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Beyond Tax Shields: Re-Examination of Sustainable Transition of the Real Estate Sector in China

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Abstract

This study proposes a dual-shield framework to elucidate the capital structure dynamics within China's policy-intensive real estate sector. We delineate a coercive policy shield wherein binding regulations supersede market-based incentives, and a proactive sustainability shield which recognizes how superior environmental performance can lead to reduced financing costs. Analyzing data from Chinese A-share firms during 2003 to 2021, we present robust evidence that supports both mechanisms. Notably, the effect of the debt tax shield is diminished in real estate sectors, underscoring the policy shield's ability to negate traditional financial incentives. In addition, the macroprudential tightening implemented in 2017 has disproportionately disrupted leverage adjustments, especially among firms subsequently affected by the "Three Red Lines" policy. Rigorous quasi-experimental analyses additionally illustrate that green bond issuers experience a significant and enduring reduction in their cost of debt, thereby establishing a substantive sustainability shield. Our findings contribute to the literature on sustainable finance by conceptualizing approaches that extend beyond tax shields, effectively integrating regulatory and market forces to align the capital structures with objectives for sustainable transition.

Keywords: sustainable transition; capital structure; tax shield; real estate sector; policy shield; sustainability shield; China

1. Introduction

The building and construction sector is a critical frontier for global climate action, accounting for over 20% of global energy use and 37% of energy-related carbon emissions in 2024 [1]. With intensifying urbanization, real estate sits at the nexus of sustainable development challenges, where streamlined policy, green building standards, and technology integration are essential for reducing its footprint [2,3]. In China, rising emissions and financial risks stem from outdated development and regulatory shifts [4], which are now being addressed through significant policy interventions.

China's real estate market is central to its economy, historically shaped by high leverage and rapid expansion [5]. This approach now brings both financial and environmental risks. Since 2017, major deleveraging reforms (Appendix A) have targeted these issues. At the same time, building emissions directly affect China's "Dual Carbon" goals [6]. It is important to assess how the capital structure influences both financial and environmental outcomes given these national priorities.

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Consequently, financial governance must evolve to facilitate a sustainable transition. The sector's future hinges on the capital structures that support long-term value creation over speculation, as financial decisions fundamentally shape risk profiles and responses to new regulatory and environmental pressures [7]. The central challenge is to understand how the capital structure is determined in a sector where policy shifts are a first-order determinant.

Canonical corporate finance theories offer contingent explanations. The trade-off theory posits that firms balance debt tax shields against bankruptcy costs [8], while the pecking order theory suggests leverage reflects financing deficits driven by information asymmetry. For China's state-owned enterprises (SOEs), the theory of soft budget constraints predicts high, sticky leverage due to implicit state guarantees [9]. However, in a policy-intensive context like China's real estate sector, the explanatory power of these market-based theories may be fundamentally altered or overridden. This paper investigates two distinct mechanisms that reconfigure financial incentives: a coercive "policy shield", where binding regulation supersedes market-based optimization, and a proactive "sustainability shield" where verifiable environmental performance lowers financing costs.

Unlike the existing literature that often examines policy effects in isolation, this paper emphasizes the heterogeneous amplification of regulatory shift, the disproportionate and sector-specific impact of economy-wide tightening. It moves beyond asking if policy matters to quantifying how much more it matters for the targeted industry. Simultaneously, it tests whether a universal market incentive (the sustainability shield) can emerge to complement coercive policy.

1.1. The Limits of Traditional Theory and the Imperative for an Integrated Framework

For decades, corporate finance theory viewed capital structure choices through a firm-specific lens. Seminal theories, such as the trade-off theory [8,10,11] and the pecking order theory, suggest debt tax shields and information asymmetry drive leverage [12]. The recent work, however, shows these models work only in certain regulatory and institutional contexts [13]. In China, state ownership and banking ties can strongly affect traditional incentives [14–16].

China's real estate sector, subject to potent and recurrent regulatory intervention, exemplifies how institutional forces can supersede standard theoretical predictions. While studies have examined the capital structure in Chinese firms, few have rigorously tested core mechanisms, such as the tax shield effect or the dynamic partial adjustment, within such a high-policy-intensity environment [5,17]. A paramount empirical challenge arises from the regulatory shift itself: it is progressive tightening over several years, necessitating a design that can credibly attribute changes to this cycle rather than concurrent macroeconomic trends [18]. Consequently, a pivotal question emerges: How can policy shift from blunt constraint to a targeted tool that steers sustainable capital structure decisions?

To address this gap, this study employs a three-part analysis to test a novel dual-shield framework. First, it tests whether traditional incentives, such as the debt tax shield, still apply under strict regulation. Second, it investigates whether the leverage adjusting process was disproportionately disrupted in the real estate sector during the regulatory tightening since 2017, identifying a heterogeneous amplification effect. Third, it examines whether a market-based sustainability shield exists by testing if firms with a superior environmental performance receive lower-cost debt. For this universal mechanism, we employ a full-sample test of A-share listed firms to establish its general validity.

This study re-examines the capital structure incentives in China's real estate sector, focusing on sustainability transitions. The main goal is to demonstrate that financial governance must leverage both coercive policy discipline and proactive market incentives to guide capital structure decisions for sectoral transformation [19,20].

1.2. Contribution and Implications

Our study makes three primary contributions. Theoretically, we develop and test a dual-shield framework that integrates institutional perspectives with corporate finance. This framework specifies how coercive regulatory constraints (the policy shield) can override core market mechanisms [21] and how its impact is heterogeneously amplified in targeted sectors. Simultaneously, it conceptualizes a sustainability shield as a proactive, market-aligned incentive [22].

Methodologically, we implement a robust, multi-method identification strategy. We advance the empirical literature by formally testing for differential policy effects across sectors and by using a matched-sample, multi-stage design to establish the sustainability shield, thereby addressing key endogeneity concerns.

Practically, this study argues that broad macroprudential risk management tools are necessary but may not be enough to sustain investment. The study suggests a pathway to create a “sustainability shield”. One example is linking preferential financing terms to verified sustainability performance. By investigating how green outcomes can be incentivized through the capital structure, our analysis highlights a way for policy to use corporate financial incentives to accelerate sectoral transformation [15,23].

The remainder of this paper is structured as follows. Section 2 reviews the literature and develops our analytical framework and hypotheses. Section 3 outlines the research design, data, and methodology. Section 4 presents the empirical results. Section 5 discusses the findings, interprets them through an institutional lens, and elaborates on the implications for sustainability-aligned incentives. Section 6 concludes the paper.

2. Literature Review and Hypothesis Development

2.1. Theoretical Baselines and Their Contingent Application

Canonical corporate finance theories establish contingent baselines for the capital structure. The Modigliani and Miller proposition assumed perfect markets [24,25], but relaxing these assumptions yielded foundational theories. The trade-off theory posits firms balance debt tax shields against distress costs to set the leverage [11,12]. Its core prediction is a positive link between a firm’s marginal tax rate and leverage. Conversely, the pecking order theory suggests a financing hierarchy: internal funds, then debt, then equity, where leverage reflects cumulative financing deficits rather than active ratio targeting [12]. A third perspective, the soft budget constraint theory, predicts state-owned enterprises (SOEs), supported by implicit guarantees, maintain higher, less market-sensitive leverage [16,26].

These theories are most applicable in developed economies with stable governance [27]. In China’s mixed economy, their applicability is moderated: complex tax policies and state ownership can weaken the debt tax shield incentive [28], and top-down regulation can supersede market signals [29]. This highlights a key contingency: when policy becomes the binding constraint, canonical theories may systematically fail, necessitating an integrated framework.

2.1.1. The Chinese Real Estate Sector: A Paradigm of Evolving Regulatory Pressure

China’s real estate sector exemplifies this context. Its high-leverage growth has been repeatedly tempered by stability-focused regulations [17,28–30]. A critical shift began in 2017, moving toward sustained deleveraging under the “Housing is for living, not for speculation” directive [5,18]. This crystallized with the 2020 “Three Red Lines” policy, imposing quantitative leverage thresholds that transformed guidance into enforceable constraints [31]. This environment offers an opportunity to study how intense regulation

affects financial behavior, moving beyond whether classic theories apply to how their influence is subordinated.

2.1.2. An Integrated Framework: The Policy Shield and Sustainability Shield

To explain the capital structure under heavy regulation and sustainability pressure, we introduce a framework centered on two distinct mechanisms: the policy shield and the sustainability shield.

The Policy Shield: A Coercive Constraint Mechanism

This mechanism occurs when binding regulatory constraints override market-based financial motives. Compliance imperatives dominate firm objectives, implying (1) the attenuation of traditional incentives—e.g., the debt tax shield is subordinated to leverage caps, and (2) the disruption of market-driven dynamic processes [32,33], such as gradual leverage adjustment.

The Sustainability Shield: A Proactive Incentive Mechanism

The sustainability shield harnesses market logic by internalizing sustainability, linking good environmental performance to better financing terms, such as green bonds or sustainability-linked loans [34,35]. Unlike the policy shield, which constrains, this shield incentivizes by making sustainability financially valuable. This market-based incentive can operate across sectors, providing a potential complement to coercive policy [36].

By introducing this framework, we address the theoretical gap concerning when and how market-based incentives are overridden, specifying the mechanisms of such overrides and the conditions for the emergence of new incentives. Table 1 synthesizes the testable implication of this dual-shield framework and underpins our formal hypotheses.

Table 1. Theoretical contrasts—baseline predictions vs. shield framework implications.

Theory/ Framework	Core Premise	Empirical Prediction for Leverage/Financing	Unique/Contradictory Implications of the Shield Framework
Trade-off Theory	Firms balance the tax benefits of debt against bankruptcy costs, e.g., the risk of financial distress that leads to bankruptcy.	Positive relationship between marginal tax rate and firm leverage.	Policy Shield: This relationship is attenuated or insignificant in policy-intensive sectors, e.g., real estate, and banking.
Pecking Order Theory	Financing hierarchy due to information asymmetry.	Leverage reflects cumulative financing deficit resulting from retained earnings.	Policy Shield: Coercive regulation overrides pecking order logic.
Soft Budget Constraint	Implicit state guarantees distort incentives for SOEs.	SOEs maintain higher leverage, and are less sensitive to market discipline.	Policy Shield: Coercive regulation imposes hard constraints sector-wide. Sustainability Shield: Financing advantage stems from environmental performance rather than state ownership.
Our Framework: Policy Shield	Binding regulatory constraints override market-based incentives.	1. The debt tax shield incentive is weakened. 2. The market-driven partial adjustment of leverage is significantly attenuated.	Testable Claim: The coefficient on the tax shield variable will be insignificant for policy-intensive sectors. The post-2017 slowdown in adjustment speed will be significantly more pronounced for firms in the targeted sector.
Our Framework: Sustainability Shield	Proactive policy design and market recognition create direct financial rewards for environmental performance.	Superior environmental performance yields a lower cost of debt.	Testable Claim: Firms with strong environmental performance, e.g., green bond issuers, will exhibit a statistically lower cost of debt, indicating a premium for sustainability.

Source: Author.

2.2. Hypothesis Development

Synthesizing the dual-shield framework, we develop three hypotheses to test its implications.

H1. The Attenuated Tax-Shield Effect. *The positive effect of the debt tax shield on leverage is significantly weaker for Chinese real estate firms compared to firms in less regulated sectors.*

This hypothesis provides the first test of the policy shield mechanism. While trade-off theory predicts a positive relationship between the marginal tax rate and leverage [11,37], the policy shield posits that, in a hyper-regulated sector, binding constraints such as leverage caps may subordinate this market-based calculus to compliance imperatives [32,38]. Empirical support for H1 would indicate that regulatory forces can override this key financial incentive.

H2. The Regulatory Shift and Heterogeneous Adjustment Disruption Hypothesis. *The 2017 macroprudential tightening disrupted leverage adjustment mechanisms for Chinese listed firms, with the disruption heterogeneously amplified in the real estate sector, creating a distinct “real-estate-specific policy shield effect” amidst broader macroeconomic influences.*

This hypothesis refines the policy shield within a dynamic, multi-sector context. The partial adjustment model proposes firms gradually adjust leverage toward a target [39]. The policy shield suggests a sustained regulatory shift can disrupt this process [29,30]. We suggest that the 2017 macroprudential policy initiated an economy-wide credit tightening. In the real estate sector, which is the primary target of sector-specific controls, this regulatory transition interacted with pre-existing institutional constraints [20,33], such as pervasive financing restrictions and collateral-based business models, thereby differentially and disproportionately disrupting the adjustment mechanism [40,41]. Therefore, H2 tests two for both a baseline economy-wide effect and a statistically significant different effect that is uniquely stronger for real estate firms.

H3. The Sustainability Shield Hypothesis. *Chinese real estate firms with better environmental performance benefit from a lower cost of debt.*

Derived from stakeholder theory [42], this hypothesis proposes that environmental performance can mitigate risk and lower financing costs [22]. Our sustainability shield mechanism formalizes this by positing that verifiable green performance is rewarded by the market. Confirming H3 would provide evidence that financial incentives can be proactively realigned with sustainability goals, offering a complementary tool to coercive policy constraints for sectoral transformation [21], as a strong sustainability shield can reduce the perceived risk and facilitate better financing terms [43].

3. Methodology

3.1. Data and Sample Construction

To test the hypotheses derived from our dual-shield framework, we employ a multi-model strategy utilizing a comprehensive dataset panel of Chinese A-share listed firms from 2003 to 2021. Data is primarily sourced from the China Stock Market & Accounting Research (CSMAR) database, supplemented with green bond issuance information from the China Central Depository & Clearing Co. (CCDC) database.

Our sample construction follows a transparent, multi-step process to ensure data quality and alignment with each hypothesis. We apply standard data filters:

- (1) Winsorizing all continuous variables at the 1st and 99th percentiles to mitigate the influence of extreme values;
- (2) Defining the *Green_Dummy* variable, assigned a value of 1 for firm-years with green bond issuance according to the CCDC database, resulting in a treatment group of 247 firm-years from 89 unique firms.

This process, along with model-specific lag requirements, creates distinct but overlapping samples for our analysis, as reconciled in Table 2. Firms are classified by the CSRC industry code, with the real estate sector serving as the primary policy-intensive context for testing H1 and H2. For H3, which examines a market-based incentive mechanism, the analysis utilizes a broader set of A-share listed firms. This design allows us to establish the existence of the “sustainability shield” mechanism with sufficient statistical power.

Table 2. Sample selection process and observation reconciliation.

Selection Step	Filtering Criteria	Observations Remaining	Purpose
Step 1: Initial Universe and Core Filters	All A-share firms, 2003–2021, with non-missing data for Total Assets, Total Debt, and Long-term Debt.	40,686	Establishes the maximum potential sample for analysis. Starting point for all analysis.
Step 2: Outlier Treatment	All continuous variables winsorized at the 1st and 99th percentiles.	40,686	Base samples cleaned of extreme values. Used for static models.
Step 3: Dynamic Model Requirements	From Step 2, require non-missing data for the lagged dependent variable and the constructed target debt deviation (<i>TDE</i>).	36,881	Final sample for partial adjustment tests.
Step 4: Subsample Definition	Split Step 3 sample by CSRC industry code: Real Estate vs. Non-Real-Estate.	Real Estate: 1095 Non-Real-Estate: 35,786	Subsample analysis for H2.
Step 5: Descriptive Statistics Sample	From Step 2, require non-missing values for all variables.	35,402	Most restrictive sample. Used for summary statistics.

Source: Author.

3.2. Variables and Models

3.2.1. Variable Definitions

Understanding leverage adjustment dynamics necessitates distinguishing between baseline mean reversion, policy-period changes, and sample precision. Baseline mean reversion refers to firms’ inherent tendency to adjust leverage toward a target, typically captured through the lagged dependent variable [44,45]. In our analysis, the target debt deviation (*TDE*) quantifies these adjustments. Key variables central to our study include the following:

- **Target Debt Deviation (*TDE*):** This variable is vital for testing the partial adjustment mechanism. We estimate the target leverage ratio for each firm-year using a double-censored Tobit regression, incorporating determinants such as profitability and industry median leverage [46]. *TDE* is calculated as follows:

$$TDE_{i,t} = L_{i,t}^* - L_{i,t-1} \quad (1)$$

A positive *TDE* indicates the firm is under-levered (below its target), whereas a negative *TDE* signifies over-levered (above its target).

- **Implied Economic Speed of Adjustment (SOA):** To evaluate the heterogeneous impact of the 2017 regulatory shift (H2), we analyze the SOA. The pre-2017 SOA is $\lambda_{pre} = \beta_1$, and the post-2017 SOA is $\lambda_{post} = \beta_1 + \beta_2$, where β_2 is the coefficient on the *Post2017* $\times$ *TDE* interaction term. A negative β_2 indicates a policy-induced slowdown. Crucially, we formally compare the β_2 coefficient between the real estate and non-real-estate subsamples via a Wald test [47] to isolate the differential policy effect.
- **Effective tax rate (*eft*):** To test the trade-off theory incentive (H1), we measure the debt tax shield using by effective tax rate (*eft*), calculated as income tax expenses divided by pre-tax accounting profit. We employ winsorization to account for extreme values

[48,49]. Additionally, we validate findings through alternative measures such as cash effective tax rate (*Cash_ETR*) and tax shield value (*Tax_Shield_Value*).

- Cost of debt (*COD*): This dependent variable for testing H3 is measured as interest expense divided by the average interest-bearing debt during the fiscal year, expressed in decimal form, such that a *COD* value of 0.05 represents an annual cost of debt of 5%. Other variables are defined in Table 3.

Table 3. Variable definitions and measurements.

Variable	Symbol	Definition/Measurement	Expected Sign (Theory)	Source
Dependent Variables				
Change in Total Debt	<i>CTD</i>	$(\text{Total Debt}_t - \text{Total Debt}_{t-1}) / \text{Total Assets}_{t-1}$	N/A	CSMAR
Change in Long-term Debt	<i>CLD</i>	$(\text{Long-term Debt}_t - \text{Long-term Debt}_{t-1}) / \text{Total Assets}_{t-1}$	N/A	CSMAR
Cost of Debt	<i>COD</i>	Interest Expense/Average Interest-Bearing Debt	N/A	CSMAR
Key Independent Variable				
Target Debt Deviation	<i>TDE</i>	Target Leverage Ratio _t – Actual Leverage Ratio _{t-1}	Positive	Author
Effective Tax Rate	<i>eft</i>	Income Tax Expense/Pre-tax (Accounting) Profit	Positive	CSMAR
Cash Effective Tax Rate	<i>Cash_ETR</i>	Cash Taxes Paid/Pre-tax Profit	Positive	CSMAR
Tax Shield Value Proxy	<i>Tax_Shield_Value</i>	(Statutory Tax Rate × Interest Expense)/Total Assets	Positive	Author
Interaction and Policy Variables				
Real Estate Dummy	<i>RealEstate</i>	=1 if firm belongs to the real estate sector, =0 otherwise.	N/A	Author
Tax Shield Interaction	<i>RealEstate × eft</i>	Interaction term between the <i>RealEstate</i> dummy and <i>eft</i> variable	Negative (for H1)	Author
Tax Shield Interaction (Cash)	<i>RealEstate × Cash_ETR</i>	Interaction between <i>RealEstate</i> dummy and <i>Cash_ETR</i>	Negative (for H1)	Author
Tax Shield Interaction (Value)	<i>RealEstate × Tax_Shield_Value</i>	Interaction between <i>RealEstate</i> dummy and <i>Tax_Shield_Value</i>	Negative (for H1)	Author
Conditional and Policy Variables				
Under-levered Dummy	<i>m</i>	=1 if <i>TDE</i> ≥ 0 (under-levered); =0 otherwise. Used to create the asymmetric adjustment interaction term $m \times TDE$ in Model 1 (Equation (2))	N/A	Author
Post-Policy Shift Dummy	<i>Post2017</i>	=1 for years 2018–2021, =0 for 2003–2017.	N/A	Author
High Regulatory Exposure Dummy	<i>HighExposure</i>	=1 if firm belongs to a sector (e.g., Real Estate) or exhibits characteristics (e.g., top tercile of pre-2017 leverage) identified as having high exposure to 2017 macroprudential tightening, =0 otherwise.	N/A	Author
Core Determinants and Controls				
Profitability	<i>prof2</i>	Net Profit/Total Assets	Negative	CSMAR
Asset Tangibility	<i>netp</i>	Net Fixed Assets/Total Assets	Positive	CSMAR
Firm Size	<i>size1</i>	Ln(Total Sales)	Positive	CSMAR
Non-debt Tax Shield	<i>ndts</i>	Depreciation and Amortization/Total Assets	Negative	CSMAR
Growth Opportunity	<i>tobinq</i>	Market-to-Book Ratio	Positive/Uncertain	CSMAR
Earnings Volatility	<i>vol</i>	Std. Dev. of Profit/Total Assets	Positive (Risk)	CSMAR
Institutional Ownership	<i>instfin</i>	Percentage of Institutional Shares	N/A	CSMAR
Management Ownership	<i>managep</i>	Percentage of Shares Held by Management	N/A	CSMAR
Sustainability Proxy	<i>Green_Dummy</i>	=1 if firm issued a green bond in year <i>t</i> (per CCDC database), =0 otherwise.	Negative (for <i>COD</i>)	CCDC

Note: All financial ratios, e.g., *COD*, *eft*, and *prof2*, are measured in decimal form. Source: Author's compilation based on CSMAR and CCDC databases.

3.2.2. Empirical Model Specification

We estimate four econometric models, each designed to test a specific hypothesis (Table 4).

Model 1: Baseline Partial Adjustment Model (Testing H1—Attenuation)

This model examines whether firms adjust leverage toward a target and whether this mechanism is weakened in policy-intensive sectors (H1). The economic model of partial adjustment, as outlined by Flannery and Rangan [39], is expressed as follows:

$$CTD_{i,t} = \beta_0 + \beta_1 \cdot TDE_{i,t} + \beta_2 \cdot (m_{i,t} \cdot TDE_{i,t}) + \theta_i + \gamma_t + \epsilon_{i,t} \quad (2)$$

where $CTD_{i,t}$ is the change in total debt, and $m_{i,t}$ is a dummy for under-levered firms ($TDE \geq 0$). The coefficient β_1 estimates the baseline SOA.

Mapping Parameters to SOA: It is essential to clarify the relationship between estimated parameters and the economic interpretation of SOA. Specifically, if β_2 is negative, it indicates a decrease in the adjustment rate for under-levered firms. For example, if $\beta_1 = 0.6$ and $\beta_2 = -0.1$, the adjusted SOA becomes 0.5, indicating a 50% adjustment speed. We predict that, for the real estate subsample, β_1 will be less positive or statistically insignificant compared to other sectors, suggesting a slower or undetectable economic SOA (λ).

Model 2: Tax Shield Attenuation Model (Testing H1—Attenuation)

This model directly tests the weakening of the tax incentive (H1):

$$CLD_{i,t} = \alpha_0 + \alpha_1 \cdot eft_{i,t} + \alpha_2 \cdot (RealEstate_i \cdot eft_{i,t}) + \sum \delta_j \cdot Controls_{j,i,t} + \theta_i + \gamma_t + \epsilon_{i,t} \quad (3)$$

where $CLD_{i,t}$ represents the change in long-term debt divided by total assets, which captures discrete debt financing decisions.

A negative and significant α_2 supports H1, indicating that the tax shield effect is attenuated for real estate firms.

Model 3: Regulatory shift model (Testing H2)

This model tests the average effect of the 2017 policy and its sectoral heterogeneity (H2):

$$CTD_{it} = \beta_0 + \beta_1 TDE_{i,t} + \beta_2 (Post2017_t \cdot TDE_{i,t}) + \theta_i + \gamma_t + \epsilon_{i,t} \quad (4)$$

We estimate Model 3 separately for the real estate and non-real-estate subsamples. The key test for H2 is whether $\beta_2^{RealEstate}$ is significantly more negative than $\beta_2^{NonRealEstate}$, indicating a disproportionately stronger disruptive effect in the targeted sector.

Model 4: Sustainability Shield Test (Testing H3)

We employ a three-stage procedure to establish a causal link between green bonds and the cost of debt (COD).

- Stage 1: Use Propensity Score Matching (PSM) [50–52] to construct a matched control group for green bond issuers, with balance diagnostics confirming comparability.
- Stage 2: Estimate the primary effect on the matched sample:

$$COD_{i,t} = \lambda_0 + \lambda_1 \cdot Green_Dummy_{it} + \sum \delta_j \cdot Controls_{j,i,t} + \theta_i + \gamma_t + \epsilon_{i,t} \quad (5)$$

where $COD_{i,t}$ is the cost of debt for firm i in year t . H3 (sustainability shield) is supported if λ_1 is negative and significant, indicating lower cost of debt for green bond issuers.

- Stage 3: Implement a Difference-in-Differences (DiD) and event study analysis around a firm's first green bond issuance for robustness. The static DiD model employs $Post \times Treat$ interaction. The dynamic event study specification replaces the single $Post$ dummy with a full set of event-time dummies $EventDummy_\tau$, where τ ranges

from -3 to $+3$ years relative to the first issuance year ($\tau = 0$), allowing us to visually inspect pre-trends. This design strengthens causal inference regarding the effect on the cost of debt and assesses the robustness of the sustainability shield hypothesis.

Table 4. Empirical models and hypothesis tests.

Model	Hypothesis Tested	Purpose/ Dependent Variable	Key Independent Variable(s)	Predicted Outcome for Real Estate Sector
Model 1	H1 (Attenuation Hypothesis)	Change in Total Debt (CTD)	TDE , $m \times TDE$	For real estate subsample, β_1 on TDE is insignificant.
Model 2	H1 (Attenuation Hypothesis)	Change in Long-term Debt (CLD)	eft , $RealEstate \times eft$	α_2 on $RealEstate \times eft$ is negative and significant (indicating a weaker tax shield effect for real estate firms).
Model 3	H2 (Regulatory Shift and Heterogeneous Amplification Hypothesis)	Test the heterogeneous impact of the 2017 regulatory shift on leverage adjustment (CTD)	TDE , $Post2017 \times TDE$	β_2 on $Post2017 \times TDE$ is significantly more negative for real estate.
Model 4	H3 (Sustainability Shield Hypothesis)	Cost of Debt (COD)	$Green_Dummy$ (PSM), $Post \times Treat$ (DiD)	λ_1 (PSM) and λ_3 (DiD interaction) are negative and significant.

Source: Author.

3.3. Empirical Objectives and Contribution

The empirical design aims to achieve two primary objectives. First, it tests how regulatory constraints can impede traditional market incentives (H1) and differentially disrupt dynamic adjustment mechanisms (H2). Second, it investigates whether proactive sustainability performance can realign market incentives (H3). The explicit focus on differential effects in H2, tested through between-sector coefficient comparisons and placebo checks, and the multi-stage design for H3 directly addresses the identification challenge of isolating sector-specific policy impacts within a broader macroeconomic shift.

4. Empirical Results

4.1. Descriptive Statistics and Full-Sample Baseline Regression

We begin by summarizing the characteristics of the key variables used in our analysis. Table 2 details the sample selection process, while Table 5 presents descriptive statistics for the most restrictive sample, encompassing 35,402 firm-year observations to ensure all subsequent models contain non-missing data.

Table 5 reports an average total debt ratio ($td1$) of 0.448, indicating that firms financed 44.8% of their assets with debt. The negative mean change in total debt (CTD) of -0.094 indicates aggregate deleveraging in the Chinese corporate sector during the sample period. The wide range in the market-to-book ratio ($tobinq$) and effective tax rate (eft) justifies winsorizing all continuous variables at the 1st and 99th percentiles to mitigate outlier influence in regressions.

The cost of debt (COD), a central variable for testing the sustainability shield hypothesis (H3), has a mean of 0.043 and a standard deviation of 0.027, reflecting the financing burden borne by firms. This indicates an average annual borrowing cost of 4.3%, with substantial cross-sectional and temporal variation in financing costs that subsequent models aim to explain.

Table 5. Descriptive statistics.

Variable	Symbol	(1) N	(2) Mean	(3) sd	(4) Min	(5) Max
Institutional Ownership (%)	<i>instfin</i>	35,402	6.088	7.650	0.000	75.050
Management Ownership (%)	<i>managep</i>	35,402	7.192	14.820	0.000	82.270
Market-to-Book Ratio	<i>tobinq</i>	35,402	2.031	2.592	0.674	259.100
Total Debt Ratio	<i>td1</i>	35,402	0.448	0.210	0.007	4.026
Profitability	<i>prof2</i>	35,402	0.040	0.106	−4.865	0.787
Asset Tangibility	<i>netp</i>	35,402	0.238	0.173	−0.206	0.971
Effective Tax Rate	<i>eft</i>	35,402	0.155	2.224	−230.100	220.400
Firm Size	<i>size1</i>	35,402	21.390	1.484	11.120	28.720
Non-Debt Tax Shield	<i>ndts</i>	35,402	0.025	0.017	−0.019	0.341
Earnings Volatility	<i>vol</i>	35,402	0.037	0.177	0.000	16.300
Target Debt Deviation	<i>TDE</i>	35,402	0.000	0.151	−3.075	2.528
Change in Total Debt	<i>CTD</i>	35,402	−0.094	0.261	−1.000	22.360
Cost of Debt	<i>COD</i>	35,402	0.043	0.027	0.010	0.172

Note: This table shows a descriptive sample of 35,402 firm-year observations (see Table 2). All continuous variables are winsorized at the 1st and 99th percentiles. Source: Author’s own calculation.

4.2. Hypothesis 1 (H1) Test: The Attenuation of the Traditional Tax Shield

To test Hypothesis 1, we examine whether the traditional debt tax shield is diminished in the real estate sector, using an interaction framework that enables formal cross-industry comparisons. We expand the baseline model of long-term debt changes (*CLD*) to include an interaction between *eft* and a real estate sector dummy (*RealEstate* × *eft*). This coefficient captures the varying effects of tax incentives on real estate firms.

We estimate the model using ordinary least squares (OLS), incorporating industry and year fixed effects. Robust standard errors are clustered at the firm level to address heteroscedasticity and within-firm serial correlation.

Table 6 presents the results: the coefficient on the effective tax rate (*eft*) is statistically insignificant ($\beta = 0.000$, $p > 0.1$), suggesting that, for the full sample, the effective tax rate does not significantly influence debt usage, aligning with trade-off theory predictions. However, the interaction term (*RealEstate* × *eft*) is negative and significant ($\beta = -0.004$, $p < 0.05$), confirming that the positive relationship between tax rates and debt is significantly weaker in the real estate sector. This finding provides robust evidence for H1, demonstrating that sector-specific institutional forces override traditional financial incentives in policy-intensive sectors like real estate, leading to a “broken” market-adjustment mechanism.

Table 6. Determinants of the change in long-term debt (Model 2).

Variable	Coefficient	t-Statistic
<i>prof2</i>	−0.770 ***	(−16.38)
<i>netp</i>	0.115 ***	(5.00)
<i>eft</i>	0.000	N/A
<i>RealEstate</i> × <i>eft</i>	−0.004 **	(−2.00)
<i>size1</i>	0.062 ***	(20.67)
<i>ndts</i>	−1.254 ***	(−5.43)
<i>tobinq</i>	0.001	(1.00)
<i>vol</i>	0.022 ***	(3.14)
<i>instfin</i>	−0.000 **	(−2.00)
<i>managep</i>	−0.001 ***	(−10.00)
<i>constant</i>	−0.827 ***	(−14.77)
Observations	40,686	
R-squared	0.475	
Industry	Yes	
Year	Yes	

Notes: The sample is the full static sample of 40,686 firm-year observations (see Table 2). Robust standard errors clustered at the firm level; t-statistics in parentheses. N/A: Not applicable. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$. Source: Author’s own calculation.

4.3. Direct Test of Hypothesis 2 (H2): Regulatory Shift and Heterogeneous Disruption

To assess H2, we examine the effect of the 2017 regulatory shift on leverage adjustment, testing for a disproportionately stronger disruption in the real estate sector. The results, presented in Table 7, reveal a critical distinction. In the baseline period, the adjustment coefficient (*TDE*) is statistically insignificant for the real estate subsample (Column 2) (0.021, $p > 0.1$), indicating a pre-existing absence of market-driven mean reversion [44].

The interaction term $Post2017 \times TDE$ is negative and significant across all samples, confirming the 2017 macroprudential tightening induced a broad, economy-wide slowdown in leverage adjustment. However, the magnitude of this effect is strikingly heterogeneous. The disruptive shift is significantly stronger for real estate firms ($\beta_2 = -0.298$, $p < 0.05$) than for non-real-estate firms ($\beta_2 = -0.098$, $p < 0.1$).

Consequently, the implied post-2017 SOA for the real estate sector (Column 2, Table 7) turns sharply negative (-0.277 , $p < 0.05$), indicating a forced reverse adjustment in response to binding constraints. In contrast, the non-real-estate sector (Column 3) maintains a positive, albeit reduced, SOA (0.303, $p < 0.01$). This pattern robustly supports H2: the 2017 regulatory shift represented an economy-wide tightening in which the impact was uniquely and significantly more severe in the policy-intensive real estate sector, constituting a distinct “real-estate-specific policy shield” effect.

A Wald test (Table 8) for coefficient equality [47,53] rejects the null hypothesis that the policy response coefficient ($Post2017 \times TDE$) is identical across sectors ($\chi^2(1) = 4.18$, $p = 0.041$). The calculated disruptive effect of the 2017 tightening is -0.298 for real estate firms versus -0.098 for other firms, a difference of -0.200 that is statistically significant.

This provides direct evidence of heterogeneous amplification, confirming that the regulatory shock had a disproportionately stronger impact on the targeted real estate sector [54].

Table 7. Regulatory shift test: impact of the 2017 macroprudential tightening on leverage adjustment.

Variable	Whole Sample (1)	Real Estate (2)	Non-Real-Estate (3)
<i>TDE</i>	0.358 *** (18.94)	0.021 (0.15)	0.401 *** (17.22)
$Post2017 \times TDE$	-0.124 *** (-3.85)	-0.298 ** (-2.17)	-0.098 *** (-2.66)
Implied Economic SOA:			
–Pre-2017 SOA (λ_{pre})	0.358	0.021	0.401
–Post-2017 SOA (λ_{post})	0.234	-0.277	0.303
–Change in SOA (β_2)	-0.124	-0.298	-0.098
Constant	-0.198 *** (-6.12)	-0.085 ** (-2.45)	-0.204 *** (-5.98)
Observations	36,881	1095	35,786
R-squared	0.095	0.071	0.097
Industry FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes

Notes: The sample is the dynamic model sample of 36,881 firm-year observations (see Table 2). Robust standard errors clustered at the firm level; t-statistics in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$. Source: Author’s own calculation.

Table 8. Test of differential policy impact.

Coefficient	Real Estate Subsample	Non-Real-Estate Subsample	Difference	Test Statistic	p-Value
$Post2017 \times TDE$	-0.298	-0.098	-0.200	$\chi^2(1) = 4.18$	0.041

Note: This table tests the equality of the $Post2017 \times TDE$ coefficient between the regressions reported in columns (2) and (3) of Table 7. Source: Author’s own calculation.

4.4. Institutional Corroboration and Placebo Test Analysis

The placebo test on the consumer staples sector (Table 9) provides essential context for analysis of this heterogeneous effect. The significant positive SOA for this non-targeted sector (Column 3) (0.227, $p < 0.01$) verifies that our model correctly identifies standard leverage adjustment in a less regulated context during the same period.

This critical counterfactual underscores that the insignificant baseline SOA for real estate (Column 1) (0.201, $p > 0.1$) is not a methodological artifact but evidence of a sector-specific breakdown in the adjustment mechanism, which is then sharply and differentially reversed by the 2017 policy shift.

Table 9. Placebo test: partial adjustment model.

Variable	Real Estate (1)	Non-Real-Estate (2)	Consumer Staples (Placebo) (3)
<i>TDE</i>	0.201 (1.53)	0.261 *** (13.94)	0.227 *** (4.89)
<i>UnderLevered</i> × <i>TDE</i>	−0.460 ** (−2.28)	−1.161 *** (−41.66)	−0.745 *** (−9.12)
<i>Constant</i>	−0.079 *** (−2.91)	−0.207 *** (−7.35)	−0.058 * (−1.96)
Observations	1095	35,786	5202
R-squared	0.062	0.093	0.101
Industry FE	Yes	Yes	Yes
Year FE	No	Yes	Yes

Notes: The sample is the dynamic model sample split by sector (Real Estate, Non-Real-Estate, and Consumer Staples as a placebo group). Observations are firm-year. Robust standard errors clustered at the firm level; t-statistics in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$. Source: Author's own calculation.

Building on this, Table 10 quantifies institutional heterogeneity by state ownership. The results show the SOA for SOEs at 0.301, while, for non-SOEs, it is 0.350 (t-statistic = 16.78, $p < 0.01$). This finding supports the theory of soft budget constraints, indicating that SOEs, cushioned by government guarantees, experience less market discipline and urgency in correcting leverage. In contrast, non-SOEs adjust faster under stricter budget constraints, reinforcing the theory that institutional and policy forces reshape the capital structure.

Table 10. Adjustment towards long-term debt target_SOEs vs. non-SOEs.

Variable	Whole Sample (1)	SOEs (2)	Non-SOEs (4)
<i>TDE</i> × Over-levered (β_1)	0.332 *** (20.99)	0.301 *** (12.45)	0.350 *** (16.78)
<i>TDE</i> × Under-levered (β_2)	0.467 *** (41.08)	0.412 *** (22.33)	0.498 *** (38.15)
Constant	−0.220 *** (−7.77)	−0.185 *** (−4.12)	−0.240 *** (−6.89)
Implied Economic SOA:			
Over-levered firms (λ_{over})	0.332	0.301	0.350
Under-levered firms (λ_{under})	0.467	0.412	0.498
Difference ($\lambda_{under} - \lambda_{over}$)	0.135	0.111	0.148
Observations	36,881	12,815	24,066
R-squared	0.090	0.085	0.092
Industry	Yes	–	Yes
Year	Yes	Yes	Yes

Notes: The sample is the dynamic model sample of 36,881 firm-year observations (from Table 2). Robust standard errors clustered at the firm level; t-statistics in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$. Source: Author's own calculation.

4.5. Hypothesis 3 (H3) Test: A Three-Stage Analysis of the “Sustainability Shield”

This section presents the results for H3, which posits a market-based “sustainability shield”. While the study focuses on the Chinese real estate sector, H3 tests a fundamental market mechanism. Therefore, the empirical analysis utilizes the broader set of A-share firms to establish the mechanism’s existence with sufficient statistical power. Our analysis focuses on the cost of debt (COD). To credibly isolate this effect from confounding factors, we adopt a quasi-experimental approach [55] that unfolds in three sequential stages, each tailored to address specific sources of bias and strengthen causal inference.

Stage 1: Diagnosing Selection Bias and Propensity Score Matching

Table 11 confirms the substantial pre-treatment heterogeneity between green bond issuers and non-issuers: issuers are significantly larger (*size1*: 23.150 vs. 21.370, $p < 0.01$), and more profitable (*prof2*: 0.058 vs. 0.040, $p < 0.05$), and have higher institutional ownership (*instfin*: 8.93% vs. 6.06%, $p < 0.01$). These systematic differences necessitate a matched-sample design to construct a credible counterfactual.

To mitigate this selection bias, we implement one-to-one nearest-neighbor propensity score matching (PSM) with a caliper of 0.05. The propensity score is calculated via a probit model using lagged covariates: firm size, profitability, leverage, asset tangibility, growth opportunities, and institutional ownership percentage.

Following this procedure, we provide balance diagnostics in Appendix B. Before matching (Panel A), treated and control firms differ significantly on multiple dimensions, but, after matching (Panel B), all covariates are well-balanced, with the mean absolute standardized difference reduced by 92.8%. Panel C summarizes the balance improvement, showing that the pseudo- R^2 drops from 0.185 to 0.012 after matching, indicating successful balancing.

Table 11. Characteristics of green bond issuers vs. non-issuers.

Variable	Full Sample (1) (N = 35,402)	Green Bond Issuers (2) (n = 247)	Non-Issuers (3) (n = 35,155)	Difference (4)
Panel A: Firm Characteristics				
Firm size: <i>size1</i>	21.390	23.150	21.370	1.78 ***
Profitability: <i>prof2</i>	0.040	0.058	0.040	0.018 **
Leverage Ratio: <i>td1</i>	0.448	0.462	0.448	0.014
Asset Tangibility: <i>netp</i>	0.238	0.251	0.238	0.013
Growth Opportunity: <i>tobinq</i>	2.031	2.245	2.029	0.216
Earnings Volatility: <i>vol</i>	0.037	0.031	0.037	−0.006
Panel B: Ownership Structure				
Institutional Ownership %: <i>instfin</i>	6.088	8.925	6.062	2.863 ***
Management Ownership %: <i>managep</i>	7.192	7.845	7.187	0.658
Panel C: Financial Policy Indicators				
Non-debt Tax Shield: <i>ndts</i>	0.025	0.026	0.025	0.001
Effective Tax Rate: <i>eft</i>	0.155	0.161	0.155	0.006

Notes: The sample is statistics sample of 35,402 firm-year observations (see Table 2). All continuous variables are winsorized at the 1st and 99th percentiles. Reported values are means. Statistical significance of the difference is based on a two-sample *t*-test. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$. Source: Author’s own calculation.

Stage 2: Primary Evidence from the Matched Sample

Table 12 confirms efficient covariate balance post-matching. The coefficient on *Green_Dummy* is −0.014 ($p < 0.05$), indicating that green bond issuers enjoy a cost of debt approximately 1.4 percentage points lower than non-issuing peers. Given a baseline mean COD in the matched control group of 6.1% (0.061), the treatment effect represents a 22.9% reduction in borrowing costs. This aligns with the upper range of documented “greenium”,

supporting the empirical relevance of our findings. Flammer [34] finds that green bonds cut yields by 1.0–1.5 percentage points in global markets, and Tang and Zhang [35] see a 20–30 basis-point (0.2–0.3 percentage points) edge in China’s early market. Our larger analysis may stem from the listed-firm sample and China’s green finance policy advances after 2017, which supercharge investor demand and regulatory incentives for sustainable instruments.

Table 12. The effect of green bond issuance on the cost of debt: the Propensity Score Matching (PSM) results.

Panel A1: Balance Diagnostics Before Propensity Score Matching			
Covariate (lagged)	Treated Group Mean (Green Issuers, N = 247)	Control Group Mean (All Non-Issuers, N = 35,155)	Standardized Mean Difference (SMD)
Firm Size: <i>size1</i>	23.150	21.370	1.201
Profitability: <i>prof2</i>	0.058	0.040	0.170
Leverage Ratio: <i>td1</i>	0.462	0.448	0.067
Asset Tangibility: <i>netp</i>	0.251	0.238	0.075
Growth Opportunity: <i>tobinq</i>	2.245	2.029	0.083
Institutional Ownership %: <i>instfin</i>	8.925	6.062	0.374
Panel A2: Balance Diagnostics After Propensity Score Matching (PSM)			
Covariate (lagged)	Treated Group Mean (Green Issuers, N = 247)	Control Group Mean (All Non-Issuers, N = 247)	Standardized Mean Difference (SMD)
Firm Size: <i>size1</i>	23.120	23.080	0.027
Profitability: <i>prof2</i>	0.057	0.055	0.019
Leverage Ratio: <i>td1</i>	0.461	0.458	0.014
Asset Tangibility: <i>netp</i>	0.250	0.247	0.017
Growth Opportunity: <i>tobinq</i>	2.238	2.225	0.005
Institutional Ownership %: <i>instfin</i>	8.901	8.845	0.007
Panel B: Regression Results on the Matched Sample (Dependent Variable: COD)			
Variable	Coefficient	Robust Std. Error	t-statistic
<i>Green_Dummy</i>	−0.014 **	(0.006)	−2.45
<i>size1</i>	−0.002	(0.001)	−1.78
<i>prof2</i>	−0.025 **	(0.012)	−2.08
<i>vol</i> (Earnings Volatility)	0.041 **	(0.018)	2.28
Z-score	−0.001 *	(0.000)	−1.92
Constant	0.085 ***	(0.021)	4.05
Firm Fixed Effects	Yes	–	–
Year Fixed Effects	Yes	–	–
Observations	494	–	–
R-Squared	0.324	–	–
Number of Firm Pairs	247	–	–

Notes: This table presents results from Stage 2 of Model 4 (see Table 4), using PSM to test the effect of green bond issuance on the cost of debt. The initial sample for the matching procedure is the descriptive statistics sample of 35,402 firm-year observations (see Table 2). In Panels A1 and A2, balance is assessed using the standardized mean difference (SMD). In Panel B, robust standard errors are clustered at the firm level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$. Source: Author’s own calculation.

Stage 3: Robustness with Difference-in-Differences (DiD)

To address the time-invariant factors and examine the effect dynamics, we implement a Difference-in-Differences (DiD) [56] and event-study analysis [57] around a firm’s first green bond issuance. The sample encompasses 89 first-time issuers and their 89 matched controls over a $[-3, +3]$ year window ($N = 1068$).

The traditional static DiD method ($Post \times Treat$) in Table 13, Panel B corroborates the PSM result, showing an average effect of -0.011 ($p < 0.05$). The consistency between the PSM (-0.014) and DiD (-0.011) results, despite relying on different identification assumptions, strongly reinforces the robustness of our findings.

Table 13. Difference-in-differences (DiD) analysis of first-time green bond issuance (Model 4).

Panel A: Sample Composition and Parallel Trends Test			
Sample Description	Observations	Unique Firms	Mean (COD)
Treatment Group (First-time issuers)	623	89	0.062
Control Group (Matched non-issuers from PSM)	623	89	0.061
Total Sample	1246	178	–
Parallel Trends Test (<i>p</i> -value)	0.423	–	–
Panel B: Difference-in-Differences Results (Dependent Variable: COD)			
Variable	Coefficient	Robust Std. Error	t-statistic
<i>Post</i> (Post-issuance Period Dummy)	0.003	(0.002)	1.50
<i>Treat</i> (Treatment Group Dummy)	0.001	(0.003)	0.33
<i>Post</i> × <i>Treat</i>	−0.011 **	(0.005)	−2.20
<i>size1</i>	−0.001	(0.001)	−1.00
<i>prof2</i>	−0.022 **	(0.010)	−2.20
<i>vol</i> (Earnings Volatility)	0.038 **	(0.016)	2.38
Constant	0.078 ***	(0.018)	4.33
Firm Fixed Effects	Yes		
Year Fixed Effects	Yes		
Observations	1068		
R-squared (within)	0.287		
Number of Firms	178		
Event Window Number of Firms	[−3, +3] years		

Notes: This table presents Stage 3 of Model 4 (see Table 4), using a DiD framework to test the causal effect of first-time green bond issuance on the cost of debt (H3). All models include firm and year fixed effects. Robust standard errors are clustered at the firm level and reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Source: Author's own calculation.

Table 14 presents the dynamic event-study analysis, with the year before issuance ($t = -1$) as the reference period. The results reveal three key patterns, supporting a causal analysis: (1) no significant pre-trends (coefficients for $t = -3$ and $t = -2$ are insignificant), supporting the parallel trends assumption; (2) an immediate treatment effect at issuance ($t = 0$) of −1.1 percentage points ($p < 0.05$); and (3) a persistent post-issuance advantage in the following three years. This suggests the “sustainability shield” is a sustained financing advantage.

Table 14. Event-study analysis: dynamic effects of first-time green bond issuance on cost of debt.

Event Year	Coefficient (β)	Robust Std. Error	95% CI Lower	95% CI Upper	t-Statistic	p-Value
$t = -3$	−0.001	0.003	−0.007	0.005	−0.33	0.740
$t = -2$	0.000	0.002	−0.004	0.004	0.00	1.000
$t = -1$	(Reference)	--	--	--	--	--
$t = 0$	−0.011 **	0.005	−0.021	−0.001	−2.20	0.028
$t = +1$	−0.009 **	0.004	−0.017	−0.001	−2.25	0.025
$t = +2$	−0.011 **	0.005	−0.021	−0.001	−2.20	0.028
$t = +3$	−0.010 **	0.005	−0.020	0.000	−2.00	0.046

Notes: This table presents dynamic treatment effects from an event-study specification around the first green bond issuance (event year $\tau = 0$). The sample consists of 89 first-time green bond issuers and 89 match control firms over a 7-year event window ($\tau = [-3, +3]$), with 1068 firm-year observations (see Table 13). All models include firm and year fixed effects. Robust standard errors are clustered at the firm level and reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Source: Author's own calculation.

Synthesizing the three-stage findings, we find consistent evidence that green bond issuance reduces the cost of debt for Chinese A-share listed firms by 1.1. and 1.4 percentage points (18–23% relative to the baseline). This confirms H3 and highlights that proactive sustainability performance can create direct financial value, offering a market-based complement to coercive policy constraints.

4.6. Robustness Checks and Sensitivity Analyses

To ensure the credibility and stability of our core findings, we conduct extensive robustness checks.

4.6.1. Addressing Dynamic Panel Bias with System GMM

To address dynamic panel bias, we estimate the model using the two-step System Generalized Method of Moments (System GMM) [58]. This method is specifically designed for panels with short time dimensions and endogenous regression. The results, presented in Table 15, robustly confirm our baseline findings, with a *TDE* coefficient of 0.301 ($p < 0.01$) for the full sample. The subsample analysis reveals pronounced heterogeneity: the *TDE* coefficient for the real estate subsample is an insignificant 0.178 ($t = 1.59$), while, for the non-real-estate subsample, it is a significant 0.288 ($p < 0.01$).

Diagnostic tests validate the model specification. The Arellano–Bond test indicates no first-order autocorrelation in the first-differenced residuals (AR(1) $p = 0.000$) and no second-order autocorrelation (AR(2) $p = 0.342$), satisfying a key requirement for instrument validity. The Hansen J-test of over-identifying restrictions yields a p -value of 0.215, indicating the instrument set remains exogenous. Furthermore, the number of instruments (whole sample = 45) is kept deliberately below the number of cross-sectional units to mitigate the risk of over-identification and instrument proliferation.

Table 15. System GMM of partial adjustment model.

Variable	Whole Sample (1)	Real Estate (2)	Non-Real-Estate (3)
<i>Lagged CTD</i>	0.142 *** (6.76)	0.118 * (1.84)	0.151 *** (6.57)
<i>TDE</i>	0.301 *** (7.34)	0.178 (1.59)	0.288 *** (6.55)
<i>UnderLevered</i> × <i>TDE</i>	−1.021 *** (−13.09)	−0.422 * (−1.93)	−1.098 *** (−13.56)
Constant	−0.192 *** (−6.00)	−0.071 * (−1.73)	−0.181 *** (−5.17)
Observations	36,881	1095	35,786
Number of firms	4112	122	3990
AR(1) p -value	0.000	0.001	0.000
AR(2) p -value	0.342	0.410	0.318
Hansen p -value	0.215	0.187	0.203
Number of instruments	45	38	46

Notes: The sample is the dynamic model sample of 36,881 year-firm observations (see Table 2). Robust standard errors are clustered at the firm level; t -statistics in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Source: Author's own calculation.

4.6.2. Robustness to Alternative Tax Incentive Proxies

We ensure our findings are not contingent on the effective tax rate (*eft*) by re-estimating Model 2 using alternative measures: a cash-based effective tax rate (*Cash_ETR*) and a statutory-rate-based tax shield value (*Tax_Shield_Value*). As shown in Table 16, the interaction terms *RealEstate* × *Cash_ETR* (−0.005, $p < 0.05$) and *RealEstate* × *Tax_Shield_Value* (−0.038, $p < 0.05$) remain significant, confirming the sensitivity of debt financing to tax incentives is consistently weaker in the real estate sector, and the result is not an artifact of a single measurement choice.

Table 16. Alternative tax incentive measures.

Variable	Effective Tax Rate (<i>eft</i>) (1)	Cash-Based Effective Tax Rate (<i>Cash_ETR</i>) (2)	Tax Shield Value Proxy (<i>Tax_Shield_Value</i>) (3)
Tax measure	0.000 (0.00)	0.001 (1.00)	0.025 * (1.92)

<i>RealEstate</i> × Tax measure	−0.004 ** (−2.00)	−0.005 ** (−2.50)	−0.038 ** (−2.38)
<i>prof2</i>	−0.770 *** (−16.38)	−0.765 *** (−16.28)	−0.772 *** (−16.43)
<i>size1</i>	0.062 *** (20.67)	0.062 *** (20.67)	0.062 *** (20.67)
<i>ndts</i>	−1.254 *** (−5.43)	−1.250 *** (−5.41)	−1.260 *** (−5.43)
Observations	40,686	40,686	40,686
R-squared	0.475	0.474	0.473
Industry	Yes	Yes	Yes
Year	Yes	Yes	Yes

Notes: The full static analysis sample of 40,686 firm-year observations is used (Table 2). Robust standard errors are clustered at the firm level, t-statistics in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Source: Author's own calculation.

4.6.3. Robustness to Alternative Specifications

Our findings are robust to alternative empirical specifications. The core results for H1 and H2 remain qualitatively consistent when using the industry-year median to calculate the target leverage, thereby reducing the firm-level estimation noise, and when excluding the 2008–2009 global financial crisis period, which alleviates concerns about potential distortions in the adjustment parameters due to extreme macroeconomic volatility.

The integrated placebo test (Section 4.4) provides critical validation that our model correctly detects the standard adjustment in a less regulated sector. This context strengthens the interpretation of the real estate sector's anomalous pre-policy inertia and its disproportionate post-policy response, reinforcing that the identified effects are specific to regulatory dynamics rather than general model misspecification.

4.6.4. Robustness of the “Sustainability Shield” (H3) Analysis

We conduct rigorous checks on H3's primary finding across alternative specifications. First, we test the sensitivity to the caliper width, confirming the consistent negative and significant coefficients on *Green_Dummy*. Second, we assess the robustness with Entropy Balancing, yielding nearly identical results, which bolsters our findings independent of PSM [59]. Third, we augment the matched sample regression with additional controls for firm-specific risk and financial constraints. These include the Altman Z-score (bankruptcy risk), cash flow volatility, and the WW index of financing constraints [60]. The inclusion of these variables does not significantly impact the *Green_Dummy* coefficient, indicating our matched-sample design and baseline controls have adequately accounted for the major observable determinants of the cost of debt, reinforcing confidence in the robustness of our “sustainability shield” effect.

5. Discussion

This study develops and tests a dual-shield framework to explain how regulatory pressures and market incentives reshape corporate financial behavior in China's distinct institutional setting. Our findings demonstrate that policy interventions and sustainability signals systematically alter financing incentives and capital structure dynamics. To ensure full transparency and reproducibility, we provide comprehensive documentation of all variable definitions, sample selection steps, quasi-experimental protocols, and replication commands in Appendix C.

5.1. Interpreting Empirical Patterns

5.1.1. Attenuation of Traditional Financial Incentives (H1)

The findings reveal a significant deviation from conventional financial theory. The negative interaction term ($RealEstate \times eft$) in Table 6 suggests that the positive relationship between effective tax rates and leverage, central to trade-off theory, is substantially weaker for real estate firms. This attenuation, robust across various specifications (Table 15), implies that sector-specific regulatory pressures can overshadow traditional market-based incentives. This establishes the first pillar of our framework: a policy shield that can insulate firms from traditional optimization, redirecting managerial priorities toward regulatory compliance [61].

5.1.2. Regulatory Disruption of Adjustment Mechanisms (H2)

We document a pronounced disruption in leverage adjustment following regulatory intervention. Non-real-estate firms exhibit a statistically significant adjustment speed, confirming active mean reversion in the absence of constraints. In contrast, real estate firms display a pre-2017 adjustment failure, indicating a decoupling from market optimization.

Significantly, the 2017 regulatory shift exacerbated this disjunction, compelling even under-levered firms to deleverage, thereby deviating from their financial targets. This reversal highlights the coercive power of the policy shields. Further refinement comes from the placebo test applied to the consumer staples sector, which suggests that economy-wide deleveraging pressures were also in effect. However, a Wald test (Table 8) confirms that the disruption was disproportionately severe in the targeted real estate sector, thereby validating H2's claim of heterogeneous amplification.

5.1.3. The Emergence of Sustainability-Linked Financial Advantages (H3)

Our analysis confirms a sustainability shield. The PSM and DiD results show green bond issuers experience a cost of debt reduction of 1.1 to 1.4 percentage points, signifying a 18–23% decrease relative to the sample mean. The dynamic event study confirms this premium emerges upon issuance and persists for at least three years. This indicates financial markets reward verifiable sustainability, offering a proactive incentive that can operate alongside or counterbalance coercive policy.

5.2. Theoretical Implications: Toward an Integrated Policy-Finance Framework

Our findings challenge the context-free application of Western capital structure theories. We advance the institutional theory by demonstrating how coercive isomorphic pressures [62] can override market-based financial logic. This relationship provides a micro-foundational link between macro-institutional contexts and firm-level outcomes, enriching the “varieties of capitalism” perspective in finance [63].

Additionally, we contribute to the sustainable finance literature by formally contrasting a constraint-based policy shield with an incentive-based sustainability shield. This illustrates how state policy can architect market mechanisms to generate financial value from environmental performance, moving beyond a paradigm of pure compliance cost.

Table 17 synthesizes the boundary conditions moderating both shields, clarifying their contingent applicability. The policy shield is strongest in systemically important, heavily regulated sectors during active intervention, while the sustainability shield emerges most clearly in sectors with high environmental externalities and mature green certification pathways.

Table 17. Boundary conditions and scope of the shield mechanisms.

Boundary Dimension	Policy Shield (Coercive Constraint)	Sustainability Shield (Proactive Incentive)
Industry Context	Strongest in: Systemically important, heavily regulated sectors (e.g., real estate, banking, and energy).	Strongest in: Sectors with high environmental pathways and established green certification standards (e.g., real estate green buildings, and energy).
	Weaker in: Competitive, innovation-driven sectors with light-touch regulation (e.g., technology, and consumer services).	Weaker in: Sectors with low environmental impact (e.g., software, and certain financial services).
Ownership Type	Affects all firms due to universal compliance, with different channels for SOEs and non-SOEs.	Effect moderated by ownership: Non-SOEs may respond more to market incentives, while SOEs may view sustainability as a compliance cost.
Time Period/ Regulatory Cycle	Manifests during period of macroprudential tightening (e.g., post-2017 deleveraging campaign). Less visible during policy-neutral periods.	Emerges as green finance matures, particularly post-Paris Agreement and the 2020 “Dual Carbon” policy acceleration in China. Weak in the early stages of sustainable finance development.
Financing Regime	Dominant in: Hybrid or state-influenced financial systems with direct credit quotas (e.g., China’s managed credit system).	Operative in: Financing regimes that have developed specific instruments (green bonds, and SLBs), verification agencies, and regulatory guidelines for sustainability.

Source: Author.

5.3. Policy Implications: Architecting Effective Shield Mechanisms

Our findings offer practical guidance in three areas:

1. **Regulatory measures:** Regulators should implement direct leverage constraints to manage risk while recognizing potential capital allocation distortions. They must prioritize sustainability-linked policies, including standardized green certifications combined with time-bound systemic risk shields.
2. **Corporate adaptation:** Corporate managers and industry stakeholders must proactively adapt to policy changes. Environmental performance is becoming financially significant, and early sustainability initiatives can facilitate financing and lower capital costs, especially in real estate and heavy industries.
3. **Investor strategies:** Investors should modify strategies to incorporate sustainability metrics to capture the growing “greenium”. Developing models that anticipate regulatory risks will position portfolios favorably for changing market and policy conditions.

5.4. Limitations and Future Research Directions

This study highlights several limitations that outline fruitful research avenues. First, while we document the attenuation of traditional tax incentives, forward-looking, cash-flow-based measures could better capture managerial expectations. Second, our operationalization of sustainability via green bonds could be complemented by project-level environmental data and corporate carbon footprints. Finally, our sample period ends in 2021, at the announcement of China’s “Dual Carbon” goals. Since then, the sustainable transition has accelerated, including the actual implementation of the “Three Red Lines” policy and the expansion of green finance. Future research should track firms through this period to see whether the sustainability shield grows, whether policy shields shift from strict constraints to guidance, and how these factors affect real estate’s long-term decarbonization.

6. Conclusions

This study moves beyond traditional tax shields to propose and validate a dual-shield framework for understanding the capital structure in China's real estate sector during its sustainable transition. We demonstrate how coercive regulatory constraints and the policy shield can override fundamental market incentives, neutralize the benefits of the debt tax shield, and disrupt standard adjustment mechanisms. Simultaneously, we document the emergence of a proactive sustainability shield, where verifiable environmental performance leads to a persistent reduction in the cost of debt.

The core implication of this re-examination of the capital structure in China's real estate sector is that the pathway to a sustainable transition is not merely a technical challenge of engineering and finance, but a strategic one of institutional redesign. The powerful regulatory capacity evidenced by the policy shield must be deliberately harnessed to architect the sustainability shield.

In conclusion, the challenge goes beyond tax shields to develop a robust, forward-looking financial logic for sustainability. China's real estate transition, and that of other carbon-intensive sectors, depends on this paradigm shift. Moving from regulatory constraints to aligning incentives is crucial. Our framework clarifies that the regulatory shift is already underway, emphasizing the need for bold and rapid action in research and policy to expand and secure these changes. The financial system of the future must lead and reward the transition to a sustainable economy.

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Abbreviations

The following abbreviations are used in this manuscript:

CCDC	China Central Depository & Clearing Co., Ltd.
CSMAR	China Stock Market & Accounting Research
CSRC	China Securities Regulatory Commission
DiD	Difference-in-Differences
ESG	Environmental, Social, and Governance
KPIs	Key Performance Indicators
PSM	Propensity Score Matching
System GMM	System Generalized Method of Moments
SLBs	Sustainability-Linked Bonds
SOA	Speed of Adjustment
SOE	State-owned Enterprises
TWFE	Two-Way Fixed Effects

Appendix A

According to Chinese state key news "People.cn", 2017 was a year in which the real estate industry experienced particularly strict and frequent regulatory measures. This year, the central government launched over 200 financial regulatory and real estate control measures, surpassing the number and intensity of policies related to the real estate market

seen in previous years. These measures are aimed at curbing speculation, stabilizing housing prices, and guiding healthy market development. Additionally, the policies such as dual-track housing supply, equal rights for renting and purchasing, shared ownership, and sales restrictions were gradually put into effect, and a framework for a stable and healthy real estate development mechanism emerged, aligning with national conditions and adapting to market rules. (Source: People.cn <http://house.people.com.cn/n1/2017/1229/c164220-29736270.html>) (accessed on 8 December 2025).

The following are the major measures taken by the Chinese Central Government in 2017.

- | |
|--|
| <ul style="list-style-type: none"> • The Central Economic Work Conference sets the tone for “risk prevention” and “deleveraging.” <p>In December 2016, the Central Economic Work Conference of the Chinese government raised its emphasis on financial risk prevention as a priority. This conference set the tone for 2017. The government planned to prevent and control asset bubbles and improve regulation to ensure no systemic financial risk. Lowering enterprises’ leverage ratios was a top priority in deleveraging.</p> <p>Source: https://cpc.people.com.cn/n1/2016/1217/c64094-28956616.html (accessed on 8 December 2025)</p> |
| <ul style="list-style-type: none"> • The Central Financial and Economic Affairs Commission suggests a long-term real estate mechanism. <p>In February 2017, the Central Financial and Economic Affairs Commission conducted the 15th meeting, and the committee first proposed to “establish a long-term mechanism and fundamental institutional arrangements for the real estate market.” This marked a shift in China’s approach to real estate regulation from short-term control to a new direction focused on long-term mechanisms and housing system reform.</p> <p>Source: https://cpc.people.com.cn/n1/2017/0228/c64094-29114257.html (accessed on 8 December 2025)</p> |
| <ul style="list-style-type: none"> • The People’s Bank of China has started increasing interest rates to facilitate deleveraging <p>In January 2017, the People’s Bank of China (PBOC) began raising interest rates as part of monetary tightening measures to reduce financial leverage.</p> <p>Source: PBOC Annual Report 2017 https://www.pbc.gov.cn/english/130739/3661502/3652553/2025080815061675386/2018102918484953963.pdf (accessed on 8 December 2025)</p> |
| <ul style="list-style-type: none"> • The Political Bureau meeting reaffirms the continuity and stability of macroeconomic policies <p>On 25 April 2017, at the meeting of the Political Bureau of the CPC Central Committee, the committee confirmed its commitment to maintaining the continuity and stability of macroeconomic policies, continuing to implement a proactive fiscal policy and a prudent monetary policy.</p> <p>Source: https://paper.people.com.cn/rmrbhwb/html/2017-04/26/content_1769437.htm (accessed on 8 December 2025)</p> |
| <ul style="list-style-type: none"> • Ministry of Land and Resources optimizes land supply structure to regulate the market <p>On 10 May 2017, China’s Ministry of Land and Resources issued the 2017 National Land Use Plan to optimize the land supply structure. To promote stable and healthy development of the real estate market, cities and towns with excessive real estate inventory pressure should reduce, or even suspend, the allocation of new construction land quotas for housing projects. Cities facing significant pressure from rising housing prices should coordinate existing and incremental construction land, comprehensively consider factors such as regional population, employment, and public service facilities,</p> |

optimize the land supply structure, and, correspondingly, increase the annual supply of residential land.

Source: https://www.gov.cn/gongbao/content/2017/content_5232375.htm (accessed on 8 December 2025)

- Ministry of Finance and Ministry of Land Resources pilot special bonds for local government land reserve

On 1 June 2017, the Ministry of Finance and the Ministry of Land and Resources issued the Measures for the Administration of Special Bonds for Local Government Land Reserve (Trial), specifying that, in order to improve the management of local government special bonds, regulate land reserve financing activities, establish a system linking land reserve special bonds with project assets and returns, and promote the sustainable and healthy development of land reserve initiatives, local governments will first pilot land reserve bonds. In the future, the scope of special bonds will be gradually expanded.

Source: https://yss.mof.gov.cn/zhuantilanmu/dfzgl/zcfg/201706/t20170601_2612924.htm (accessed on 8 December 2025)

- CBRC and the Ministry of Land Resources standardize real estate mortgage registration procedures for financial institutions

On 9 June 2017, the China Banking Regulatory Commission and the Ministry of Land and Resources jointly issued the “Notice on Several Issues Concerning Real Estate Mortgage Registration in the Business Operations of Financial Asset Management Companies and Other Institutions”, further standardizing the relevant procedures for real estate mortgage registration by financial institutions.

Source: <https://www.icbc.com.cn/page/721853508256301079.html> (accessed on 8 December 2025)

- Political Bureau meeting calls for resolving local government debt risks

On 24 July 2017, the Political Bureau of the CPC Central Committee proposed to actively and prudently resolve accumulated local government debt risks, effectively regulate local government debt financing, and resolutely curb the increase of implicit debt.

Source: <https://cpc.people.com.cn/n1/2017/0725/c64094-29425573.html> (accessed on 8 December 2025)

- State Council Executive Meeting deploys measures to reduce leverage at central SOEs

On 23 August 2017, the State Council Executive Meeting decided to further reduce leverage at central state-owned enterprises (SOEs) by establishing multiple channels to reduce corporate debts.

Source: https://english.www.gov.cn/premier/news/2017/08/23/content_281475810278868.htm (accessed on 8 December 2025)

- Politburo Meeting prioritizes housing reform and multi-pronged long-term mechanism

The Politburo Meeting of the Communist Party of China held on December 8 also proposed that accelerating housing system reform and establishing a long-term mechanism are key tasks to focus on in the coming year. In addition to implementing corresponding real estate policies, adjustments in areas such as finance and taxation, as well as breakthroughs in the rental market, will also influence the establishment of a long-term real estate mechanism.

Source: <https://www.rmzxw.com.cn/c/2017-12-11/1896022.shtml> (accessed on 8 December 2025)

Appendix B

Appendix B provides detailed balance diagnostics for the propensity score matching procedure used to construct the control group for the sustainability shield analysis (H3). The table reports the mean (with standard deviations in parentheses), standardized mean differences (SMD), variance ratios, *t*-test, and *p*-values for all covariates used in the matching process, both before and after matching. Conventional thresholds for an adequate balance are $|SMD| < 0.10$ and variance ratios between 0.5 and 2 [51,52].

Table A1. Comprehensive balance diagnostics for propensity score matching (Before matching (full sample)).

Covariate	Treatment Group (Green Issuers) (N = 247)	Control Group (All Non-Issuers) (N = 35,155)	Standardized Mean Difference (SMD)	Variance Ratio	<i>t</i> -Test <i>p</i> -Value
Firm Characteristics					
Firm Size: <i>size1</i>	23.15 (1.29)	21.37 (1.42)	1.201	0.82	<0.001 *
Profitability: <i>prof2</i>	0.058 (0.085)	0.040 (0.104)	0.170	0.67	0.006 *
Leverage Ratio: <i>td1</i>	0.462 (0.184)	0.448 (0.209)	0.067	0.78	0.281
Asset Tangibility: <i>netp</i>	0.251 (0.168)	0.238 (0.173)	0.075	0.94	0.195
Growth Opportunities: <i>tobinq</i>	2.245 (2.117)	2.029 (2.589)	0.083	0.67	0.167
Earnings Volatility: <i>vol</i>	0.031 (0.028)	0.037 (0.179)	-0.042	0.02	0.573
Ownership Structure					
Institutional Ownership: <i>instfin</i>	8.93% (10.22)	6.06% (7.61)	0.374	1.80	<0.001 *
Management Ownership: <i>managop</i>	7.85% (13.45)	7.19% (14.81)	0.045	0.82	0.527
Financial Policy					
Non-debt Tax Shield: <i>ndts</i>	0.026 (0.018)	0.025 (0.017)	0.056	1.12	0.331
Effective Tax Rate: <i>eft</i>	0.161 (0.152)	0.155 (2.224)	0.003	0.00	0.968

Notes: For continuous variables, means are reported with standard deviations in parentheses. Standard Mean Difference (SMD) = $(Mean_Treated - Mean_Control) / \sqrt{[(SD_Treated^2 + SD_Control^2)/2]}$. Variance Ratio = $SD_Treated^2 / SD_Control^2$. Conventional threshold for adequate balance is $|SMD| < 0.10$ and $0.5 < \text{Variance Ratio} < 2$. This panel shows significant baseline imbalance, justifying the use of PSM. T-test *p*-values test the null hypothesis of equal means between the treatment and control groups. Statistical significance is indicated by the following: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Source: Author's own calculation.

Table A2. Comprehensive balance diagnostics for propensity score matching (After matching (matched sample)).

Covariate	Treatment Group (Green Issuers) (N = 247)	Control Group (Matched Non-Issuers) (N = 247)	Standardized Mean Dif- ference (SMD)	Variance Ratio	<i>t</i> -Test <i>p</i> -Value
Firm Characteristics					
Firm Size: <i>size1</i>	23.12 (1.30)	23.08 (1.28)	0.027	1.03	0.752
Profitability: <i>prof2</i>	0.057 (0.084)	0.055 (0.082)	0.019	1.05	0.804
Leverage Ratio: <i>td1</i>	0.461 (0.183)	0.458 (0.180)	0.014	1.03	0.864
Asset Tangibility: <i>netp</i>	0.250 (0.167)	0.247 (0.165)	0.017	1.02	0.848
Growth Opportunities: <i>tobinq</i>	2.238 (2.110)	2.225 (2.105)	0.005	1.01	0.948
Earnings Volatility: <i>vol</i>	0.031 (0.028)	0.032 (0.029)	-0.035	0.93	0.694
Ownership Structure					
Institutional Ownership: <i>instfin</i>	8.90% (10.20)	8.85% (10.15)	0.007	1.01	0.950
Management Ownership: <i>managop</i>	7.84% (13.43)	7.81% (13.40)	0.002	1.00	0.983
Financial Policy					
Non-debt Tax Shield: <i>ndts</i>	0.026 (0.018)	0.026 (0.018)	0.000	1.00	1.000
Effective Tax Rate: <i>eft</i>	0.161 (0.152)	0.159 (0.150)	0.013	1.03	0.891

Note: One-to-one nearest-neighbor propensity score matching was performed with a caliper of 0.05. All covariates are balanced with $|SMD| < 0.10$ and variance ratios within the acceptable range (0.5 to 2), indicating successful matching. T-tests fail to reject the null hypothesis of equal means for all covariates (all *p*-values > 0.10), confirming that the matched treatment and control groups are statistically indistinguishable on observable characteristics. Source: Author's own calculation.

Table A3. Balance improvement summary.

Metric	Before Matching	After Matching	Improvement		
Mean Absolute SMD	0.207	0.015	92.8%		
% of Covariates with	SMD	< 0.10	40.0% (4/10)	100.0% (10/10)	+60.0%
% of Covariates with	SMD	< 0.05	30.0% (3/10)	90.0% (9/10)	+60.0%
Variance Ratio within [0.5, 2]	80.0% (8/10)	100.0% (10/10)	+20.0%		
Pseudo-R ² from Probit Model	0.185	0.012	93.5%		
Likelihood Ratio Test (<i>p</i> -value)	<0.001	0.851	-		

Note: Summary statistics demonstrate substantial improvement in covariate balance after matching. The pseudo-*R*² drops from 0.185 to 0.012, indicating that the matched samples are statistically indistinguishable on observable characteristics. The ratio test after matching fails to reject the null that all coefficients are zero (*p* = 0.851), confirming successful balancing. Source: Author's own calculation.

Appendix C. Replication Details and Data Protocols

Appendix C provides comprehensive details on variable construction, sample selection, quasi-experimental protocols, and estimation commands employed in the study.

Table A4. Variable construction and data sources.

Variable	Definition/ Measurement	Raw Data Source	Key Notes
Cost of Debt (<i>COD</i>)	Interest Expense divided by Average Interest-Bearing Debt.	CSMAR: A001219000 (Interest Expense) CSMAR: A002101000 (Interest-Bearing Debt)	- All financial data are from the annual financial statements. - Average debt is used to mitigate period-end measurement noise. - Ratios are in decimal form.
Target Debt Deviation (<i>TDE</i>)	Target Leverage Ratio _{<i>t</i>} minus Actual Leverage Ratio _{<i>t-1</i>} .	Calculation using CSMAR determinants Industry median uses CSRC 2-digit classification	- The Tobit model censors the target at 0 and 1. - The model is evaluated separately for each year.
Effective Tax Rate (<i>eff</i>)	Income Tax Expense divided by Pre-tax (Accounting) Profit	CSMAR: A002129000 (Income Tax Expense) CSMAR: B002129000 (Pre-tax Profit)	- Winsorized at 1st and 99th percentiles. - Set to missing if pre-tax profit ≤ 0.
Post-2017 Dummy (<i>Post2017</i>)	Set to 1 if the fiscal year is 2018 or later. Otherwise set to 0.	Author's calculation	The 2017 macroprudential tightening is assumed to affect financial decisions from the 2018 fiscal year onward.
Green Bond Dummy (<i>Green_Dummy</i>)	<i>Green_Dummy</i> = 1 if firm <i>i</i> has at least one green bond issuance in the CCDC database in fiscal year <i>t</i> .	CCDC Green Bond Database	- Matched to listed firms via firm name and ISIN code. - Only bonds classified as "Green Bond" are included.
First Green Bond Issuance Event Time	For DiD/Event Study: Event year $\tau = 0$ is the fiscal year of the firm's first recorded green bond issuance in the CCDC database.	CCDC Green Bond Database	- The fiscal year of the date of issuance is determined. - If the issuance date is after June 30, $\tau = 0$ is assigned to the following fiscal year to align with annual financial reporting.

Notes: This table provides detailed definitions, measurement methods, raw data sources, and key notes for each variable used in the study. It explains how key variables such as Cost of Debt (*COD*), Target Debt Deviation (*TDE*), Effective Tax Rate (*eff*), and others are constructed. Source: Author.

Table A5. Sample selection flowcharts (Main analysis sample (for H1 and H2)).

Step	Filter Description	Observations Remaining	Observations Dropped	Rationale
1	- Raw CSMAR universe for A-share listed firms during 2003–2021. - Keep firm-years with non-missing Total Assets, Total Debt, and Long-term Debt.	40,686	~409,314	Defines core financial variable coverage.
2	Apply 1%/99% winsorization to all continuous variables.	40,686	0	- Standard outlier treatment. - This is the Static Sample.
3	Require non-missing Lagged <i>CTD</i> and constructed <i>TDE</i> .	36,881	3805	- Loss due to lag structure for dynamic models. - This is the Dynamic Model Sample.
4	Split by CSRC industry: Real Estate (Code: K70) vs. Non-Real-Estate.	RE: 1095 Non-RE: 35,786	-	Creates subsamples for heterogeneous effect analysis.

Table A6. Sample selection flowcharts (Green bond analysis sample (for H3)).

Step	Description	Treated Group	Matched Group
1	Identify all green bond issuance firm-years (2003–2021).	247 (89 unique firms)	35,155 (all other firm-years)
2	- Perform 1:1 PSM on Static Sample (Step 2 above). - Match on lagged: <i>size1</i>, <i>prof2</i>, <i>td1</i>, <i>netp</i>, <i>tobinq</i>, and <i>instfin</i>. - Caliper = 0.05.	247	247 (matched controls)
3	- For DiD/Event Study: From matched pairs, keep only the first issuance event for treated firms and their matched controls. - Restrict to window $\tau = [-3, +3]$ years around event.	89 firms $\times$ 7 yrs = 623 obs.	89 firms $\times$ 7 yrs = 623 observations. - Total DiD Sample = 1246 observations

Note: Tables A5 and A6 outlines the sample selection process for the main analysis (Table A5) and the green bond analysis (Table A6). Source: Author.

Table A7. Quasi-experimental design protocols.

Protocol Element	Specification Details	Implementation & Rationale
1. Propensity Score Matching (PSM) for H3	- Matching Objectives: Construct a comparable control group for green bond issuers. - Sample: The full static sample ($N = 40,686$, Table 2) - Treated Group: Firm-years with <i>Green_Dummy</i> = 1 ($N = 247$). - Control Pool: All firm-years with <i>Green_Dummy</i> = 0 ($N = 35,155$). - Propensity Score Model: Probit regression. - Matching Algorithm: 1:1 Nearest-Neighbor Matching without replacement. - Caliper: 0.05 times the standard deviation of the linear propensity score. - Balance Assessment: SMD for all covariates. Success criterion: All post-matching $SMD < 0.10$ (0.10 is set commonly in applied econometrics).	- To estimate the Average Treatment Effect on the Treated and mitigate selection bias from observable confounders. - Provides the largest pool for matching. - Ensures that the control group is a valid counterfactual by achieving balance between treated and control groups.
2. Difference-in-Differences (DiD) and Event Study for H3	- Treatment Event: A firm's first green bond issuance. - Event Time (τ): $\tau = 0$ is the fiscal year of the first issuance; assign to the following fiscal year if date is after June 30. - Event Window: $\tau = [-3, +3]$ years around $\tau = 0$. - Sample: 89 first-time issuers and their 89 PSM-matched control firms within the $[-3, +3]$ window. - Final $N = 1246$ firm-year obs. (178 firms $\times$ 7 yrs). - Static DiD Model: Two-way fixed effects (TWFE) model with firm and year fixed effects. - Event-Study Model: Uses event-time dummies to trace dynamic effects. - Inference: Standard errors clustered at the firm level in all	- Focuses on the initial market signal and financing impact, avoiding confounding from subsequent issuances. - Aligns the treatment timing with the annual financial reporting cycle to ensure the post-treatment <i>COD</i> is measured after the issuance effect is realized. - Extracts dynamic treatment effects while testing the parallel trends assumption.
3. Wald Test for Coefficient Equality (H2)	- Purpose: To formally test if the policy shift coefficient ($Post2017 \times TDE$) differs between the real estate and non-real-estate sectors. - Procedure: Test Model 3 separately for the two subsamples. Conduct a Wald test on the linear restriction: $\beta_2(\text{Real Estate}) = \beta_2(\text{Non-Real-Estate})$.	Provides statistical evidence for the "heterogeneous amplification" central to the revised H2.
4. System GMM Estimation (Robustness)	- Estimator: Two-step System GMM. - Instruments: For difference equation: lagged levels of the dependent and endogenous variables; for level equation: lagged differences. - Diagnostic Tests: Arellano-Bond AR(1), AR(2): Tests for serial correlation in the first-differenced errors. Hansen J-test: Test of over-identifying restrictions (instrument exogeneity).	- Addresses dynamic panel bias in the partial adjustment model by using internal instruments. - Validates instrument exogeneity and model robustness while avoiding instrument proliferation.

- Instrument Count: Kept below the number of cross-sectional units to avoid over-identification.

Note: This table describes the quasi-experimental design protocols used in the study, including Propensity Score Matching (PSM) for H3, Difference-in-Differences (DiD) and Event Study for H3, Wald Test for coefficient equality (H2), and System GMM estimation for robustness. Source: Author.

Table A8. Replication commands for key tables.

Target Table	Model/Hypothesis	Model Specification	Details
Table 6	Model 2 (H1): Tax Shield Attenuation	$CLD_{i,t} = \alpha_0 + \alpha_1 \cdot eft_{i,t} + \alpha_2 \cdot (RealEstate_i \cdot eft_{i,t}) + \sum \delta_j \cdot Controls_{j,i,t} + \theta_i + \gamma_t + \epsilon_{i,t}$	- Key coefficient: α_2 (interaction). A negative, significant α_2 supports H1. - Controls: <i>prof2</i>, <i>netp</i>, <i>size1</i>, <i>ndts</i>, <i>tobinq</i>, <i>vol</i>, <i>instfin</i>, and <i>managep</i>. - Fixed Effects: Industry (θ_i), Year (γ_t).
Table 7	Model 3 (H2): Regulatory Shift	For each sector in {Real Estate, Non-Real-Estate): $CTD_{i,t} = \beta_0 + \beta_1 TDE_{i,t} + \beta_2 (Post2017_t \cdot TDE_{i,t}) + \theta_i + \gamma_t + \epsilon_{i,t}$	- Run separately for each sector. - Key Coefficient: β_2 (policy shift). - Fixed Effects: Industry (θ_i), Year (γ_t).
Table 8	Wald Test of H2: Coefficient Equality	- Test the two models from Table 7 and store results. - Test: $\beta_2(\text{Real Estate}) = \beta_2(\text{Non-Real-Estate})$.	Test Statistic: Wald (χ^2). The reported p-value corresponds to this test of equality for the $Post2017 \times TDE$ coefficient.
Table 12 (Panel B)	Model 4, Stage 2 (H3): PSM Matched Sample	$COD_{i,t} = \lambda_0 + \lambda_1 \cdot Green_Dummy_{i,t} + \sum \theta_j \cdot Controls_{j,i,t} + \theta_i + \gamma_t + \epsilon_{i,t}$	- Sample: PSM-matched pairs (N = 494). - Key Coefficient: λ_1 (treatment effect). - Controls: <i>size1</i>, <i>prof2</i>, <i>vol</i>, <i>zscore</i>. - Fixed Effects: Firm (θ_i), Year (γ_t).
Table 13 (Panel B)	Model 4, Stage 3 (H3): Static DiD	$COD_{i,t} = \lambda_0 + \lambda_1 Post + \lambda_2 Treat + \lambda_3 (Post \times Treat) + Controls_{j,i,t} + \theta_i + \gamma_t + \epsilon_{i,t}$	- Sample: Event window $[-3, +3]$ for first-time issuers & matched controls. - Key Coefficient: λ_3 (DiD estimator). - Fixed Effects: Firm (θ_i), Year (γ_t).
Table 14	Model 4, Stage 3 (H3): Event Study	$COD_{i,t} = \lambda_0 + \sum [\tau = -3, +3] \lambda_{-\tau} \cdot EventDummy_{-\tau} + \sum \theta_j \cdot Controls_{j,i,t} + \theta_i + \gamma_t + \epsilon_{i,t}$	- Sample: Same as DiD. - Key Coefs.: $\lambda_{-\tau}$ for $\tau = \{0, +1, +2, +3\}$. - Reference: Event year $\tau = -1$ is omitted.
Table 15	Robustness: System GMM	$CTD_{i,t} = \alpha \cdot CTD_{t-1} + \beta_1 \cdot TDE + \beta_2 \cdot (UnderLevered \times TDE) + \theta_i + \epsilon_{i,t}$	- Estimator: Two-step System GMM. - Instruments: Lagged levels and differences. - Diagnostics: AR(1), AR(2), and Hansen J-test reported.

Note: This table presents the econometric specifications for key results in the study. Source: Author.

Table A9. Primary model specifications.

Table	Model Tested and Purpose	Specifications	Details and Notes
Table 6	Model 2 (H1): Tax shield attenuation via the interaction between the effective tax rate and the real estate sector dummy.	- A linear regression model is tested where the dependent variable is the change in long-term debt (CLD). - The key independent variables are the effective tax rate (<i>eft</i>) and its interaction with the real estate sector indicator (<i>RealEstate</i>). - The model includes standard capital structure determinants as controls (profitability, tangibility, size, non-debt tax shield, growth, volatility, and ownership) as well as industry and year fixed effects.	- Standard errors are clustered at the firm level. - The coefficient on the interaction term <i>RealEstate</i> $\times$ <i>eft</i> is the statistic of interest for H1. - A significant negative coefficient supports the hypothesis.
Table 7	Model 3 (H2): Partial adjustment model with a policy shift interaction ($Post2017 \times TDE$).	- For the real estate subsample, the change in total debt (CTD) is regressed on the target deviation (TDE) and its interaction with a post-2017 policy dummy, with industry and year fixed effects. - An independent regression is run on the non-real-estate subsample.	- Standard errors are clustered at the firm level. - The model is tested separately for the two groups to allow all coefficients to vary. - The coefficient on the $Post2017 \times TDE$ interaction in each regression measures the policy-induced change in the SOA for that sector.

Table 8	Test of H2: A Wald test for the equality of the $Post2017 \times TDE$ coefficient across the two subsample regressions (Real Estate vs. Non-Real-Estate).	- Two regressions for Table 7 are stored as separate models. - A linear hypothesis test is conducted to determine if the $Post2017 \times TDE$ coefficient from the real estate model is statistically different from the corresponding coefficient in the non-real-estate model.	- This test generates a chi-squared statistic and associated p-value. - A statistically significant result ($p < 0.05$) provides formal evidence for the heterogeneous amplification effect central to the revised H2.
Table 12 (Panel B)	Model 4, Stage 2 (H3): Primary test of the sustainability shield on the Propensity Score Matched (PSM) sample.	- A two-way fixed effects regression is tested on the PSM-matched sample. - The dependent variable is the cost of debt (COD). The key regressor is a dummy variable for green bond issuance ($Green_Dummy$). - The model includes firm-level controls (size, profitability, earnings volatility, and Altman Z-score) and absorbs firm and year fixed effects.	- Standard errors are clustered at the firm level. - Perform test on the matched sample of 494 firm-year observations (247 treated, 247 control). - The coefficient on $Green_Dummy$ shows the average treatment effect on the treated.
Table 13 (Panel B)	Model 4, Stage 3 (H3): Difference-in-Differences (DiD) analysis around the first green bond issuance.	- A two-way fixed effects DiD model is performed on the event-study sample. The dependent variable is COD. - The model includes dummies for the post-event period ($Post$), treatment group membership ($Treat$), and their interaction ($Post \times Treat$), along with time-varying controls and firm and year fixed effects.	- Standard errors are clustered at the firm level. - The sample is restricted to a $[-3, +3]$-year window around the first issuance event for the 89 treated firms and their 89 matched controls. - The coefficient on the $Post \times Treat$ interaction is the DiD estimator.
Table 14	Model 4, Stage 3 (H3): Dynamic event-study analysis of the first green bond issuance.	- A two-way fixed effects model is implemented, replacing the single $Post$ dummy in the DiD specification with a full set of event-time dummies for years $t = -3$ to $t = +3$ relative to the issuance year ($t = 0$), omitting $t = -1$ as the reference period. - The model includes the same controls and fixed effects as the static DiD model.	- Standard errors are clustered at the firm level. - The coefficients on the event-time dummies (particularly for $t = 0, +1, +2, +3$) illustrate the dynamic treatment effects and test the parallel pre-trends assumption (via coefficients for $t = -3, -2$).
Table 15	Robustness Check: System Generalized Method of Moments (GMM) analysis of the dynamic partial adjustment model.	- The dynamic panel model is tested using the two-step System GMM model. CTD is the dependent variable, and the model includes its first lag, TDE, and an interaction between TDE and an under-levered dummy, along with a constant term.	- The model uses lagged levels (for the difference equation) and lagged differences (for the level equation) as instruments. - Diagnostic tests for Arellano–Bond AR(1) and AR(2)) and instrument validity (Hansen J-test) are reported. - The number of instruments is kept below the number of cross-sectional units to avoid over-identification.

Note: This table summarizes the specifications of each model, facilitating replication and verification of the study's findings. Source: Author.

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