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Bitcoin Exposure and the Cost of Debt Financing: Evidence from U.S. Publicly Listed Firms

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Abstract

This study investigates whether Bitcoin exposure affects the cost of debt financing among U.S. publicly listed firms, extending the emerging literature on corporate cryptocurrency exposure from firm risk and equity sensitivity to creditor pricing and borrowing costs. Motivated by the growing integration of digital assets into corporate financial policy, the paper examines whether creditors price Bitcoin exposure as a risk-enhancing firm characteristic. Drawing on the literature on creditor pricing, firm risk, and financing frictions, the study argues that Bitcoin exposure may increase debt-financing costs by amplifying perceived volatility, opacity, and uncertainty in firm-level financial positions. Using a panel-data framework, the analysis estimates pooled OLS, fixed-effects, random-effects, firm-clustered fixed-effects, lagged-exposure, dynamic fixed-effects, and two-step system GMM models. The results consistently show that Bitcoin exposure is positively and significantly associated with the cost of debt financing. In the preferred fixed-effects specification with firm-clustered robust standard errors, firms with Bitcoin exposure face materially higher effective debt costs than non-exposed firms. This finding remains robust in the dynamic fixed-effects and system GMM specifications, indicating that the main relationship is not driven by a single estimation approach. Diagnostic tests support the use of fixed effects, confirm the presence of heteroskedasticity, and show that multicollinearity is not a concern. By contrast, lagged Bitcoin exposure is not significant, and the dynamic specifications do not support a conventional positive persistence pattern in debt-financing costs. Overall, the findings suggest that debt markets treat Bitcoin exposure as a financially relevant source of firm-level risk and incorporate it into borrowing costs. The study contributes to the emerging literature on corporate cryptocurrency exposure by extending it from equity-market and firm-risk outcomes to a core corporate-finance variable: the cost of debt financing.

Keywords: Bitcoin exposure; cost of debt financing; creditor pricing; corporate finance; U.S. publicly listed firms; fixed effects; system GMM.

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INTRODUCTION

Corporate financing costs are central to corporate finance because they shape firms' capital-structure decisions, investment capacity, liquidity management, and long-run value creation. Within this broader agenda, the cost of debt is especially important because creditors translate their assessment of firm risk into interest charges, lending terms, and monitoring intensity. The classic corporate-finance literature has long shown that financing and liquidity outcomes respond systematically to risk, cash-flow uncertainty, and access to external capital. Opler et al. (1999) show that firms with stronger growth opportunities and riskier cash flows hold more cash, while Bates et al. (2009) document a substantial increase in U.S. corporate cash ratios over time and relate it to changes in risk and firm structure. These foundational studies establish a broader principle that is highly relevant here: when markets perceive an exposure to be risk-enhancing, financing conditions and financial policy adjust accordingly. These foundational studies establish a broader principle that is highly relevant here: when markets perceive an exposure to be risk-enhancing, financing conditions and financial policy adjust accordingly (Opler et al., 1999; Bates et al., 2009). Against this background, Bitcoin has emerged as a new and increasingly consequential source of corporate financial exposure. What was once treated primarily as a speculative digital asset has gradually entered the corporate sphere through treasury allocations, mining operations, exchange-related activities, custody services, payment integration, and broader disclosure-based exposure. As a result, Bitcoin is no longer relevant only to asset-pricing or portfolio-diversification research; it has become increasingly relevant to firm-level risk assessment and financial policy (Mercik et al., 2024; Leong et al., 2025). Recent evidence supports this shift. Mercik et al. (2024) show that crypto-asset exposure changes listed firms' risk profiles and stock-return sensitivity, indicating that crypto exposure is financially material once it enters the firm's balance sheet or operational environment.

This development raises a natural corporate-finance question: how do creditors price Bitcoin exposure? From a lender's perspective, Bitcoin exposure can affect the firm's risk profile through several channels. First, Bitcoin is associated with substantial price volatility and valuation uncertainty. Second, corporate Bitcoin exposure may increase information asymmetry because digital-asset disclosures remain uneven across firms and because the economic implications of such exposure are not always transparent from conventional financial statements alone. Third, Bitcoin exposure may be interpreted as a signal of greater managerial risk appetite or higher balance-sheet uncertainty, both of which can increase creditor concern over future repayment capacity. This reasoning is consistent with the broader debt-pricing literature showing that information asymmetry, borrower opacity, and disclosure quality materially affect external financing conditions and borrowing costs (Bellucci et al., 2023; Chen et al., 2024; Huang et al., 2025). Bellucci et al. (2023) show that information asymmetry and external certification matter for the cost of bank debt, while newer evidence continues to show that information quality and disclosure quality shape credit-market outcomes and financing constraints.

Emerging empirical evidence is increasingly aligned with that argument in the crypto setting. Gao et al. (2025) find that U.S. firms with cryptocurrency exposure incur higher effective interest costs on debt financing, using hand-collected data on corporate cryptocurrency holdings over 2013–2023. Their evidence suggests that creditors treat cryptocurrency exposure as a high-risk investment that raises the firm's overall risk profile and therefore warrants a higher financing-cost premium. This is a significant development because it shifts the corporate crypto discussion away from stock-price reactions alone and toward a core financing outcome: the price at which firms access debt capital.

Even so, the broader literature remains highly uneven. Most Bitcoin and cryptocurrency studies continue to focus on price dynamics, volatility, spillovers, investor behavior, connectedness, and diversification rather than on firm-level financing outcomes. Even within the smaller literature on corporate crypto exposure, the dominant themes are stock-return sensitivity, firm risk, and market spillovers rather than creditor pricing specifically. Yet this omission is important. Debt-financing costs are among the most direct mechanisms through which external capital providers discipline perceived firm risk, uncertainty, and opacity. If Bitcoin exposure affects creditor pricing, then its consequences extend beyond digital-asset valuation and into the core of corporate financing policy. Recent work on crypto risk in broader financial portfolios also suggests that Bitcoin-related exposures are increasingly relevant to mainstream financial risk management rather than to niche speculation alone. This study addresses that gap by examining whether Bitcoin exposure increases the cost of debt financing among U.S. publicly listed firms. The U.S. setting is appropriate because it combines relatively rich corporate disclosure, active capital markets, and an observable recent history of firm-level cryptocurrency exposure. The central argument is straightforward: when firms adopt, hold, or materially disclose Bitcoin exposure, creditors may revise their assessment of firm risk, disclosure quality, and earnings uncertainty, and these revisions may be reflected in higher effective debt costs. In this sense, the paper connects the emerging literature on corporate cryptocurrency exposure to the more established literature on creditor pricing, information asymmetry, and financing frictions.

The paper contributes to the literature in three ways. First, it extends the emerging literature on corporate cryptocurrency exposure by focusing on a specific and economically important financing outcome: the cost of debt. Second, it places Bitcoin exposure within a mainstream corporate-finance setting by examining creditor response rather than limiting the analysis to equity-market sensitivity. Third, it employs a panel-data framework that allows the Bitcoin exposure effect to be examined across static and dynamic specifications, thereby testing whether the relationship remains robust once firm-level heterogeneity and temporal dependence are considered. In doing so, the study contributes to the growing intersection of digital assets, firm-level risk, and corporate financing policy.

Accordingly, the study asks a simple but important question: does Bitcoin exposure raise the cost of debt financing for U.S. publicly listed firms? The central expectation is that it does. If creditors perceive Bitcoin exposure as amplifying firm risk, opacity, or balance-sheet uncertainty, then Bitcoin-exposed firms should face higher effective debt-financing costs than comparable non-exposed firms. By investigating that relationship, the study seeks to clarify whether Bitcoin exposure is now being priced not only in equity markets, but also in debt markets, where the implications for corporate financial policy may be even more immediate.

LITERATURE REVIEW

The cost of debt is fundamentally a risk-pricing outcome. Creditors do not evaluate borrowers solely on the basis of leverage or current repayment capacity; they also price uncertainty, information asymmetry, disclosure quality, and the stability of expected cash flows. This broader creditor-pricing logic is deeply embedded in corporate-finance research. In the classic cash-holdings literature, firms with stronger growth opportunities and riskier cash flows retain more internal liquidity, while changes in cash-flow risk and firm structure help explain long-run changes in financial policy (Opler et al., 1999; Bates et al., 2009). Although these studies focus on liquidity rather than borrowing costs directly, they establish an essential principle for the present study: when markets perceive a firm to be riskier or more difficult to evaluate, financing conditions adjust accordingly.

That principle has been reinforced by the modern literature on creditor pricing and information asymmetry. Lenders respond not only to conventional accounting ratios, but also to the quality of the information environment in which those ratios are interpreted. Bellucci et al. (2023) show that the cost of bank debt reflects public information about borrower quality and interacts with information asymmetry and certification. More recent work similarly shows that stronger information quality and higher disclosure quality improve financing conditions by reducing uncertainty and easing financing constraints (Chen et al., 2024; Huang et al., 2025). These studies are highly relevant because they imply that any exposure that increases opacity, valuation complexity, or uncertainty may be transmitted into the price of debt, even when traditional financial controls are held constant.

Bitcoin exposure fits naturally within this framework. Once Bitcoin enters the firm through treasury holdings, mining operations, exchange-related activities, custody services, payment integration, or broader disclosure-based exposure, it may alter how creditors assess the firm's overall risk profile. The issue is not simply that Bitcoin is volatile, but that it introduces a form of exposure whose valuation, reporting treatment, and strategic significance may be difficult for outside lenders to interpret. From a creditor's perspective, Bitcoin exposure may increase uncertainty in at least three ways: it can raise perceived asset-value volatility, it can complicate the interpretation of balance-sheet quality, and it can signal greater managerial willingness to engage with nontraditional financial risk. In this sense, Bitcoin exposure is not a niche digital-asset topic; it is a corporate-finance issue that sits directly within the broader literature on borrower risk, information asymmetry, and creditor response.

The emerging literature on corporate crypto-asset exposure provides direct support for treating Bitcoin exposure as a firm-level financial characteristic rather than a peripheral disclosure item. Mercik et al. (2024) show that adding crypto-assets to listed companies' balance sheets changes their risk profiles and stock-return sensitivity, implying that crypto exposure is financially material once it becomes part of the firm's financial structure. This is an important shift in the literature because it moves the discussion away from cryptocurrency prices alone and toward the firm as the relevant unit of analysis. If crypto exposure affects how equity markets price listed firms, it is reasonable to expect that debt providers may respond as well, particularly because creditors are typically more conservative than shareholders when incorporating new or opaque sources of risk.

The broader literature on crypto-related financial risk strengthens this expectation. Recent evidence suggests that cryptocurrency exposures are increasingly relevant to mainstream financial risk management rather than to isolated speculative behavior. Leong et al. (2025), for example, show that cryptocurrency risk exposures have become more consequential in equity-portfolio settings, indicating that Bitcoin-related risk is no longer confined to standalone crypto markets. This broader financial relevance matters for debt financing because creditors are concerned not only with current balance-sheet positions, but also with how new exposures may affect the firm's future cash-flow stability, downside risk, and refinancing capacity. Once Bitcoin exposure is understood as part of the broader firm-risk environment, the expectation that it may increase the cost of debt becomes much more compelling.

The most directly relevant evidence comes from the small but growing literature linking cryptocurrency exposure to debt-financing costs. Gao et al. (2025) provide the clearest evidence to date. Using hand-collected data on cryptocurrency holdings for U.S. firms from 2013 to 2023, they find that firms with cryptocurrency exposure incur higher effective interest costs on debt financing. Their interpretation is explicit: cryptocurrency exposure represents a high-risk investment that raises the firm's overall risk profile and therefore leads creditors to demand higher lending costs. This study is central to the present paper because it demonstrates that the debt-cost channel is not merely conceptual. It also shows that the implications of crypto exposure extend beyond stock-price reactions and into a core corporate-finance outcome.

Even so, the broader literature remains highly uneven. Most Bitcoin and cryptocurrency studies continue to focus on price dynamics, volatility, spillovers, connectedness, forecasting, and portfolio diversification, while comparatively few examine how crypto exposure affects firm-level financing outcomes. Even within the smaller literature on corporate crypto exposure, the dominant themes are stock-return sensitivity, broader firm risk, and market spillovers rather than creditor pricing specifically. This imbalance matters because debt-financing costs are among the most direct mechanisms through which external capital providers discipline perceived firm risk, opacity, and uncertainty. If Bitcoin exposure truly changes how firms are financed, then concentrating only on equity-market responses leaves a major part of the financial story incomplete.

A further issue concerns heterogeneity. The financing-cost consequences of Bitcoin exposure are unlikely to be uniform across firms. Standard corporate-finance reasoning suggests that creditors should penalize risky or opaque exposures more strongly when they coincide with weaker balance sheets, lower profitability, tighter liquidity, or greater information asymmetry. This implies that Bitcoin exposure should not be interpreted as a purely symbolic binary event. Its consequences are more likely to depend on the broader financial and informational environment in which the exposure occurs. The literature on bank debt, bond financing, and financing constraints supports exactly this intuition: when public information is weaker or harder to interpret, external finance becomes more sensitive to uncertainty and external risk signals (Bellucci et al., 2023; Chen et al., 2024; Huang et al., 2025). That logic provides a strong rationale for estimating firm-level panel models with controls and fixed effects rather than relying on simple cross-sectional comparisons.

Taken together, the literature points to three broad conclusions. First, the cost of debt responds to perceived risk, information asymmetry, and disclosure quality, not merely to mechanical accounting ratios. Second, corporate crypto-asset exposure is increasingly recognized as a material source of firm-level financial risk rather than a peripheral disclosure characteristic. Third, the limited direct evidence available suggests that cryptocurrency exposure raises the cost of debt, but the literature remains too small to treat that conclusion as fully settled. These observations make Bitcoin exposure a legitimate and timely subject for creditor-pricing research and justify a more focused firm-level examination of whether U.S. publicly listed firms with Bitcoin exposure face higher debt-financing costs.

Research Gap

Despite growing evidence that corporate crypto-asset exposure is financially consequential, its implications for creditor pricing remain insufficiently examined. The broader cryptocurrency literature continues to be dominated by studies of prices, volatility, connectedness, and trading behavior, while the corporate-finance implications of Bitcoin exposure remain comparatively underdeveloped. Even within the newer literature on firm-level crypto exposure, the emphasis has largely fallen on stock returns, market sensitivity, and general risk rather than on how creditors price such exposure in debt markets. At the same time, the small body of direct evidence that does exist suggests that cryptocurrency exposure may indeed increase effective debt costs. What remains insufficiently developed is a broader firm-level assessment of whether Bitcoin exposure is consistently associated with higher debt-financing costs within a panel-data corporate-finance framework. The present study addresses that gap by examining Bitcoin exposure and the cost of debt financing among U.S. publicly listed firms.

HYPOTHESES DEVELOPMENT

The central expectation of this study follows directly from the literature on creditor pricing, information asymmetry, and firm-level risk. Creditors demand higher financing costs when firms appear riskier, opaquer, or less predictable in their future cash flows. Bitcoin exposure can trigger each of these concerns. First, Bitcoin is associated with substantial price volatility and valuation uncertainty. Second, once Bitcoin becomes part of the firm's financial position or disclosure environment, it may increase information asymmetry because the scale, purpose, and implications of that exposure are not always transparent to outside lenders. Third, Bitcoin exposure may be interpreted as a signal of greater managerial risk appetite or higher balance-sheet uncertainty, both of which can increase lender concern over future repayment capacity. In this setting, the expected creditor response is a higher cost of debt for firms with Bitcoin exposure. This reasoning is consistent with the broader corporate-finance literature showing that financing conditions adjust to risk and uncertainty, and with the recent evidence that firms with cryptocurrency exposure incur higher effective interest costs on debt financing (Opler et al., 1999; Bates et al., 2009; Mercik et al., 2024; Gao et al., 2025).

Accordingly, the study advances the following main hypothesis:

H1: Bitcoin exposure has a positive and significant effect on the cost of debt financing among U.S. publicly listed firms.

A second issue concerns whether debt-financing costs exhibit a dynamic component. In corporate-finance settings, financing conditions are not always determined independently in each period. They may partly reflect prior borrowing conditions, persistent lender perceptions, and gradual updating in the assessment of firm quality. For that reason, empirical studies often include lagged dependent variables to test whether current financing outcomes depend on past financing conditions. The present study treats this as a supplementary dynamic question rather than the core theoretical contribution of the paper. The motivation is to test whether the pricing of debt displays persistence once Bitcoin exposure and firm fundamentals are taken into account (Orlova & Rao, 2018).

This leads to the second hypothesis:

H2: Debt-financing costs are dynamically persistent, such that lagged cost of debt has a positive and significant effect on current cost of debt.

A further question is whether the effect of Bitcoin exposure varies across firms depending on their financing structure. Leverage is particularly relevant in this respect. Highly leveraged firms already face greater refinancing pressure and lower tolerance for additional risk. If such firms are also exposed to Bitcoin, creditors may regard the combined risk as more severe than they would for less leveraged firms. This implies that Bitcoin exposure may not affect all firms uniformly; instead, its financing consequences may be stronger when it interacts with higher leverage. Because the literature has not yet established a settled pattern on this point, the moderating role of leverage is treated as an extension to the core argument rather than the principal contribution of the study. The test remains important, however, because it helps determine whether creditors penalize Bitcoin exposure more strongly when firms already appear financially stretched (Gao et al., 2025).

The third hypothesis is therefore stated as follows:

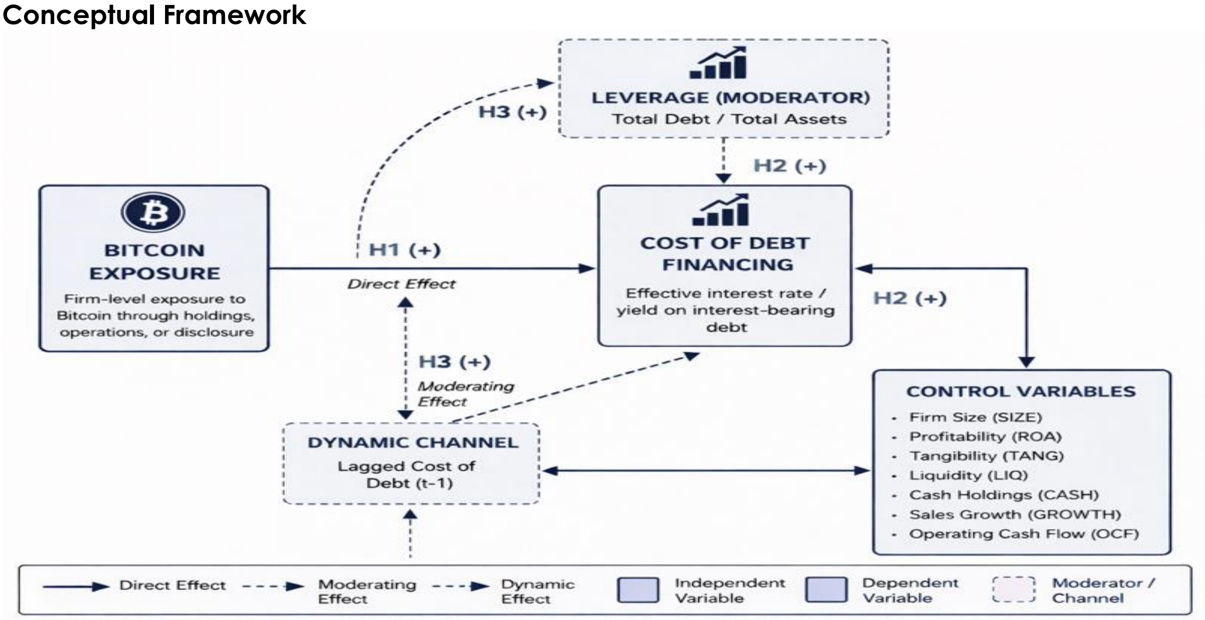
H3: Leverage moderates the relationship between Bitcoin exposure and the cost of debt financing.

CONCEPTUAL FRAMEWORK

The conceptual framework reflects a direct creditor-pricing channel, a supplementary dynamic channel, and a conditional cross-sectional channel. At the center of the framework is the direct relationship between Bitcoin exposure and the cost of debt financing. The central proposition is that once a firm becomes materially exposed to Bitcoin, creditors may reassess the firm's risk profile and require higher financing costs. This is the principal relationship tested in the paper and represents the core theoretical logic of the study. It follows from the broader view that financing costs respond to novel sources of uncertainty, balance-sheet opacity, and firm-level risk (Opler et al., 1999; Gao et al., 2025). The framework also includes a dynamic channel through lagged cost of debt. This channel is incorporated to capture the possibility that current debt-financing costs partly reflect prior financing conditions. Its role is supplementary: it does not replace the central exposure pricing relationship, but rather tests whether the cost of debt exhibits persistence over time once Bitcoin exposure and firm characteristics are controlled for. In this sense, the dynamic channel provides a more complete empirical treatment of debt-cost adjustment in panel settings (Orlova & Rao, 2018).

In addition, the framework includes leverage as a moderating variable. The purpose of this component is to assess whether the pricing effect of Bitcoin exposure depends on the firm's financing structure. If creditors are more sensitive to Bitcoin exposure when firms are already highly leveraged, then the Bitcoin exposure cost of debt relationship should be stronger at higher levels of leverage. This moderating path therefore captures a possible heterogeneity effect rather than the main theoretical mechanism. Standard firm-level controls are also included in the framework. These comprise firm size, profitability, tangibility, current ratio, cash holdings, sales growth, operating cash flow, and net working capital. Their role is to isolate the Bitcoin-exposure effect from other established determinants of debt-financing costs. Consistent with creditor-pricing theory, these variables are modelled as direct influences on the dependent variable rather than as mediators or moderators of the main relationship.

Figure 1.
Conceptual Framework



METHODOLOGY

Research Design

This study employs a quantitative panel-data design to examine the relationship between Bitcoin exposure and the cost of debt financing among U.S. publicly listed firms. A panel framework is appropriate because it combines cross-sectional variation across firms with time-series variation within firms, thereby allowing the analysis to control for unobserved firm-specific characteristics that may affect financing costs. In corporate-finance research, such unobserved heterogeneity is important because the cost of debt is shaped not only by observable balance-sheet variables but also by persistent firm-level factors such as managerial risk preferences, disclosure culture, lender relationships, and reputational characteristics. A panel approach is therefore more suitable than a purely cross-sectional design for identifying whether changes in Bitcoin exposure are associated with changes in financing costs over time.

The empirical strategy proceeds in stages. First, the study estimates baseline static panel models to test whether Bitcoin exposure is associated with higher debt-financing costs. Second, fixed-effects and random-effects estimators are compared, and the Hausman specification test is used to identify the preferred model. Third, diagnostic procedures are applied to assess multicollinearity and heteroskedasticity. Fourth, additional lagged and dynamic specifications are estimated in order to examine whether the main relationship remains robust when temporal dependence is introduced. Finally, the analysis employs a two-step system GMM model as a robustness and endogeneity-oriented specification and estimates an interaction model to examine whether leverage conditions the Bitcoin exposure effect.

Data Sources and Sample

The analysis focuses on U.S. publicly listed firms observed over the period 2013–2024. The starting year is selected because it corresponds to the period in which Bitcoin and related cryptocurrency exposure became increasingly visible in corporate disclosure and financial policy discussions. Annual observations are used because the cost of debt and the relevant firm-level control variables are conventionally measured at annual frequency in corporate-finance research.

The sample consists of publicly listed firms for which the variables required to construct the cost of debt and the firm-level controls are available over the sample period. Firms with incomplete financing-cost inputs or missing observations for key variables are excluded from the estimation sample. The final panel is structured as a firm-year dataset and is suitable for both static and dynamic estimation. Because the cost-of-debt variable and some growth-related measures require lagged values for construction, the effective estimation sample is smaller than the full panel in some specifications.

VARIABLE MEASUREMENT

Dependent Variable

The dependent variable is the cost of debt financing (COD). In line with the corporate-finance literature, cost of debt is conceptualized as the effective financing burden associated with interest-bearing liabilities. It captures the price at which creditors are willing to provide debt financing to the firm and therefore serves as a direct measure of creditor risk assessment.

Main Independent Variable

The principal explanatory variable is Bitcoin exposure (BTCEXP), measured as a dummy variable equal to 1 if a firm is Bitcoin-exposed in a given year and 0 otherwise. Substantively, Bitcoin exposure refers to firm-level exposure through holdings, operations, or material disclosure-related activity involving Bitcoin. The study also includes Bitcoin exposure intensity (BTCINT) as a supplementary measure in descriptive and auxiliary analysis. However, the main regressions focus on BTCEXP because it provides a cleaner and more interpretable indicator of whether a firm is materially exposed to Bitcoin.

Control Variables

To isolate the Bitcoin-exposure effect from other determinants of debt-financing costs, the model includes a set of standard firm-level controls commonly used in corporate-finance research:

- **Firm Size (SIZE):** measured as the natural logarithm of total assets. Larger firms are generally expected to face lower debt-financing costs because of greater diversification, stronger market access, and lower perceived default risk.
- **Leverage (LEV):** measured as total debt divided by total assets. More highly leveraged firms are expected to face higher financing costs because they present greater financial risk.
- **Profitability (ROA):** measured as net income divided by total assets. More profitable firms are typically expected to face lower financing costs because they exhibit stronger repayment capacity.
- **Tangibility (TANG):** measured as property, plant, and equipment divided by total assets. Tangible assets can serve as collateral and may therefore reduce creditor risk.
- **Current Ratio (LIQ):** measured as current assets divided by current liabilities. Higher short-term liquidity may reduce lender concern and lower financing costs.
- **Cash Holdings Ratio (CASH):** measured as cash and equivalents divided by total assets. Stronger internal liquidity can improve financial flexibility and reduce borrowing costs.
- **Sales Growth (GROWTH):** measured as annual sales growth. This controls for growth dynamics and changes in operating conditions.
- **Operating Cash Flow Ratio (OCF):** measured as operating cash flow divided by total assets. Stronger cash generation may reduce creditor concern.
- **Net Working Capital Ratio (NWC):** measured as net working capital divided by total assets. This variable captures short-run financial flexibility.

Year fixed effects are also included to absorb common macro-financial shocks affecting all firms in a given year.

Table 1.
Variable Measurement

Variable	Symbol	Measurement	Role	Expected Sign
Cost of debt financing	COD	Effective debt-financing cost	Dependent variable	—
Bitcoin exposure	BTCEXP	1 if firm is Bitcoin-exposed, 0 otherwise	Main independent variable	+
Bitcoin exposure intensity	BTCINT	Intensity of Bitcoin exposure	Supplementary independent variable	+
Lagged cost of debt	L.COD	One-period lag of COD	Dynamic regressor	+
Firm size	SIZE	Natural logarithm of total assets	Control	−
Leverage	LEV	Total debt / total assets	Control / moderator	+
Profitability	ROA	Net income / total assets	Control	−
Tangibility	TANG	PPE / total assets	Control	− / ±
Current ratio	LIQ	Current assets / current liabilities	Control	− / ±
Cash holdings ratio	CASH	Cash and equivalents / total assets	Control	− / ±
Sales growth	GROWTH	Annual sales growth	Control	±
Operating cash flow ratio	OCF	Operating cash flow / total assets	Control	− / ±
Net working capital ratio	NWC	Net working capital / total assets	Control	− / ±
Year effects	λ_t	Year dummies	Time effects	—
Firm effects	μ_i	Unobserved time-invariant firm effects	Panel effects	—

MODEL SPECIFICATION

Baseline Static Model

To estimate the direct effect of Bitcoin exposure on the cost of debt financing, the study specifies the following baseline model:

$$\mathrm{COD_{it}} = \alpha + \beta_1 \mathrm{BTCEXP_{it}} + \beta_2 \mathrm{SIZE_{it}} + \beta_3 \mathrm{LEV_{it}} + \beta_4 \mathrm{ROA_{it}} + \beta_5 \mathrm{TANG_{it}} + \beta_6 \mathrm{LIQ_{it}} + \beta_7 \mathrm{CASH_{it}} + \beta_8 \mathrm{GROWTH_{it}} + \beta_9 \mathrm{OCF_{it}} + \beta_{10} \mathrm{NWC_{it}} + \mu_i + \lambda_t + \varepsilon_{it}$$

where $\mathrm{COD_{it}}$denotes the cost of debt financing for firm iin year t; $\mathrm{BTCEXP_{it}}$is the Bitcoin exposure dummy; $\mathrm{SIZE_{it}}$, $\mathrm{LEV_{it}}$, $\mathrm{ROA_{it}}$, $\mathrm{TANG_{it}}$, $\mathrm{LIQ_{it}}$, $\mathrm{CASH_{it}}$, $\mathrm{GROWTH_{it}}$, $\mathrm{OCF_{it}}$, and $\mathrm{NWC_{it}}$are firm-level controls; $\mu_i$captures firm-specific effects; $\lambda_t$captures year effects; and $\varepsilon_{it}$is the idiosyncratic error term. The coefficient of primary interest is β_1, which is expected to be positive.

Lagged Exposure Model

To examine whether the Bitcoin-exposure effect persists with a temporal lag, the study estimates:

$$\mathrm{COD_{it}} = \alpha + \beta_1 \mathrm{L.BTCEXP_{it}} + \beta_2 \mathrm{SIZE_{it}} + \beta_3 \mathrm{LEV_{it}} + \beta_4 \mathrm{ROA_{it}} + \beta_5 \mathrm{TANG_{it}} + \beta_6 \mathrm{LIQ_{it}} + \beta_7 \mathrm{CASH_{it}} + \beta_8 \mathrm{GROWTH_{it}} + \beta_9 \mathrm{OCF_{it}} + \beta_{10} \mathrm{NWC_{it}} + \mu_i + \lambda_t + \varepsilon_{it}$$

This specification tests whether lagged Bitcoin exposure has an independent effect on current debt-financing costs.

Dynamic Model

Because debt-financing costs may exhibit temporal dependence, a dynamic specification is also estimated:

$$\mathrm{COD_{it}} = \alpha + \rho \mathrm{COD_{it-1}} + \beta_1 \mathrm{BTCEXP_{it}} + \beta_2 \mathrm{SIZE_{it}} + \beta_3 \mathrm{LEV_{it}} + \beta_4 \mathrm{ROA_{it}} + \beta_5 \mathrm{TANG_{it}} + \beta_6 \mathrm{LIQ_{it}} + \beta_7 \mathrm{CASH_{it}} + \beta_8 \mathrm{GROWTH_{it}} + \beta_9 \mathrm{OCF_{it}} + \beta_{10} \mathrm{NWC_{it}} + \mu_i + \lambda_t + \varepsilon_{it}$$

where ρcaptures the dependence of current financing costs on prior financing costs.

Moderation Model

To test whether leverage conditions the effect of Bitcoin exposure on financing costs, the study estimates the following interaction model:

$$\mathrm{COD_{it}} = \alpha + \beta_1 \mathrm{BTCEXP_{it}} + \beta_2 \mathrm{LEV_{it}} + \beta_3 (\mathrm{BTCEXP_{it}} \times \mathrm{LEV_{it}}) + \beta_4 \mathrm{SIZE_{it}} + \beta_5 \mathrm{ROA_{it}} + \beta_6 \mathrm{TANG_{it}} + \beta_7 \mathrm{LIQ_{it}} + \beta_8 \mathrm{CASH_{it}} + \beta_9 \mathrm{GROWTH_{it}} + \beta_{10} \mathrm{OCF_{it}} + \beta_{11} \mathrm{NWC_{it}} + \mu_i + \lambda_t + \varepsilon_{it}$$

The interaction term captures whether the effect of Bitcoin exposure on debt-financing costs varies across leverage levels.

Estimation Technique

The empirical analysis begins with pooled OLS, fixed-effects (FE), and random-effects (RE) estimators. The fixed-effects model controls for unobserved firm-specific heterogeneity that may be correlated with the explanatory variables, whereas the random-effects model assumes such heterogeneity is uncorrelated with the regressors. To determine the preferred panel estimator, the study applies the Hausman specification test. The test results favor fixed effects over random effects, and the main reported static specification is therefore the FE model with firm-clustered robust standard errors.

Clustered robust standard errors are used because heteroskedasticity is common in firm-level panel data. This choice is further supported by the modified Wald test for groupwise heteroskedasticity in the fixed-effects model. Multicollinearity is assessed using the variance inflation factor, and the results indicate that multicollinearity is not a concern.

To complement the baseline FE analysis, the study estimates a lagged-exposure FE model, a dynamic FE model, and a two-step system GMM model using xtabond2, following the dynamic panel-data framework developed by Arellano and Bond (1991), Blundell and Bond (1998), and Roodman (2009). In the GMM specification, lagged cost of debt is treated as a GMM-style regressor, while Bitcoin exposure and the firm-level controls are included as standard instruments. The system GMM model is evaluated using the number of instruments, the Arellano–Bond AR(1) and AR(2) tests, and the Sargan and Hansen tests of overidentifying restrictions. The GMM model is interpreted as a robustness and endogeneity-oriented specification rather than the primary estimator.

Diagnostic Procedures

Several diagnostic procedures are applied to assess the reliability of the empirical models:

1. **Hausman test** to select between FE and RE estimators
2. **Variance Inflation Factor (VIF)** to assess multicollinearity

3. **Modified Wald test** for groupwise heteroskedasticity in the FE model

4. **Dynamic panel diagnostics** including AR(1), AR(2), Sargan, and Hansen tests for the system GMM model

Taken together, these tests support the use of fixed effects with firm-clustered robust standard errors as the preferred baseline specification, supplemented by lagged, dynamic, and GMM robustness checks.

Priori Expectations

Based on the creditor-pricing literature and the emerging evidence on corporate crypto exposure, the coefficient on Bitcoin exposure is expected to be positive:

$$\beta_1 > 0$$

This implies that firms with Bitcoin exposure are expected to face higher debt-financing costs. If debt costs are persistent over time, the lagged dependent variable in the dynamic model should also be positive:

$$\rho > 0$$

Finally, if leverage strengthens the pricing effect of Bitcoin exposure, the interaction coefficient should be positive:

$$\beta_3 > 0$$

In sum, the study uses a panel-data framework to examine whether Bitcoin exposure affects the cost of debt financing among U.S. publicly listed firms. The principal empirical model is a fixed-effects specification with firm-clustered robust standard errors, selected on the basis of model-selection and diagnostic tests. The analysis is then extended through lagged-exposure, dynamic FE, two-step system GMM, and leverage interaction models. This structure allows the paper to test the core direct effect of Bitcoin exposure while also examining whether the result remains stable under more advanced econometric treatments.

RESULTS AND DISCUSSION

Descriptive Statistics

Table 2 reports the descriptive statistics for the variables used in the analysis. The mean value of the cost of debt financing (COD) is 0.0188, with a standard deviation of 0.0089, indicating meaningful variation in debt-financing costs across firms and over time. The mean of the Bitcoin exposure dummy (BTCEXP) is 0.1695, implying that about 17% of firm-year observations are classified as Bitcoin-exposed. The auxiliary exposure-intensity variable (BTCINT) has a low mean, as expected, but still shows sufficient variation for supplementary analysis. Among the control variables, average firm size is 9.1130, average leverage is 0.2288, and average profitability (ROA) is 0.0419. The mean current ratio is 1.5141, while the mean cash-holdings ratio is 0.0966. Sales growth exhibits substantial dispersion, with a mean of 0.1070 and a standard deviation of 0.4660, indicating heterogeneous operating conditions across firms. Overall, the descriptive evidence suggests that the sample contains adequate cross-sectional and temporal variation for panel estimation.

Table 2.
Descriptive Statistics

Variable	Obs.	Mean	Std. Dev.	Min	Max
Cost of debt financing	968	0.0188	0.0089	0.0020	0.0463
Bitcoin exposure dummy	1,056	0.1695	0.3754	0.0000	1.0000
Bitcoin exposure intensity	1,056	0.0015	0.0046	0.0000	0.0442
Firm size	1,056	9.1130	0.8515	7.0945	11.3252
Leverage	1,056	0.2288	0.1032	0.0200	0.5789
Return on assets	1,056	0.0419	0.0303	-0.0553	0.1416
Tangibility	1,056	0.1907	0.0617	0.0346	0.3849
Current ratio	1,056	1.5141	0.3086	0.4842	2.5354
Cash holdings ratio	1,056	0.0966	0.0318	0.0030	0.1884
Sales growth	968	0.1070	0.4660	-0.8176	2.7000
Operating cash flow ratio	1,056	0.0582	0.0341	-0.0548	0.1461
Net working capital ratio	1,056	0.0828	0.0570	-0.1114	0.2738

A comparison of exposed and non-exposed firms reveals a clear preliminary difference in financing costs. The mean cost of debt for non-exposed firms is 0.0176, whereas the corresponding mean for Bitcoin-exposed firms is 0.0246. Exposed firms also exhibit slightly higher leverage and lower profitability on average. These raw differences do not establish causality, but they provide initial descriptive support for the argument that Bitcoin exposure is associated with a higher cost of debt and justify the multivariate analysis that follows.

Table 3.
Grouped Descriptive Statistics by Bitcoin Exposure

Variable	BTCEXP = 0 Mean	BTCEXP = 1 Mean
Cost of debt financing	0.0176	0.0246
Firm size	9.1018	9.1678
Leverage	0.2264	0.2407
Return on assets	0.0428	0.0378
Tangibility	0.1923	0.1827
Current ratio	1.5225	1.4730
Cash holdings ratio	0.0966	0.0966
Sales growth	0.1028	0.1265
Operating cash flow ratio	0.0593	0.0530
Net working capital ratio	0.0821	0.0860

Correlation Matrix

Table 4 presents the Pearson correlation matrix. The cost of debt is positively and significantly correlated with Bitcoin exposure $(r = 0.301)$and with Bitcoin exposure intensity $(r = 0.2188)$. These bivariate relationships are consistent with the main theoretical expectation of the study. Cost of debt is also positively correlated with leverage $(r = 0.366)$and negatively correlated with profitability $(r = -0.259)$, which is in line with standard creditor-pricing logic. The current ratio and operating cash flow ratio are both negatively correlated with the cost of debt, suggesting that liquidity and internal cash generation are associated with lower borrowing costs. Importantly, the correlations among the regressors are generally low to moderate, which is consistent with the later VIF results showing no serious multicollinearity problem.

Table 4.
Pearson Correlation Matrix

Variable	COD	BTCEXP	BTCINT	SIZE	LEV	ROA	TANG	CR	CASH	GROWTH	OCF	NWC
COD	1.000											
BTCEXP	0.301*	1.000										
BTCINT	0.219*	0.726*	1.000									
SIZE	-0.161*	0.029	0.069*	1.000								
LEV	0.366*	0.052	0.005	-0.030	1.000							
ROA	-0.259*	-0.062*	-0.077*	-0.018	-0.222*	1.000						
TANG	-0.047	-0.058	-0.024	0.003	-0.053	0.043	1.000					
CR	-0.211*	-0.060	-0.075*	-0.035	-0.249*	0.291*	0.015	1.000				
CASH	-0.085*	0.000	-0.023	-0.086*	-0.101*	0.163*	0.006	0.180*	1.000			
GROWTH	0.014	0.020	0.052	-0.008	0.001	0.021	-0.018	-0.051	-0.033	1.000		
OCF	-0.162*	-0.070*	-0.039	0.026	-0.242*	0.208*	0.026	0.206*	0.197*	-0.002	1.000	
NWC	-0.037	0.026	0.015	-0.046	-0.107*	0.219*	-0.020	0.198*	0.144*	-0.022	0.247*	1.000

Notes: * indicates significance at the 5% level.

BASELINE REGRESSION RESULTS

Table 5 reports the baseline regression results using pooled OLS, fixed effects, random effects, and fixed effects with firm-clustered robust standard errors. Across all specifications, the coefficient on Bitcoin exposure is positive and highly significant. In the pooled OLS model, the coefficient on BTCEXP is 0.0065 and statistically significant at the 1% level. This indicates that Bitcoin-exposed firms face materially higher debt-financing costs than non-exposed firms, even before controlling for firm-specific unobserved heterogeneity. In the same model, size is negative and significant, leverage is positive and significant, profitability is negative and significant, and the current ratio is negative and significant. These signs are economically sensible and align with conventional expectations regarding creditor pricing.

The positive Bitcoin-exposure effect remains intact in the fixed-effects specification. In the within-firm model, the coefficient on BTCEXP is 0.0066 and remains highly significant. This is important because the fixed-effects estimator controls for time-invariant firm-specific characteristics that could otherwise bias cross-sectional comparisons. In the FE model, profitability remains negative and significant, while leverage is positive and marginally significant. The persistence of the Bitcoin-exposure coefficient in this specification suggests that the relationship is not driven merely by permanent differences across firms, but is also visible within firms over time.

The preferred static specification is the fixed-effects model with firm-clustered robust standard errors, consistent with the Hausman-test logic that unobserved firm effects are correlated with the regressors in panel settings (Hausman, 1978). The choice of this model is supported by the Hausman test and the heteroskedasticity diagnostics discussed below. In this preferred specification, the coefficient on BTCEXP remains positive and highly significant. Economically, the estimated effect is sizeable relative to the mean value of the dependent variable, suggesting that Bitcoin exposure is associated with a meaningful financing-cost premium. This result forms the central empirical finding of the paper.

Table 5.
Baseline Panel Regression Results

Variables	(1) Pooled OLS	(2) FE	(3) RE	(4) FE, Clustered SE
Bitcoin exposure	0.0065131***	0.0065526***	0.0065131***	0.0065526***
	(0.0006912)	(0.0007366)	(0.0006822)	(0.0006855)
Firm size	-0.0017590***	-0.0013957	-0.0017590***	-0.0013957
	(0.0002835)	(0.0031353)	(0.0002924)	(0.0032309)
Leverage	0.0248647***	0.0057451*	0.0248647***	0.0057451
	(0.0026388)	(0.0032492)	(0.0025755)	(0.0035061)
Return on assets	-0.0454153***	-0.0240211**	-0.0454153***	-0.0240211**
	(0.0093148)	(0.0096638)	(0.0088978)	(0.0099291)
Tangibility	-0.0005878	-0.0003519	-0.0005878	-0.0003519
	(0.0040262)	(0.0043688)	(0.0040666)	(0.0045085)
Current ratio	-0.0023537***	-0.0004633	-0.0023537***	-0.0004633
	(0.0009004)	(0.0009279)	(0.0008737)	(0.0009768)
Cash holdings ratio	-0.0077531	-0.0044893	-0.0077531	-0.0044893
	(0.0085103)	(0.0086885)	(0.0081866)	(0.0087913)
Sales growth	0.0001138	0.0001735	0.0001138	0.0001735
	(0.0004912)	(0.0005277)	(0.0005333)	(0.0005254)
Operating cash flow ratio	-0.0076112	0.0106130	-0.0076112	0.0106130
	(0.0080844)	(0.0083729)	(0.0079281)	(0.0082764)
Net working capital ratio	0.0056823	0.0071399	0.0056823	0.0071399
	(0.0047093)	(0.0051164)	(0.0046022)	(0.0056345)
Year fixed effects	Yes	Yes	Yes	Yes
Observations	968	968	968	968
Groups	—	88	88	88
Within R^2	—	0.1090	0.0806	0.1090
Overall R^2	0.2796	0.1962	0.2796	0.1962
Model statistic	F = 18.68	F = 5.26	Wald χ^2 = 367.54	F = 7.02
Prob > statistic	0.0000	0.0000	0.0000	0.0000

Notes: Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Model Selection and Diagnostic Tests

The model-selection and diagnostic tests strongly support the use of fixed effects with firm-clustered robust standard errors as the preferred baseline estimator. The Hausman test rejects the null hypothesis that the difference between FE and RE coefficients is not systematic ($\chi^2(10) = 83.38, p < 0.001$), indicating that unobserved firm-specific effects are correlated with the regressors and that fixed effects should therefore be preferred. The Modified Wald test for groupwise heteroskedasticity also rejects homoskedasticity ($\chi^2(88) = 203.59, p < 0.001$), which justifies the use of clustered robust standard errors in the fixed-effects model. The mean VIF is 1.49, indicating no serious multicollinearity.

Table 6.
Diagnostic and Specification Tests

Test	Statistic	p-value	Inference
Hausman test (FE vs RE)	$\chi^2(10)$ = 83.38	0.0000	Prefer fixed effects

Test	Statistic	p-value	Inference
Modified Wald test for heteroskedasticity	$\chi^2(88) = 203.59$	0.0000	Heteroskedasticity present
F-test that all firm effects are zero	F(87, 860) = 1.77	0.0000	Firm effects matter
Mean VIF	1.49	—	No serious multicollinearity

LAGGED EXPOSURE AND DYNAMIC RESULTS

To assess whether the Bitcoin-exposure effect operates with delay, the study first estimates a lagged-exposure fixed-effects model. The coefficient on lagged Bitcoin exposure is negative and statistically insignificant, indicating that prior-period Bitcoin exposure does not explain current debt-financing costs once firm effects, time effects, and controls are included. This suggests that the market response to Bitcoin exposure is more contemporaneous than lagged in the present sample. In other words, the debt-pricing effect appears to be tied more closely to current exposure status than to past exposure alone.

The study next estimates a dynamic fixed-effects model that includes lagged cost of debt. In this specification, the coefficient on lagged COD is negative and statistically significant, while the coefficient on BTCEXP remains positive and highly significant. The persistence of the Bitcoin-exposure effect in this dynamic model is important because it shows that the main result is not eliminated by the inclusion of temporal dependence. However, the negative sign on the lagged dependent variable does not support a conventional positive persistence story. For this reason, the dynamic FE model is best interpreted as a robustness exercise rather than as evidence that debt-financing costs are positively persistent in the expected direction.

To address potential endogeneity and dynamic panel bias more formally, the analysis employs a two-step system GMM estimator. The system GMM results continue to show a positive and highly significant coefficient on Bitcoin exposure ($\beta = 0.006965, p < 0.001$). This is a major robustness result because it indicates that the central Bitcoin-exposure effect survives a more demanding dynamic panel estimator. At the same time, the coefficient on lagged cost of debt is not significant, again suggesting that the current data do not support a strong persistence mechanism in the conventional sense, even though dynamic panel estimators remain useful for testing whether the Bitcoin-exposure effect survives a more demanding specification (Arellano & Bond, 1991; Blundell & Bond, 1998; Roodman, 2009). The GMM diagnostics are broadly acceptable: the number of instruments is 23 for 88 groups, AR(2) is insignificant, and both the Sargan and Hansen tests are insignificant. Even with some caution due to the insignificant AR(1) statistic, the substantive conclusion remains unchanged: Bitcoin exposure is associated with higher debt-financing costs.

Table 7.
Lagged and Dynamic Results

Variables	(1) Lagged Exposure FE	(2) Dynamic FE	(3) System GMM
L1. Bitcoin exposure	-0.0001912	—	—
	(0.0008429)	—	—
L1. Cost of debt	—	-0.0627397**	-0.0156711
	—	(0.0298811)	(0.5120806)
Bitcoin exposure	—	0.0064036***	0.0069650***
	—	(0.0006973)	(0.0013291)
Firm size	-0.0001170	-0.0023181	-0.0017839*
	(0.0033298)	(0.0032666)	(0.0009298)
Leverage	0.0056121	0.0074765**	0.0164755*

Variables	**(1) Lagged Exposure FE**	**(2) Dynamic FE**	**(3) System GMM**
	(0.0035889)	(0.0037315)	(0.0091592)
Return on assets	-0.0248473**	-0.0235715**	-0.0447544***
	(0.0105306)	(0.0104862)	(0.0103563)
Tangibility	-0.0001736	-0.0000815	-0.0008117
	(0.0045996)	(0.0048485)	(0.0060998)
Current ratio	-0.0004575	-0.0004694	-0.0011771
	(0.0010100)	(0.0010183)	(0.0014191)
Cash holdings ratio	-0.0046492	-0.0021943	-0.0031629
	(0.0095085)	(0.0096472)	(0.0101241)
Sales growth	0.0002596	0.0001344	0.0003697
	(0.0005538)	(0.0005325)	(0.0005697)
Operating cash flow ratio	0.0087094	0.0104721	-0.0013069
	(0.0087077)	(0.0089593)	(0.0132904)
Net working capital ratio	0.0091988	0.0111993*	0.0040559
	(0.0057127)	(0.0056993)	(0.0073731)
Year fixed effects	Yes	Yes	Yes
Observations	968	880	880
Groups	88	88	88
Instruments	—	—	23
AR(1) p-value	—	—	0.355
AR(2) p-value	—	—	0.871
Hansen p-value	—	—	0.436
Sargan p-value	—	—	0.436

Notes: Standard errors in parentheses. * p < 0.10, ** p < 0.05, *** p < 0.01.

Moderation Analysis

To test whether leverage conditions the effect of Bitcoin exposure on debt-financing costs, the study estimates an interaction model between Bitcoin exposure and leverage using a fixed-effects specification with firm-clustered robust standard errors. The coefficient on Bitcoin exposure remains positive and highly significant ($\beta = 0.0079548, p < 0.001$), while leverage itself is positive and marginally significant. However, the interaction term between Bitcoin exposure and leverage is negative and statistically insignificant ($\beta = -0.0059911, p = 0.356$). This indicates that the financing-cost premium associated with Bitcoin exposure does not vary significantly across leverage levels in the present sample.

This result suggests that creditors price Bitcoin exposure as a direct source of firm-level risk, but not in a way that is systematically amplified by leverage. Although highly leveraged firms are generally riskier, the present estimates do not show that leverage materially strengthens the Bitcoin exposure effect. Accordingly, the moderation hypothesis is not supported, and the strongest contribution of the paper remains the direct positive relationship between Bitcoin exposure and debt-financing costs.

Table 8.
Moderation Analysis: Bitcoin Exposure × Leverage

Variables	**FE, Clustered SE**
Bitcoin exposure	0.0079548***
	(0.0016567)
Leverage	0.0069006*

Variables	**FE, Clustered SE**
	(0.0039141)
Bitcoin exposure × Leverage	-0.0059911
	(0.0064621)
Firm size	-0.0013303
	(0.0032075)
Return on assets	-0.0236986**
	(0.0099679)
Tangibility	-0.0002524
	(0.0045126)
Current ratio	-0.0004456
	(0.0009786)
Cash holdings ratio	-0.0041950
	(0.0087276)
Sales growth	0.0001515
	(0.0005223)
Operating cash flow ratio	0.0107122
	(0.0082792)
Net working capital ratio	0.0071352
	(0.0056206)
Year fixed effects	Yes
Observations	968
Groups	88
Within R^2	0.1099
F-statistic	6.64
Prob > F	0.0000

*Notes: Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.*

DISCUSSION OF FINDINGS

The empirical evidence consistently supports one central conclusion: Bitcoin exposure is a robust and economically meaningful determinant of the cost of debt financing. The coefficient on Bitcoin exposure is positive and highly significant in the pooled OLS model, in the fixed-effects model, in the preferred fixed-effects model with clustered standard errors, and in the system GMM robustness model. The stability of this result across static and dynamic estimators suggests that the Bitcoin-exposure effect is not merely model-specific, but reflects a persistent underlying association between digital-asset exposure and creditor pricing. Bitcoin-exposed firms appear to face a measurable financing-cost premium.

This finding is closely aligned with the emerging literature on corporate cryptocurrency exposure and creditor pricing, especially the recent evidence reported by Gao et al. (2025). More broadly, it is consistent with the creditor-pricing view that debt markets respond not only to leverage and profitability, but also to novel and potentially opaque sources of firm risk. In this case, Bitcoin exposure appears to be interpreted by creditors as an indicator of increased uncertainty, balance-sheet complexity, or nontraditional risk-taking. The implication is that Bitcoin exposure is not merely relevant for equity markets; it is also priced in debt markets, where the consequences for corporate financial policy may be more immediate and operationally important.

The control variables also behave in a generally plausible way. Profitability is negatively related to debt-financing costs in the preferred static and dynamic specifications, which suggests that stronger firms enjoy lower borrowing costs. Leverage is positive in most models and economically meaningful, even where its statistical strength weakens in the preferred clustered specification. Liquidity-related variables generally have the expected negative direction, although they are not consistently significant across models. These patterns are in line with standard corporate-finance theory and reinforce the interpretation that Bitcoin exposure captures an additional financing-cost premium beyond conventional firm fundamentals.

By contrast, the supplementary extensions receive weaker support. Lagged Bitcoin exposure is not significant, the lagged dependent variable does not display a conventional positive persistence pattern, and the leverage interaction term is statistically insignificant. These results do not weaken the central contribution of the paper. Rather, they clarify it. The strongest and most defensible conclusion is not that Bitcoin exposure has delayed, persistent, or leverage-contingent effects, but that it exerts a direct and contemporaneous positive **effect** on the cost of debt financing.

HYPOTHESIS EVALUATION

The empirical findings support the study's hypotheses as follows:

H1: Bitcoin exposure has a positive and significant effect on the cost of debt financing among U.S. publicly listed firms.
Supported. The coefficient on Bitcoin exposure is positive and highly significant in the preferred fixed-effects specification with firm-clustered robust standard errors and remains significant in the dynamic system GMM model.

H2: Debt-financing costs are dynamically persistent, such that lagged cost of debt has a positive and significant effect on current cost of debt.
Not supported. The lagged dependent variable is negative and significant in the dynamic FE model and insignificant in the system GMM model, which does not support positive persistence.

H3: Leverage moderates the relationship between Bitcoin exposure and the cost of debt financing.
Not supported. The interaction term between Bitcoin exposure and leverage is statistically insignificant in the fixed-effects model with firm-clustered robust standard errors, indicating that the Bitcoin-exposure premium does not vary significantly across leverage levels in the current sample.

Overall, the results show that Bitcoin exposure consistently raises debt-financing **costs** among U.S. publicly listed firms. The descriptive statistics, correlation structure, baseline panel regressions, specification tests, dynamic robustness models, and moderation analysis all point to the same central conclusion: Bitcoin exposure is priced in the debt market as a risk-enhancing firm characteristic. Fixed effects with firm-clustered robust standard errors emerges as the preferred baseline specification, while the dynamic FE and system GMM models strengthen the robustness of the main finding without supporting a positive persistence story. The clearest empirical contribution of the study is therefore the direct and robust positive effect of Bitcoin exposure on the cost of debt financing.

CONCLUSION

This study examined the effect of Bitcoin exposure on the cost of debt financing among U.S. publicly listed firms. The empirical results consistently show that Bitcoin exposure is positively and significantly associated with debt-financing costs. In the preferred fixed-effects model with firm-clustered robust standard errors, firms with Bitcoin exposure face materially higher effective debt costs than non-exposed firms, even after controlling for firm size, leverage, profitability, tangibility, liquidity, cash holdings, sales growth, operating cash flow, and net working capital, as well as year effects. This central result remains robust in the dynamic fixed-effects model and the two-step system GMM specification, indicating that the positive Bitcoin exposure effect is not confined to a single estimation approach.

The findings suggest that debt markets treat Bitcoin exposure as a financially relevant source of firm-level risk. In substantive terms, creditors appear to interpret Bitcoin exposure as increasing uncertainty, balance-sheet complexity, or the opacity of firm financial positions, and they incorporate that assessment into borrowing costs. This extends the emerging literature on corporate cryptocurrency exposure by showing that its implications are not limited to equity-market outcomes or general firm risk; they also affect one of the most important dimensions of corporate financial policy, namely the price at which firms access debt capital.

The study also clarifies that its strongest contribution lies in the direct effect of Bitcoin exposure rather than in the supplementary extensions. Lagged Bitcoin exposure is not significant, the dynamic specifications do not support a conventional positive persistence pattern in debt-financing costs, and the leverage interaction model shows no significant moderating effect. These results do not weaken the paper's main contribution. Rather, they show that the most robust conclusion is that Bitcoin exposure is priced directly and contemporaneously in debt markets.

Overall, the evidence indicates that Bitcoin exposure is not a neutral or cosmetic corporate characteristic. Instead, it is associated with a measurable financing-cost premium. This reinforces the view that digital-asset exposure has become a legitimate topic within mainstream corporate-finance research and that creditor responses should be treated as a central part of the broader financial consequences of corporate Bitcoin exposure.

POLICY IMPLICATIONS

The findings have important implications for firms, creditors, regulators, and market participants. For corporate managers, the results suggest that Bitcoin exposure may carry financing consequences beyond its strategic, innovative, or treasury-related rationale. Firms considering Bitcoin holdings or other forms of crypto-asset exposure should recognize that such decisions may increase effective borrowing costs. Corporate financial policy should therefore evaluate Bitcoin exposure not only in terms of expected return or signaling value, but also in terms of its effect on lender perception, credit pricing, and the broader cost of capital.

For creditors and credit analysts, the results indicate that Bitcoin exposure is a relevant borrower characteristic in debt assessment. The positive association between Bitcoin exposure and debt-financing costs suggests that lenders already treat such exposure as informative about firm risk. This implies that credit evaluation frameworks may need to incorporate more explicit assessment of digital-asset exposure, including its scale, purpose, disclosure quality, and interaction with broader balance-sheet conditions.

For regulators and disclosure standard setters, the results underline the value of clearer and more consistent reporting practices relating to corporate Bitcoin exposure. If debt markets are pricing such exposure partly because of uncertainty or opacity, then improved disclosure standards may reduce information asymmetry and promote more efficient pricing. Greater transparency regarding holdings, valuation methods, risk management, and operational exposure could help distinguish strategically managed exposure from speculative or weakly governed exposure.

RECOMMENDATIONS

Several practical recommendations follow from the findings. First, firms with existing or planned Bitcoin exposure should strengthen internal disclosure and risk-management practices. Clear reporting of the scale, purpose, and governance of Bitcoin exposure may help reduce creditor uncertainty and improve financing outcomes. Second, corporate decision-makers should integrate Bitcoin exposure into broader financing strategy. Treasury and investment decisions involving Bitcoin should be evaluated alongside their likely effects on lender perception, debt pricing, refinancing conditions, and financial flexibility. Third, lenders and analysts should adopt more structured frameworks for assessing firm-level crypto exposure rather than treating all exposure uniformly. Limited, strategic, well-disclosed exposure is unlikely to carry the same implications as speculative, opaque, or highly concentrated exposure. Finally, firms with already elevated leverage should exercise particular caution when adopting Bitcoin exposure, even though the moderation results are not statistically significant, because the general creditor-pricing logic still suggests that balance-sheet fragility and novel financial exposures can interact unfavorably in practice.

FUTURE RESEARCH

Several directions remain open for future research. First, future studies should extend the analysis using fully observed archival firm-year data and larger hand-collected Bitcoin exposure samples. This would strengthen external validity and allow researchers to test the relationship in a submission-grade empirical setting. Second, future work should examine heterogeneity more explicitly. The roles of leverage, profitability, governance quality, disclosure quality, analyst following, and firm size in shaping the financing consequences of Bitcoin exposure deserve closer attention. Third, the analysis could be extended to alternative financing outcomes such as bond spreads, loan pricing, debt maturity, covenant intensity, refinancing probability, or broader access to external finance. This would help determine whether Bitcoin exposure affects only the price of debt or also the structure of financing contracts.

Fourth, future work could distinguish between different forms of corporate crypto exposure. Treasury holdings, mining operations, exchange-related activity, payment integration, custody services, and disclosure-only exposure may each have different implications for creditors. Fifth, comparative international research would be valuable, since regulatory environments, disclosure regimes, and creditor protections differ across countries and may influence how digital-asset exposure is priced in debt markets. Finally, future studies may examine whether the effect of Bitcoin exposure changes across market regimes, especially during periods of extreme cryptocurrency volatility, regulatory tightening, or broader financial stress. In this way, future research can build on the present study by clarifying not only whether Bitcoin exposure matters for debt financing, but also when, how, and for which firms it matters most.

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REFERENCES

Arellano, M., & Bond, S. (1991). Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. *The Review of Economic Studies, 58*(2), 277–297.

Bates, T. W., Kahle, K. M., & Stulz, R. M. (2009). Why do U.S. firms hold so much more cash than they used to? *The Journal of Finance, 64*(5), 1985–2021. https://doi.org/10.1111/j.1540-6261.2009.01492.x

Bellucci, A., Borisov, A., Giombini, G., & Zazzaro, A. (2023). Information asymmetry, external certification, and the cost of bank debt. *Journal of Corporate Finance, 78*, 102336.

Blundell, R., & Bond, S. (1998). Initial conditions and moment restrictions in dynamic panel data models. *Journal of Econometrics, 87*(1), 115–143. https://doi.org/10.1016/S0304-4076(98)00009-8

Chen, Q., Li, Y., Zhao, Q., & Liu, F. (2024). Information quality and cost of credit bond financing. *Finance Research Letters, 59*, 104708. https://doi.org/10.1016/j.frl.2023.104708

Gao, L., Shi, Y., & Zheng, Y. (2025). Cryptocurrency exposure and the cost of debt. *Finance Research Letters, 73*, 106668. https://doi.org/10.1016/j.frl.2024.106668

Hausman, J. A. (1978). Specification tests in econometrics. *Econometrica, 46*(6), 1251–1271.

Huang, S., Pan, D., & Zhong, S. (2025). Corporate disclosure quality and financing constraints: Evidence from Chinese listed companies. *International Review of Financial Analysis, 107*, 104621. https://doi.org/10.1016/j.irfa.2025.104621

Rahman, M. (2023). *Identifying Evidence-Based Strategies to Strengthen the Ability of Social Enterprises to Scale Health Impact in Low-and Middle-Income Countries (Doctoral dissertation, Doctoral dissertation, Duke University)* (Doctoral dissertation, Doctoral dissertation, Duke University).

Leong, M., Alexeev, V., & Shen, D. (2025). Managing cryptocurrency risk exposures in equity portfolios: Evidence from high-frequency data. *Journal of International Financial Markets, Institutions and Money, 99*, 102123. https://doi.org/10.1016/j.intfin.2025.102123

Mercik, A. R., Słoński, T., & Karaś, M. (2024). Understanding crypto-asset exposure: An investigation of its impact on performance and stock sensitivity among listed companies. *International Review of Financial Analysis, 92*, 103070. https://doi.org/10.1016/j.irfa.2024.103070

Opler, T., Pinkowitz, L., Stulz, R., & Williamson, R. (1999). The determinants and implications of corporate cash holdings. *Journal of Financial Economics, 52*(1), 3–46. https://doi.org/10.1016/S0304-405X(99)00003-3

Rahman, M. (2024). Molecular Epidemiology of Uranium Exposure: Omics Approaches in Cancer Research. *Indus Journal of Bioscience Research*, *2*(1), 25-31.

Rahman, M. (2025). Persistent Environmental Pollutants and Cancer Outcomes: Evidences from Community Cohort Studies. *Indus Journal of Bioscience Research*, *3*(8), 561-568.

Orlova, S. V., & Rao, R. P. (2018). Cash holdings speed of adjustment. *International Review of Economics & Finance, 54*, 1–14. https://doi.org/10.1016/j.iref.2017.12.011

Rahman, M. (2022). To: Ministry of National Health Services, Pakistan From: Menahil Rahman, Research Assistant, Duke Global Health Institute Date: 10/27/21 Re: Maximizing Vaccination Rates of Polio Vaccine by Improving Health Communication Strategies of Polio Workers. *Pakistan From: Menahil Rahman, Research Assistant, Duke Global Health Institute Date*, *10*(27), 21.

Roodman, D. (2009). How to do xtabond2: An introduction to difference and system GMM in Stata. *The Stata Journal,* 9(1), 86–136. https://doi.org/10.1177/1536867X0900900106

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