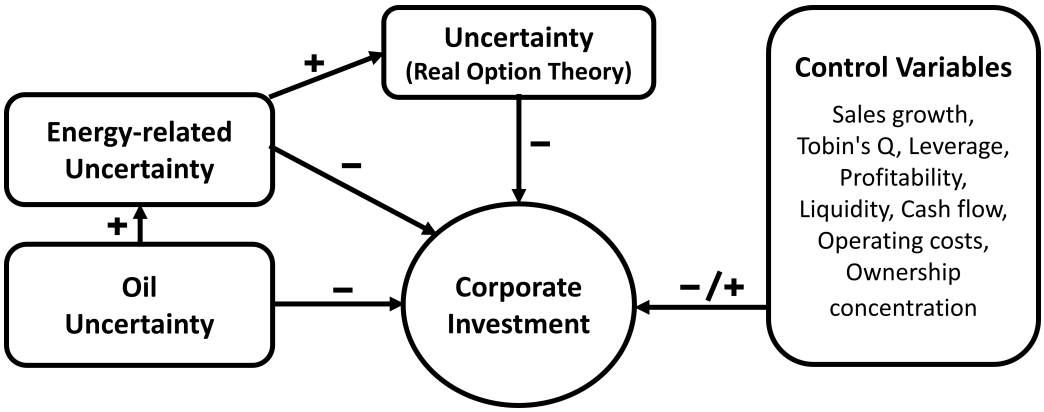

Figure 2. The theoretical model of the study based on existing literature.

Research Question 1: Impact of EUI on Corporate Investment

Informed by existing research (e.g., [16,26,30–33,37]), there appears to be an inverse correlation between EUI and Corporate Investment. This suggests that with escalating EUI levels, firms tend to exhibit diminished investment tendencies. This relationship is often attributed to the 'option value of waiting', where firms, amidst uncertainty, opt to defer investments to preserve flexibility and acquire additional information. Thus, the first hypothesis posited is:

Hypothesis 1. *An escalation in the Energy-related Uncertainty Index (EUI) correlates with a decrease in corporate investment.*

Research Question 2: Sectoral Variation in Response to EUI

The second aspect of the model discerns the differential responses to EUI between energy-related and non-energy-related firms. The presumption is that firms engaged directly in the energy sector may demonstrate a more intense adverse reaction to EUI compared to non-energy sector firms (e.g., [4,9,13–17,19,35–37]). Accordingly, the following hypothesis is proposed:

Hypothesis 2. *The negative influence of EUI on corporate investment is more pronounced in firms operating within the energy sector than in those outside it.*

Consequently, the theoretical framework sets the stage for a comprehensive investigation into the ways energy uncertainties shape corporate investment behaviors across varying types of firms in China.

3. Data, Variables and Research Design

3.1. Data

This section provides an overview of the variables used in our study. As China adopted new accounting standards in 2007, this study excludes samples predating this year in its baseline analysis [4,16,48]. The primary objective is to examine the influence of energy-related uncertainty on corporate investment strategies, focusing on data from publicly traded companies on the Shanghai and Shenzhen stock exchanges over the period from 2007 to 2022. The firm-level data, encompassing variables such as corporate investment scales, and control variables, are extracted from the China Stock Market and Accounting Research (CSMAR) Database. To ensure data integrity, the study implements several exclusion criteria: (1) exclusion of companies listed for less than a year; (2) removal of firm-year observations with incomplete data or those reporting total assets as zero; (3) elimination of companies within the financial sector and (4) exclusion of firms undergoing special treatments or certain transfers. Acknowledging the variations in the number of listed and delisted firms during the study period, an unbalanced panel data approach is adopted. To diminish the skewing effects of statistical outliers, the continuous variables in the study are winsorized at the 1% and 99% levels. Finally, the dataset is consolidated into 22,346 firm-year observations, representing a total of 2487 unique firms. This analysis extends to the investigation of the impact of energy-related uncertainty on corporate investment across diverse industries. Following the methodological approach of [16], the sample is bifurcated into two segments. The first focuses on the energy-related sector, comprising industries such as Energy, Materials, Industrials, Consumer Discretionary, and Utilities, and includes 1601 firms. The second segment explores the non-energy-related sector, featuring industries like Consumer Staples, Health Care, Real Estate, Information Technology, and Telecommunication Services, accounting for 886 firms.

The primary criterion for dividing the sectors into energy-related and non-energy-related is based on the direct and indirect exposure of these sectors to energy market fluctuations and policies. Specifically, energy-related sectors include industries that are either directly involved in energy production or are heavily dependent on energy inputs. Non-energy-related sectors, on the other hand, are less directly impacted by immediate changes in energy prices but may still experience indirect effects. This sectoral classification is grounded in the understanding that energy-related uncertainties have varying impacts depending on a sector's exposure to energy markets. For instance, studies by [49,50] have demonstrated that fluctuations in energy prices can significantly affect sectors with high energy consumption either through cost structures or supply chain dependencies. Our approach is consistent with these findings and aims to isolate the effect of energy uncertainty on sectors differently equipped to absorb or react to energy shocks.

3.2. Main Variables

3.2.1. Energy-Related Uncertainty (EUI)

In this study, the main variable of interest, the energy-related uncertainty index (EUI) of China, is taken from [10] (Data sourced from https://www.policyuncertainty.com/ (accessed on 22 August 2023). The EUI represents a novel approach to measuring uncertainties related to energy markets (Figure 3).

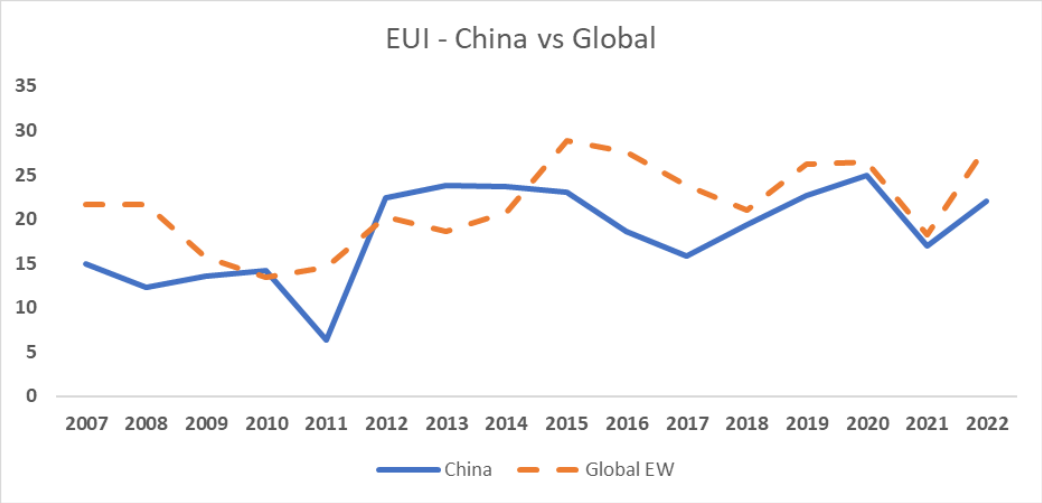

Figure 3. The Energy-related Uncertainty Index (EUI) of China and the global index from 2007 to 2022. The EUI, developed by [10]. Data are sourced from https://www.policyuncertainty.com/ (accessed on 22 August 2023).

The EUI is constructed employing text analysis methods applied to the monthly country reports published by the Economist Intelligence Unit (EIU). These reports are comprehensive documents that cover a wide array of economic, political, and sector-specific information for both developed and developing countries, providing a rich source of qualitative data. The EUI extracts quantitative uncertainty measures from this qualitative content by identifying the frequency and context of occurrences of energy-specific keywords.

Following the methodology extended from [51], the index incorporates a set of predefined keywords related to energy. These keywords include terms such as "oil price volatility", "renewable energy regulation", "energy supply disruption", among others. To enhance the specificity and relevance of the index to contemporary issues, additional keywords capturing energy shocks and crises, such as "energy embargo", "nuclear energy crisis", and "electricity shortage", have been added. The process involves scanning the EIU reports for these keywords and assessing the context in which they appear to gauge the level of uncertainty they signify. This approach ensures that the index reflects real-time changes and sentiments in the energy market, capturing both predictable fluctuations and unexpected shocks. The index is calculated relative to a base year, with a standard base index value of 100, which facilitates easy comparison of changes over time. For a detailed understanding of the specific components and their weights in the EUI calculation, readers are referred to [10].

Given that our data on EUI are recorded on a monthly basis, we convert it into an annual measure by taking the average of the monthly EUI values within each year (Note that following [4,48], we also use time-weighted EUI, giving more weight to the recent months and thereby capturing the most relevant and recent trends in energy uncertainty).

3.2.2. Corporate Investment

Following earlier studies (e.g., [16,38]), we define corporate investment as the expenditure on acquiring fixed assets, intangible assets, and other long-term assets as depicted

in the cash flow statement, divided by the total assets at the conclusion of the preceding year. This metric, which measures the proportion of invested capital relative to the firm's total assets, is denoted as our dependent variable, henceforth referred to as CINV, and is expressed as a percentage. This relative measure facilitates comparisons across firms of varying sizes and asset bases, providing a normalized view of investment intensity.

3.2.3. Control Variables

Drawing from previous studies (e.g., [16,52,53]), we include the following firm-level variables as controls: annual growth in sales, Tobin's Q, debt-capacity, return on total assets, financial leverage, cash reserves, cash-flow, ownership concentration, company size, and administrative costs. The details are provided in Table 1. The selection of control variables is meticulously based on their established influence on corporate investment decisions, as documented in the existing literature. These variables are integral to understanding the broader dynamics of investment behavior while isolating the specific impact of energy-related uncertainty.

Table 1. Variable Definitions.

Variable	Symbol	Definition
Dependent Variable		
Corporate Investment	CINV	Expenditure on fixed assets, intangible assets, and other long-term assets, adjusted relative to total assets at the year end.
Independent [Main]		
Energy-related Uncertainty Index	EUI	Derived from a text analysis of monthly country reports from the Economist Intelligence Unit (EIU).
Independent [Control]		
Financial Leverage	LEVG	Ratio of total debt to total assets.
Cash flows	CFlow	Net cash flow from operating activities divided by total assets.
Return on total assets	ROA	Net profit divided by average total assets.
Administration costs	Adexp	Administrative expenses divided by gross revenue.
Largest equity-ownership holder	T1	Ownership proportion of the largest shareholder.
Equity-ownership concentration	HI5	Herfindahl index of the top five shareholders.
Tobin's Q	TQ	Market value of the firm divided by total assets.
Growth in Sales	SGR	Year-over-year growth in sales.
Liquidity	LIQ	Sum of cash and tradable financial assets divided by total assets.
Borrowing capacity	BC	Proportion of fixed assets relative to total assets.
Firm Size	FSIZE	Natural logarithm of the total assets of the firm.

Annual Growth in Sales, Return on Total Assets (ROA), and Cash Flow are included as they directly indicate a firm's financial health and operational efficiency, which are critical determinants of investment capacity. Tobin's Q is utilized to measure market valuation compared to asset costs, providing insight into whether firms are undervalued or overvalued by the market—an essential factor for investment decisions. Debt Capacity and Financial Leverage reflect a firm's financial structure, affecting its ability to finance new projects, especially under varying economic conditions. Cash Reserves are considered to evaluate a firm's liquidity buffer, which impacts investment during uncertain times. Ownership Concentration is included to account for the impact of shareholder structure on corporate policy and strategy, particularly in investment decisions. Company Size is used to control for the scale effect, as larger companies might have different investment behaviors due to their resources and market influences. Lastly, Administrative Costs are included as they represent operational efficiency, which can free up or constrain resources available for investment.

For clarity and consistency in the analysis, all control variables within this study are either expressed in ratios or as logarithmic values. These include:

- Financial Leverage (LEVG), Cash Flows (CFlow), Return on Total Assets (ROA), Administration Costs (Adexp), Largest Equity-Ownership Holder (T1), Equity-Ownership Concentration (HI5), Tobin's Q (TQ), Growth in Sales (SGR), Liquidity (LIQ), and Borrowing Capacity (BC), all of which are dimensionless ratios. These ratios effectively normalize various financial metrics against total assets or other financial metrics to provide comparative insights across different firms regardless of their absolute sizes.
- Firm Size (FSIZE) is measured using the natural logarithm of total assets, reflecting a logarithmic transformation that helps in managing the wide variations in firm sizes, thus enabling a more meaningful comparison across firms by reducing the skewness often found in raw financial data.

These units of measurement ensure that the variables are appropriately scaled and interpreted within the context of the econometric analyses conducted in this study.

3.3. Descriptive Statistics

Table 2 offers an overview of key variables pertinent to corporate investment and performance. The distribution of these variables demonstrates significant variation, as denoted by their mean, median, and standard deviation values. Corporate Investment, characterized by a mean of 0.061 and a median of 0.040, reveals a right-skewed distribution. This is further supported by a standard deviation of 0.066, suggesting that most firms have lower investments, while a minority invest significantly more. The Energy-related Uncertainty Index exhibits a slightly left-skewed distribution, with a higher mean of 18.400 compared to its median of 18.954, accompanied by a standard deviation of 5.078. Regarding control variables, Return on Total Assets and Cash Flows, with close mean and median values (0.047 and 0.042 for the former, 0.042 and 0.041 for the latter) and moderate standard deviations (0.057 and 0.072, respectively), display a more symmetric distribution, indicative of consistent performance across firms. Conversely, Administration Costs and Liquidity, showing right-skewed distributions (means of 0.096 and 0.196, medians of 0.078 and 0.152, respectively) and high standard deviations (0.079 and 0.145), indicate that while most firms incur lower costs and maintain lower liquidity levels, there are substantial deviations. Growth in Sales, with a high standard deviation of 0.327 and a mean of 0.164, alongside a negative lower quartile, highlights extreme variability and a heavily right-skewed distribution, signifying that while some firms exhibit significant growth, many do not. Financial Leverage, Largest Equity-Ownership Holder, and Firm Size, however, present near symmetric distributions (mean and median values of 0.409 and 0.400, 0.344 and 0.325, 9.108 and 9.058, respectively) with moderate standard deviations (0.206, 0.144, 0.505), reflecting a more uniform distribution across firms.

Equity-Ownership Concentration and Borrowing Capacity also manifest right-skewed distributions (means of 0.162 and 0.218, medians of 0.136 and 0.185) with significant standard deviations (0.112 and 0.161), indicating that most firms have lower concentrations and capacities, yet some possess notably higher values. Tobin's Q, with a considerable mean of 2.346 against its median of 1.759 and a high standard deviation of 2.004, is remarkable for its right-skewed distribution and elevated variability, suggesting a broad spectrum in firm valuation. In sum, the dissection of these financial and operational metrics reveals a multifaceted landscape. While certain metrics exhibit a relatively uniform distribution, others are markedly skewed, with a few firms markedly diverging from the majority, as evidenced by the standard deviations. This diversity is pivotal for comprehending the varying financial health and operational dynamics within the sample.

Table 2. Summary Statistics of Variables.

Variable	Mean	St.dev	25%	50%	75%	Obsv.
CINV	0.061	0.066	0.016	0.040	0.083	22,346
EUI	18.400	5.078	14.721	18.954	22.741	22,346
ROA	0.047	0.057	0.017	0.042	0.075	22,346
Adexp	0.096	0.079	0.047	0.078	0.117	22,346
SGR	0.164	0.327	−0.009	0.118	0.273	22,346
LEVG	0.409	0.206	0.242	0.400	0.564	22,346
T1	0.344	0.144	0.228	0.325	0.444	22,346
HI5	0.162	0.112	0.076	0.136	0.223	22,346
TQ	2.346	2.004	0.990	1.759	3.036	22,346
CFlow	0.042	0.072	0.003	0.041	0.084	22,346
LIQ	0.196	0.145	0.093	0.152	0.256	22,346
BC	0.218	0.161	0.092	0.185	0.312	22,346
FSIZE	9.108	0.505	8.741	9.058	9.419	22,346

Note: This table provides summary statistics of the variables used in the study. Mean, standard deviation, and percentiles are reported for each variable. For more details on the variables and their units of measurement, please refer to Table 1.

3.4. Econometric Model Specification

Following the existing literature regarding the relationship between uncertainty and corporate investment, we employ the two-way fixed effect model for regression:

$$CINV_{i,t} = \alpha_0 + \alpha_1 EUI_{t-1} + \alpha CV_{i,t-1} + \eta_t + \varphi_i + \epsilon_{i,t} \quad (1)$$

In Equation (1), $\text{CINV}_{i,t}$ represents the corporate investment made by firm i in the year t. EUI_{t-1}, represents the energy-related uncertainty index. $CV_{i,t-1}$ represents a vector of control variables, as detailed in Table 1. The η_t denotes the year-fixed effect that helps mitigate the influence of macroeconomic factors, and u_i indicates the firm-fixed effect. Lastly, $\epsilon_{i,t}$ represents the unobservable exogenous error component. In accordance with existing research [16,53], investment is contemporaneously measured, while firm-specific control variables are lagged by one period. This choice is motivated by two reasons: firstly, firms commonly utilize information from the previous year's firm-level variables to inform their investment decisions, and secondly, using firm-level control variables from year $t-1$ may help in minimizing concerns related to endogeneity [53]. For more details on control variables, refer to Table 1 (Note that following [16,54,55], we use the lagged value of uncertainty proxy, which is energy-related uncertainty (EUI) in our case).

3.5. Methods of Diagnostic Analysis

In conducting our panel regression analysis, one of the primary concerns is the potential for multicollinearity among the explanatory variables. Multicollinearity can inflate the variance of the regression coefficients, leading to unreliable and unstable estimates that are sensitive to minor changes in the model. To address this, we conducted a Variance Inflation Factor (VIF) analysis, an essential diagnostic step to detect multicollinearity among predictors. Our analysis revealed that all VIF scores were below the threshold of 5, indicating no substantial multicollinearity [56]. This threshold is well below the commonly used cut-off point of 10, which many scholars suggest as a benchmark for diagnosing problematic multicollinearity [57]. This result supports the independence of our predictors and affirms the reliability of our regression results, aligning with similar findings in studies such as [58] which demonstrated the effectiveness of VIF in identifying variable redundancy in econometric models.

In our initial analysis, we detected concerns related to endogeneity, which could potentially bias our results. Endogeneity in our model could arise due to the simultaneous relationship between corporate investment $(CINV_t)$ and the Energy-related Uncertainty Index (EUI_t) or control variables, where these variables could be correlated with the error term. To test for endogeneity, we utilized the Durbin–Wu–Hausman test which helps in identifying the correlation between endogenous regressors and the error terms, indicating

that estimates from Ordinary Least Squares (OLS) may be inconsistent. Upon confirming endogeneity with this test, we used lagged variables (X_{t-1}) based on recommendations in the literature [16,53,59]. This approach enhances the robustness of our causal inference by assuming that past values of the predictors are less likely to be correlated with the current error term. This methodological adjustment was essential to mitigate the endogeneity issue effectively and was further validated through a re-application of the Durbin–Wu–Hausman test post-adjustment [60]. Although the inclusion of lagged predictors resulted in lower R^2 values, it significantly improved the reliability of our causal analysis. The acceptance of lower R^2 values, favoring more accurate and unbiased estimations, aligns with the econometric research priorities that emphasize the accuracy of causal relationships over the goodness of fit [61].

Furthermore, the issue of stationarity is paramount in panel data analysis, as non-stationary data can lead to spurious regression results. To ensure the robustness of our findings, we performed unit root tests on all panel data series. Following [62], we applied "Levin-Lin-Chu" (LLC) tests which is an extension of the Augmented Dickey–Fuller (ADF) test for panel data. It considers the presence of cross-sectional dependence and heterogeneity among individual units in the panel. The LLC test takes into account both the individual-specific effects and the common time trend in the panel data, making it suitable for panel data settings to confirm that all variables in the model are stationary. This step assures that the relationships identified in our regression models are not due to random walk characteristics of non-stationary data but reflect genuine associations among the variables. Test results show that the EPU series display unit roots, a typical feature in economic time series, requiring additional transformation to attain stationarity. To address this, we utilize a log transformation, refining the data into a stationary series (for brevity, the results of stationary tests regarding all the variables and transformation are not included here but can be provided upon request).

In our fixed-effects panel data analysis, we address the potential for heteroscedasticity and autocorrelation, which are common concerns in such studies. Heteroscedasticity occurs when the variances of the error terms are unequal across different observations, potentially leading to inefficient and biased estimates of standard errors. To correct for heteroscedasticity, we employ robust standard errors that adjust for this inconsistency, ensuring that our estimates of the coefficients remain valid even under the presence of non-constant error variance. Furthermore, given the panel nature of our data, it is also crucial to account for the within-firm correlation of the error terms, as observations within the same firm across different years are likely not independent. We address this issue by clustering our standard errors at the firm level, a method extensively discussed in the literature [63]. This adjustment is vital for correcting any within-group error correlation, thereby providing more precise and reliable inference. These methods significantly enhance the robustness of our statistical assessments and are aligned with the best practices in econometric analysis for dealing with panel data. The inclusion of robust standard errors and the clustering of these errors at the firm level are recommended to achieve more accurate and reliable estimates, particularly in the presence of heteroscedasticity and autocorrelation [64].

By implementing these corrective measures, our study adheres to rigorous econometric standards, ensuring that our findings are both robust and credible. These practices are not only pivotal for enhancing the quality of the statistical inference but also enhance the credibility and applicability of our findings to real-world economic phenomena.

4. Results and Discussion

4.1. Impact of Energy-Related Uncertainty Index (EUI) on Corporate Investment

In this study, we utilize a panel regression model for our empirical analysis (We conduct the [65] test to confirm the suitability of the panel regression model with fixed effects for our empirical investigation. While the detailed results of this test are not presented here, they can be obtained on request). The regression results are presented in Table 3 with three specifications. Model 1 is estimated without including any control variables. It provides

insight into the relationship between the dependent variable (corporate investment) and the main explanatory variable (EUI—energy-related uncertainty index) in isolation, without considering any potential confounding factors. In Model 2, control variables are included, but the EUI is excluded. By incorporating control variables, the aim is to account for other factors that may influence corporate investment, such as financial leverage, cash flows, firm size, etc. However, EUI is intentionally omitted to assess the impact of control variables without the influence of energy-related uncertainty. However, Model 3 incorporates both the EUI and the control variables. It provides a comprehensive analysis by considering the impact of both EUI and control variables simultaneously on corporate investment. This allows for a more comprehensive understanding of how energy-related uncertainty and other factors jointly affect corporate investment decisions.

A notable finding from both Model (1) and (3) is the negative coefficients observed for EUI -0.057 and -0.045, respectively, both significant at 1% level, indicating a statistically significant inverse relationship between energy-related uncertainty and corporate investment, with a 1% increase in energy-related uncertainty corresponding to a 0.045% decrease in corporate investment, keeping other factors constant. The Adjusted R^2 values (0.076 for Model 1, 0.124 for Model 2, and 0.141 for Model 3) indicate that including control variables and EUI provides a more comprehensive understanding of the factors influencing corporate investment. Model (3) explains a higher proportion of the variance in corporate investment compared to the other models.

In the continuation of our exploration of the dynamic interplay between the Energy-related Uncertainty Index (EUI) and Corporate Investment (CINV), our empirical model (3) provides intriguing insights into how certain firm-level control variables interact within this relationship. As we explore the specifics of the model's output, each variable's coefficient offers a narrative that aligns with, or in some instances, challenges traditional economic theories.

For example, the Return on Assets (ROA) emerges with a positive coefficient, suggesting that higher profitability is associated with increased corporate investment. This is attributed to the greater availability of internal funds from higher profits, which can be allocated towards investment without the need for external financing. Such an assertion is consistent with established financial literature that views profitability as a primary driver for investment decisions [66]. Contrastingly, the Sales growth (SGR) did not show a statistically significant impact on investment in the presence of other factors. This does not negate the importance of sales growth as an indicator of a firm's performance, instead, it may indicate that investment decisions are not driven solely by recent sales performance or that the effect of sales growth is captured by other variables in the model. This can align with perspectives that view sales growth as a less direct influence on investment compared to more immediate financial indicators [16,67,68].

Administration costs have a significant positive coefficient, suggesting that higher administrative expenses relative to revenue correlate with increased corporate investment, which may appear unconventional. However, this could be interpreted within the framework that firms are investing in administrative capabilities that may drive future growth and efficiency improvements. Such investments may encompass advanced information systems and human capital that can improve operational effectiveness and strategic decision-making. This is consistent with the resource-based view, which posits that firms invest in resources and capabilities to improve efficiency and competitive advantage [69].

Leverage (LEVG) stands out with a negative coefficient. The negative association between leverage (LEVG) and investment reinforces the risk-averse nature of firms with high debt levels, which aligns with the trade-off theory of capital structure. Firms with higher debt levels may face constraints on their investment capabilities due to higher costs of financing and potential financial distress, which can lead to constraints on new investments [70]. Moreover, the borrowing capacity (BC) in the model, shows a negative coefficient. Economically, this could reflect that a significant portion of their assets tied up in fixed assets might have a lower debt capacity as lenders may be reluctant to extend

additional credit due to perceived higher risk. This could limit the firm's ability to borrow for expansion, investments, or working capital needs. This finding is consistent with the trade-off theory of capital structure, which indicates that firms will strategically balance the benefits of borrowing against the risk of financial distress [71].

Table 3. Regression Results of the Impact of Energy-related Uncertainty on Corporate Investment.

Variable	(1)	(2)	(3)
EUI	−0.057 *** [0.000]		−0.045 *** [0.000]
ROA		0.078 *** [0.000]	0.075 *** [0.000]
Adex		0.029 ** [0.059]	0.030 ** [0.051]
SGR		0.001 [0.589]	0.001 [0.549]
LEVG		−0.032 *** [0.000]	−0.031 *** [0.000]
T1		0.088 *** [0.000]	0.088 *** [0.000]
HI5		−0.087 *** [0.000]	−0.088 *** [0.000]
TQ		0.007 *** [0.000]	0.007 *** [0.000]
Cflow		0.041 *** [0.000]	0.041 *** [0.000]
LIQ		0.009 ** [0.034]	0.009 ** [0.031]
BC		−0.112 *** [0.000]	−0.113 *** [0.000]
FSize		0.003 [0.271]	0.003 [0.267]
Constant	−0.039 *** [0.000]	−0.052 *** [0.000]	−0.058 *** [0.000]
Firm FE	Yes	Yes	Yes
Time FE	Yes	Yes	Yes
No. of obs.	22,346	22,346	22,346
Adjusted R^2	0.076	0.124	0.141

Note: The table presents the estimated results of the impact of energy-related uncertainty index of [10] on corporate investment. Each row represents a different variable, and each column represents a different regression model. Model (1) is estimated without including any control variables. It provides insight into the relationship between the dependent variable (corporate investment) and the main explanatory variable (EUI—energy-related uncertainty index) in isolation, without considering any potential confounding factors. In Model (2), control variables are included, but the energy-related uncertainty index (ERU) is excluded. Model 3 incorporates both the energy-related uncertainty index (EUI) and the control variables. 'Yes' under 'Firm FE' and 'Time FE' indicates the inclusion of firm and time-fixed effects in the regression models, respectively. 'No. of obs.' refers to the number of observations used in each regression, providing insight into the sample size. Additionally, 'Adjusted R^2' represents the adjusted coefficient of determination for each model, indicating the proportion of variance in the dependent variable explained by the independent variables, adjusted for the model's degrees of freedom. Moreover, significance levels are represented by *** for the 1% level, and ** for the 5% level, corresponding to the coefficients.

Upon further investigation into market dynamics, the variable for the largest equity ownership holder, T1, exhibits a positive coefficient. This suggests that a higher ownership proportion by the largest shareholder is associated with increased investment. This may reflect that concentrated ownership can result in more decisive and efficient decision-making regarding investment opportunities, aligning with the principal-agent theory

which suggests that concentrated ownership reduces agency conflicts and could encourage investment that aligns with the principal's interests [72]. Moreover, larger shareholders may have greater power to influence the firm's strategic decisions and are typically more motivated to enhance firm value, a concept supported by theories of ownership structure and firm performance [73]. On the other hand, the negative coefficient for the Herfindahl Index, a measure of market concentration, implies that firms in more competitive markets tend to invest more. This may be attributed to competitive pressures that drive corporations to invest in innovations and market expansions to maintain or increase their competitive edge [74].

Tobin's Q has a positive coefficient, suggesting that firms with higher market valuation relative to their asset replacement cost are likely to invest more. This relationship is well-supported in economic theory where a higher Tobin's Q value is typically interpreted as a signal of growth opportunities requiring investments [75]. Moreover, a positive coefficient for cash flow is consistent with the pecking order theory, which suggests that firms prefer to finance investments internally if possible. Ample cash flow provides the means to fund investments without resorting to external financing, which can carry additional costs or signaling issues [66].

Lastly, Liquidity (LIQ) and Firm Size (FSize) both register positive coefficients. The positive impact of liquidity on investment is expected as liquid assets provide firms with the flexibility to make timely investments, reduce dependency on external capital, and mitigate the effects of market frictions [76]. Finally, the positive coefficient on firm size (FSize) suggests that larger firms tend to invest more, which can be attributed to their broader access to capital markets and the benefits of economies of scale that can reduce the costs of investment, making large investments more cost-effective [77].

The results from Model (3) align with economic theory, even though some coefficients might initially seem counterintuitive. These findings highlight the complex impacts of administrative efficiency, ownership structure, and capital constraints on investment decisions, especially in the face of energy uncertainty.

Overall, these results indicate the impact of energy-related uncertainty (EUI) on corporate investment. The findings show that as EUI increases, there is a notable decrease in corporate investment. This inverse relationship is consistent across different model specifications, suggesting a robust connection between these variables. This pattern is consistent with the findings of previous studies in the field. For example, ref. [9] in their study on U.S. manufacturing firms, found that higher energy price uncertainty made firms more cautious, reducing their responsiveness of investment to sales growth. Additionally, the study conducted by [4] highlighted a strong negative relationship between policy uncertainty and corporate investment, suggesting that uncertainties in government policies, which include energy policies, can depress corporate investment by inducing delays due to investment irreversibility.

In conclusion, the regression results, in conjunction with existing literature, strongly indicate that energy-related uncertainty is a significant and influential factor in corporate investment decisions. This insight is particularly relevant in guiding policy and business strategy, underscoring the importance of stability in the energy sector for fostering a conducive environment for corporate investment.

4.2. Impact of EUI on Energy-Related Firms

Table 4 presents the results for energy and non-energy-related firms. Starting with the overall benchmark, the EUI shows a significant negative impact on corporate investment (Coefficient $= -0.045$). This suggests that higher energy-related uncertainty is associated with a decline in corporate investment across the entire sample. However, in energy-specific firms, the negative impact of EUI on investment is even more pronounced (Coefficient $= -0.057$, significant at 1% level). This heightened sensitivity in energy firms could be attributed to the direct exposure these firms have to energy market fluctuations. When comparing these results with Non-energy-related firms, we see that while still neg-

atively impacted, non-energy-related firms show comparatively lower sensitivity to EUI (Coefficient $= -0.026$, significant at 1% level). This variation suggests that although energy uncertainty influences non-energy firms, the effect is less severe compared to energy firms. This may result from their indirect involvement in energy markets, highlighting that non-energy sectors are impacted by energy uncertainty primarily through heightened costs and disruptions in the supply chain.

An important observation in our results is notable variances in the significance levels of several control variables between energy-related and non-energy-related firms. These discrepancies may be partially attributed to the differential exposure of these sectors to energy market fluctuations and their respective operational characteristics.

For non-energy-related firms, the lower significance levels observed in certain control variables could be indicative of a more diversified range of factors influencing investment decisions beyond those captured by the model. Given the broader scope of industries within this segment, it is likely that sector-specific determinants of investment, which are not contained by our model, play a substantial role. Second, the inclusion of lagged variables in our study addresses the time lag between changes in independent variables, like economic conditions or market developments, and their impact on corporate investment decisions. This temporal consideration is essential, recognizing that investment responses unfold gradually due to factors such as planning horizons, budget cycles, and execution delays. For non-energy firms, which are less immediately affected by shifts in the energy sector, the lagged effects of predictors, including EUI, may be less pronounced. This is because their investment decisions are influenced by a broader set of long-term strategic considerations beyond energy uncertainty, potentially leading to reduced immediate significance of some control variables. In contrast, energy-related firms, directly linked to energy market conditions, may show more immediate responses to EUI changes. As a result, the lagged predictors in the model for energy firms could demonstrate stronger correlations with investment behaviors, reflecting their operational realities and yielding higher significance levels.

Additionally, the variance in the number of observations between the two groups—14,447 for energy-related and 7899 for non-energy-related firms—may contribute to the differences in statistical significance. A larger dataset, as is the case with energy-related firms, typically provides more information and can result in higher statistical power to detect effects. The non-energy category is quite diverse, including sectors ranging from healthcare to technology. This diversity means that investment decisions are influenced by a variety of factors, such as regulatory changes and technological advancements. As a result, the influence of energy uncertainty might be less distinct in this group, leading to less significant levels for the control variables in the model. On the other hand, energy-related companies, which are more uniformly impacted by energy prices and policies, show a more consistent response to the control variables due to their direct connections to energy market dynamics.

Results show that the explanatory power of the models varies, with the energy-related firms model showing a slightly higher Adjusted R-squared value (0.152) compared to the overall (0.141) and non-energy (0.128) models. This indicates that the model for energy-related firms better explains the variability in corporate investment compared to others. This higher explanatory power in energy firms suggests that factors like EUI play a more critical role in these firms' investment decisions. In contrast, non-energy firms, while still affected, have additional diverse factors influencing their investment decisions, as indicated by the relatively lower Adjusted R-squared value.

The lower adjusted R^2 value in the model for non-energy firms compared to that for energy firms does not necessarily mean that the EUI has a weaker impact on investment decisions for these firms. Instead, this value indicates the portion of variability in corporate investment explained by the model's predictors. In the case of non-energy firms, the lower adjusted R-squared suggests that factors other than energy uncertainty, represented by the EUI, may have a more significant influence on investment decisions. This difference could stem from non-energy firms having less direct exposure to energy market fluctua-

tions, which impact energy-focused companies more severely. Additionally, non-energy firms might have industry-specific variables affecting investment behaviors that are not accounted for in the current model.

Table 4. Regression Results: Energy-related versus Non Energy-related.

Variable	Overall	Energy-Related	Non Energy-Related
EUI	−0.045 *** [0.000]	−0.057 *** [0.000]	−0.026 *** [0.000]
ROA	0.075 *** [0.000]	0.094 *** [0.000]	0.038 *** [0.000]
Adex	0.030 * [0.051]	0.034 ** [0.049]	0.023 * [0.073]
SGR	0.001 [0.549]	0.001 [0.589]	−0.001 [0.898]
LEVG	−0.031 *** [0.000]	−0.041 *** [0.000]	−0.016 * [0.072]
T1	0.088 *** [0.000]	0.091 *** [0.000]	0.076 * [0.067]
HI5	−0.088 *** [0.000]	−0.097 *** [0.000]	−0.069 * [0.092]
TQ	0.007 *** [0.000]	0.005 *** [0.000]	0.008 *** [0.000]
Cflow	0.041 *** [0.000]	0.052 *** [0.000]	0.022 * [0.088]
LIQ	0.009 ** [0.031]	0.004 ** [0.034]	0.018 ** [0.031]
BC	−0.113 *** [0.000]	−0.124 *** [0.000]	−0.099 *** [0.000]
FSize	0.003 [0.267]	0.001 [0.371]	0.005 * [0.082]
Constant	−0.058 *** [0.000]	−0.031 [0.112]	−0.072 *** [0.000]
Firm FE	Yes	Yes	Yes
Time FE	Yes	Yes	Yes
No. of obs.	22,346	14,447	7899
Adjusted R^2	0.141	0.152	0.128

Note: The table presents the estimated results of the impact of energy uncertainty on corporate investment for energy-related and non-energy-related firms. See Table 1 for more details on the variables. The *p*-values are provided below the coefficient of each variable within square brackets. Significance levels are represented by *** for the 1% level, ** for the 5% level, and * for the 10% level, corresponding to the coefficients.

Overall, the comprehensive analysis of corporate investment behavior, influenced by energy-related uncertainties, sheds light on the differing responses between energy and non-energy sectors. In line with the economic theory, the application of lagged predictor variables indicates temporal dispersion in investment reactions-energy firms respond more immediately to fluctuations, likely due to their direct linkages to energy markets, resulting in more significant control variables and higher adjusted R-squared values [67,71]. Non-energy firms, affected by a wider array of factors and exhibiting a delayed response as captured by the lagged variables, show reduced significance levels, which is consistent with the concept of investment decisions being spread over time due to operational and planning constraints [78]. The contrast in observational data volume further nuances these distinctions. This comprehensive understanding aligns with economic principles that posit sectoral characteristics and temporal dynamics as pivotal in influencing corporate investment under uncertainty [75]. Future research should consider these dynamics, incor-

porating sector-specific and temporally sensitive models to enhance the predictive power and relevance of economic analyses.

Furthermore, our results not only align with economic theory but also align with recent scholarly findings, particularly regarding the influence of energy-related uncertainty on corporate investment, as highlighted in our study. For example, ref. [21] in their examination of climate policy uncertainty within the Chinese energy industry, revealed that policy fluctuations significantly influence firm investment decisions in energy sectors. This study supports our findings, especially the more pronounced negative effect of EUI on investment in energy-specific firms, by illustrating how external policy environments create an atmosphere of caution among these firms, leading to restrained investment behaviors. Similarly, the study by [79], which explores the effects of fiscal policy uncertainty on corporate innovation investment in China's new energy industry, offers corroborating evidence. They found that fiscal uncertainty adversely impacts innovation investment, echoing our observation of a significant negative relationship between EUI and corporate investment across sectors. This research is particularly telling in the context of non-energy firms, where our study noted a comparatively lower but still significant sensitivity to EUI, highlighting the broader reach of energy-related uncertainties beyond the immediate energy sector.

Additionally, the asymmetrical effects of uncertainties like oil price fluctuations, as explored by [80], further substantiate the differential impact of EUI on energy and non-energy firms. Their focus on renewable energy companies in China under the lens of oil price uncertainty provides a parallel to our findings, showing how such uncertainties have a more substantial impact on sectors directly involved with energy, thereby offering a nuanced understanding of investment behaviors in these sectors. This is complemented by the work of [14], which explores the ramifications of economic policy uncertainty on inefficient investments in energy and power industries. Their insights into how this uncertainty influences energy-related firms resonate with our observations, particularly regarding the amplified effect of EUI in energy-related firms as compared to their non-energy counterparts, thereby adding another layer of validation to our results.

In summary, these studies collectively reinforce our findings, underlining the significant and varied impacts of energy-related uncertainties on corporate investment decisions across different sectors. They provide a broader academic context that validates the nuances and complexities captured in our analysis.

5. Robustness Analysis

5.1. Alternative Energy Uncertainty Measures

In addressing the potential endogeneity of the Energy-related Uncertainty Index (EUI), our study aligns with the approach suggested by [81] and adopts an instrumental variable methodology. This involves using a lagged U.S. EUI variable, selected due to its close association with China's EUI, as reflected by a correlation coefficient of 0.610. The interconnection between the EUI in the United States and the uncertainty within China's EUI is critical, considering the substantial spillover effects of the U.S. economy on emerging economies, as highlighted in the existing literature. Our empirical findings, as reported in Table 5, demonstrate a strong alignment with our primary results presented in Table 3. The Wu–Hausman F tests lend credence to the effectiveness of this approach in mitigating potential endogeneity issues by employing the U.S. EUI as an instrumental variable.

In summary, this methodological approach allows for a more nuanced exploration of the direct impact of EUI on corporate investment while addressing potential endogeneity concerns. The consistent observation that an elevation in EUI corresponds to a decline in corporate capital investment substantiates the central premise of our study. This effect is in contrast to the expected increase in investment under more stable conditions. Such findings reinforce our initial hypothesis regarding the adverse effects of EUI on corporate investment, adding a layer of robustness to our research and contributing valuable insights to the broader discourse on energy uncertainty and corporate investment dynamics.

Table 5. Robustness Analysis: Instrumental Variable.

Variable	(1)	(2)
EUI	−0.061 ***	−0.047 ***
	[0.000]	[0.000]
ROA		0.079 ***
		[0.000]
Adex		0.028 **
		[0.059]
SGR		0.001
		[0.589]
LEVG		−0.031 ***
		[0.000]
T1		0.088 ***
		[0.000]
HI5		−0.086 ***
		[0.000]
TQ		0.008 ***
		[0.000]
Cflow		0.042 ***
		[0.000]
LIQ		0.009 **
		[0.034]
BC		−0.112 ***
		[0.000]
FSize		0.002
		[0.271]
Constant	−0.039 ***	−0.053 ***
	[0.000]	[0.000]
Wu–Hausman F test	0.139	0.139
Firm FE	Yes	Yes
Time FE	Yes	Yes
No. of obs.	22,346	22,346
Adjusted R^2	0.074	0.123

Note: The table presents the estimated results of the impact of energy-related uncertainty index (EUI) on corporate investment for Chines Firms based on instrumental variable approach. The definition of variables can be found in Table 1. The *p*-values are provided below the coefficient of each variable within square brackets. Significance levels are represented by *** for the 1% level, and ** for the 5% level, corresponding to the coefficients.

5.2. Placebo Tests

In order to ensure the reliability of our findings and minimize the impact of random elements, we conduct a placebo test. This involves substituting the actual EUI variable with ∼EUI, which is randomly selected from the sample distribution of real EUI. By implementing this random allocation of EUI across the entire sample, we re-run our baseline regression 100 times. In unreported results, the average coefficient estimates for ∼EUI are close to zero (0.0001) and are insignificant, implying that our primary findings withstand the placebo test.

6. Conclusions, Practical Significance and Future Directions

6.1. Conclusions

This study has systematically examined the significant effects of fluctuations in the Energy-related Uncertainty Index (EUI) on corporate investment within Chinese non-financial listed companies. Our extensive dataset covering 2487 firms from 2007 to 2022, comprising 22,346 firm-year observations, provides a robust basis for our analysis. The results indicate that a 1% increase in the EUI leads to a reduction in corporate investment by 0.045% on average. This effect is more pronounced in energy-related firms, where the same 1% increase in the EUI causes a 0.057% decrease in investment, compared to a 0.026%

decrease in non-energy sectors. This differential impact highlights the particular sensitivity of energy-related firms to energy market uncertainties. Over the entire sample period, the average annual EUI increase of 27.71% corresponds to a significant 1.246% annual reduction in corporate investment. This quantification not only substantiates the tangible impact of energy-related uncertainty on investment decisions but also illustrates the macroeconomic implications of such dynamics, particularly in a rapidly growing and evolving economy like China's.

The robustness of these conclusions is reinforced by corroborative evidence obtained through alternate EUI measurement methods, enhancing the credibility of the study. The insights garnered are invaluable for policymakers and corporate strategists, providing an in-depth comprehension of the interplay between energy-related uncertainties and corporate investment activities, particularly in the evolving economic context of a nation like China. This research not only augments the body of knowledge in energy economics and corporate investment but also serves as a strategic guide for business leaders and policymakers confronting the complexities introduced by energy-related uncertainties. The findings highlight the need for customized strategies that consider the unique characteristics of firms, especially those operating in energy-intensive industries, to make well-informed investment decisions in an increasingly uncertain global energy market.

6.2. Practical Significance

The results of our study carry significant practical implications for a range of stakeholders in both corporate and policy-making arenas, especially within the dynamic context of China's evolving energy sector. These implications span several key areas:

1. **Corporate Investment Strategy:** The identification of a negative relationship between EUI and corporate investment is of vital importance for business leaders. Firms, especially those in the energy sector, can apply this insight to tailor their investment strategies in the face of variable energy uncertainty. Strategies might include diversifying investment portfolios, enhancing risk management measures, or postponing investments until periods of lower uncertainty.
2. **Policy Formulation:** These findings can be instrumental for policymakers in developing and refining energy policies aimed at stabilizing the energy market and mitigating uncertainties. Recognizing the differential impacts on diverse firm types, policies can be tailored to support sectors or businesses more vulnerable to energy uncertainties.
3. **Investment in Renewable Energy:** As the importance of sustainable energy sources grows, our research provides pivotal guidance for investments in renewable energy initiatives. Understanding the influence of energy uncertainties on traditional energy sectors aids investors and corporations in diversifying their portfolios, including investments in more stable renewable energy ventures.
4. **Risk Management for Investors:** For investors contemplating entering the Chinese market or investing in energy-related stocks, this study offers crucial insights for a more nuanced risk assessment. Knowledge of how different firms react to energy uncertainties enables investors to make more judicious investment decisions.
5. **Global Implications:** While the focus of the study is China, the implications are globally pertinent, given China's significant role in the global energy market. International firms and investors can use these insights to better navigate the global energy landscape and understand the impact of energy uncertainties on investment behaviors in other emerging economies.

In summary, the practical importance of this study lies in its capacity to enlighten and improve decision-making processes across a wide range of domains, spanning from corporate strategic planning to public policy, investment decisions, and global market analysis.

6.3. Research Limitations

While this study covers a broad scope, it acknowledges the specific limitations that contextualize the interpretation of the findings. One limitation is relying solely on the

Energy-related Uncertainty Index (EUI) as a proxy for energy uncertainty. Although the EUI is thorough, there may be other uncertainties affecting investment decisions that this study did not address. The second limitation is the use of lagged predictor variables, chosen for their theoretical and practical relevance to capture delayed effects on corporate investment. However, the precise lag structure and its implications on investment behavior may require further exploration to ensure the robustness of the findings. Another limitation of this study is its reliance predominantly on quantitative data. Factors like managerial decision-making processes, corporate culture, and consumer sentiments, which could influence investment dynamics in response to energy uncertainty, have not been explicitly considered in the analysis.

The difference in sample sizes between energy-related and non-energy-related firms is another limitation, potentially influencing the statistical power of our analysis. This difference might affect the significance of our results, thereby impacting the comparability and generalizability of our findings across different sectors. Moreover, while we categorized firms as 'energy-related' and 'non-energy-related' based on established industry classifications, this distinction might oversimplify the intricate and sometimes ambiguous relationships these sectors have with energy markets. Additionally, we assumed that control variables remain consistent across sectors. However, given the inherent diversity in firm behaviors and strategic decision-making processes, this uniformity may not always be accurate.

6.4. Future Directions

Looking ahead, future research could address the limitations and build upon the current study's findings. This includes the exploration of firm-specific factors alongside the Energy Uncertainty Index (EUI) in relation to corporate investment. Future studies could investigate the causal mechanisms underlying the observed impacts of the EUI on investment while considering firm-specific factors such as firm size, return on investment, ownership type (state versus non-state), the capital intensity of products, and others. Understanding whether these effects are driven primarily by risk aversion, changes in financing conditions, or other factors would enrich our comprehension of the interplay between energy uncertainty, firm characteristics, and corporate behavior. In addition to this, the role of product market competition in the relationship between EUI and investment can also be explored.

Further granularity could be achieved by categorizing the non-energy sector into more detailed industry categories, shedding light on sector-specific behaviors in response to energy uncertainty. Broadening the scope of our analysis to encompass diverse geographic contexts or sectors could validate the applicability of our findings. By examining firms operating in different regions or industries, we can assess the generalizability of our results. Including additional control variables that capture recent developments in energy markets and corporate governance could further enhance the analysis, offering a more comprehensive understanding across various sectors and geographic areas. Such comparisons across various regulatory and economic landscapes could shed light on how differing levels of energy dependency impact corporate investment behavior amidst uncertain conditions. To further expand on this study's findings, future research could use machine learning methods to forecast investment behaviors, considering a broader array of predictive factors and their intricate relationships. Exploring the long-term effects of policy shifts on corporate investment through longitudinal studies could offer valuable insights. Additionally, comparative analyses across various countries or regions might reveal the broader global impacts of energy uncertainty, providing insights to shape international policy decisions.

Another promising area of research could involve a deeper investigation into the mitigation strategies employed by firms to cope with energy uncertainty. Examining the role of financial hedging, diversification, and technological innovation in buffering firms against the shocks associated with high EUI values could provide valuable insights for risk management practices. Finally, given the ongoing evolution of the global energy

landscape towards renewable sources, there is a compelling need for future research to examine how changes in energy policy and technology impact the Energy Uncertainty Index (EUI) and subsequently influence investment patterns. This inquiry becomes especially relevant in the context of global initiatives aimed at sustainable development and mitigating climate change.

The suggestions for future research emphasize the importance of continuous exploration and refinement in the field of energy economics, especially regarding corporate investment behavior amid increasing energy challenges and environmental considerations.

Author Contributions: Conceptualization, H.A. and S.N.; methodology, H.A. and Z.X.; software, H.A.; validation, S.K. and U.A.; formal analysis, H.A., S.N. and Z.X.; investigation, S.K. and U.A.; resources, Z.X. and U.A.; data curation, S.K.; writing—original draft preparation, S.N. and H.A.; writing—review and editing, Z.X., S.K., S.N. and U.A.; visualization, H.A.; supervision, Z.X. and H.A. All authors have read and agreed to the published version of the manuscript.

Funding: This study was funded by the Humanities and Social Sciences Foundation of the Ministry of Education (18YJA630119).

Data Availability Statement: The original contributions presented in the study are included in the article, further inquiries can be directed to the corresponding author.

Acknowledgments: We extend our heartfelt gratitude to the anonymous reviewers whose insightful feedback and constructive criticism significantly contributed to the enhancement of this manuscript. Their expertise and meticulous evaluation have played a pivotal role in refining the content, clarity, and overall quality of our work. We sincerely appreciate their dedication and invaluable suggestions, which have undoubtedly elevated the standard of our research.

Conflicts of Interest: The authors declare no conflicts of interest.

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