

Examining the Threshold Effects of Financial Development on the Relationship Among Cryptocurrencies, Financial Stability, and Banking Performance in Selected Islamic Countries, with Emphasis on Institutional Quality



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Abstract: The present study aimed to examine the threshold effects of financial development on the relationship among cryptocurrency activities, financial stability, and banking performance, with emphasis on the role of institutional quality, in selected Islamic countries belonging to the Developing-8 (D-8) group, including Iran, Türkiye, Pakistan, Bangladesh, Indonesia, Malaysia, Egypt, and Nigeria. The study data covered the period from 2013 to 2024. Financial stability was measured using the logarithm of the Z-score, whereas banking performance was measured using return on assets. Cryptocurrency market capitalization, Bitcoin price volatility, and the ratio of cryptocurrency trading volume to gross domestic product were considered the main explanatory variables, while financial development, institutional quality, bank size, inflation, and economic growth were included as explanatory and control variables. To identify the nonlinear behavior of the variables and determine how the effects of cryptocurrencies change across different levels of financial development, a Panel Smooth Transition Regression (PSTR) model with a logistic transition function was employed. The results of the Levin–Lin–Chu unit root test indicated that all variables were stationary at level, while the Kao cointegration test confirmed the existence of a long-run equilibrium relationship among the variables in both models. The Wald, Fisher, and likelihood-ratio tests rejected the null hypothesis of linearity, and the results of the remaining nonlinearity tests and model-selection criteria demonstrated the adequacy of a single transition function with one threshold parameter for both models. The findings from the financial stability model indicated that cryptocurrency market capitalization, Bitcoin price volatility, and the ratio of cryptocurrency trading volume to GDP exerted negative and statistically significant effects on financial stability. In contrast, financial development, bank size, institutional quality, and economic growth improved financial stability, whereas inflation had a negative effect. The financial development threshold in this model was estimated at (-0.211146) , and the slope parameter was estimated at (0.735776) . In the banking performance model, cryptocurrency activity indicators also had negative and statistically significant effects on banks' return on assets, whereas financial development, bank size, institutional quality, and economic growth improved banking performance. The financial development threshold in this model was estimated at (0.139098) , and the slope parameter was (0.177326) . Overall, the expansion of cryptocurrency activities may weaken bank stability and profitability through deposit outflows, reduced financial intermediation, increased liquidity and credit risks, higher regulatory and compliance costs, and lower fee-based revenues. However, higher levels of financial development and institutional quality mitigate the banking system's vulnerability to these adverse effects by enhancing transparency, supervisory effectiveness, and risk-management capacity.

Keywords: Cryptocurrencies, Financial Stability, Banking Performance, Financial Development, Institutional Quality, Threshold Effects

1. Introduction

The rapid expansion of cryptocurrencies and other digital assets has transformed the structure of contemporary financial markets and created a new set of strategic challenges for banks, regulators, investors, and policymakers. Cryptocurrencies initially emerged as decentralized alternatives to conventional means of payment, but their role has expanded considerably beyond payment functions to encompass investment, speculation, portfolio diversification, cross-border transfers, decentralized finance, collateralization, and technology-driven financial intermediation. This transformation has blurred the traditional boundaries between banking markets, capital markets, and technology-based financial ecosystems. At the same time, the high volatility, limited intrinsic valuation anchors, regulatory heterogeneity, and behavioral characteristics of cryptocurrency markets have raised concerns about their possible implications for financial stability and banking-sector performance. Recent evidence indicates that cryptocurrency market dynamics are increasingly influenced by behavioral biases, investor sentiment, and nonlinear responses to market conditions, which can intensify both price movements and risk transmission across financial markets [1]. The growing technological and market integration surrounding cryptocurrencies also suggests that their development cannot be analyzed independently from broader technological innovation and market activity, because these dimensions increasingly interact and reinforce one another [2]. Moreover, the time-varying network structure of cryptocurrency markets indicates that volatility transmission is dynamic rather than constant, meaning that the risk posed by cryptoassets may differ substantially across periods of market expansion, stress, and structural change [3]. These characteristics make the relationship between cryptocurrencies, financial stability, and banking performance inherently nonlinear and create a strong rationale for examining whether the effects of cryptocurrency activity depend on the level of financial development and institutional quality.

The interaction between cryptocurrencies and conventional financial markets is particularly important because cryptoassets are no longer isolated from the traditional financial system. Increasing participation by institutional investors, financial technology firms, asset managers, payment companies, banks, and other financial intermediaries has strengthened the channels through which shocks may move between cryptocurrency and conventional markets. Empirical evidence has identified dynamic and time-varying causal relationships between cryptocurrencies and traditional financial assets, showing that the direction and magnitude of influence can change over time [4]. Similarly, studies of spillovers in regulated environments indicate that cryptocurrency markets can transmit and receive risk from broader financial markets across different quantiles, suggesting that the effects are particularly important during extreme market conditions rather than being uniformly distributed [5]. M'Bakob demonstrated that sequential attention cycles among cryptocurrency investors can generate spillover effects with implications for financial market stability, thereby emphasizing the behavioral and systemic dimensions of crypto-related risk [6]. The resilience of major cryptocurrencies such as Bitcoin and Ethereum also appears to vary across inflationary conditions and periods of financial instability, indicating that cryptoassets may respond differently depending on the macro-financial regime [7]. In addition, asymmetric risk spillovers between conventional and green cryptocurrencies under geopolitical and financial risk conditions suggest that transmission mechanisms are heterogeneous and state-dependent [8]. These findings reinforce the proposition that cryptocurrency-related risks

should be investigated using models capable of identifying regime shifts and threshold effects rather than relying exclusively on linear relationships.

Volatility represents one of the most important mechanisms through which cryptocurrency markets may affect financial stability. Compared with many traditional financial assets, cryptocurrencies are characterized by large and frequent price fluctuations, which can amplify investment losses, margin calls, liquidity shortages, and balance-sheet deterioration among exposed institutions. Advanced stochastic modeling of cryptocurrency prices confirms that volatility remains a defining feature of this market and requires specialized estimation approaches to capture its dynamics accurately [9]. The network structure of crypto markets further suggests that volatility can propagate across individual digital assets rather than remaining confined to a single cryptocurrency [3]. Such spillovers become more relevant to systemic stability when banks, investment funds, corporations, or financial intermediaries have direct or indirect exposure to cryptoassets. Herding behavior can further magnify this process because investors may respond collectively to market signals, thereby intensifying price movements and generating self-reinforcing market dynamics. Transaction-level evidence confirms the presence of herding in cryptocurrency markets and demonstrates that collective investor behavior can shape trading patterns and market instability [10]. The significance of market behavior is also consistent with broader evidence that different categories of investors may contribute differently to the correction or persistence of asset mispricing [11]. Therefore, cryptocurrency volatility is not only a property of digital assets themselves but also a potential transmission mechanism through which behavioral responses, liquidity shocks, and market interconnectedness can affect the stability of the broader financial system.

The implications of cryptocurrency development for banking institutions are equally substantial. Banks traditionally perform financial intermediation by mobilizing deposits, extending credit, facilitating payments, managing liquidity, and transforming maturities and risks. The spread of cryptocurrencies, stablecoins, decentralized finance, and blockchain-based payment technologies potentially challenges several components of this business model. Cryptocurrency-based systems may permit individuals and firms to transfer value directly without relying on conventional banking intermediaries, thereby reducing demand for some bank-based payment and settlement services. Evidence regarding the international impact of cryptocurrencies on banking suggests that digital assets can alter the competitive environment in which banks operate and require adjustments in payment services, compliance procedures, risk management, and strategic positioning [12]. Qualitative evidence further indicates that digital currencies may influence banking models and monetary policy frameworks by changing the channels through which payments, savings, and financial transactions are conducted [13]. The increasing role of decentralized finance is particularly relevant because lending and liquidity provision can be conducted through smart contracts rather than through conventional intermediaries. However, decentralized lending is also exposed to liquidation mechanisms that may influence borrowers' and lenders' behavior; evidence shows that liquidations can affect lending incentives within DeFi markets [14]. These developments suggest that banks face both competitive pressures and new risk exposures as digital financial markets expand.

The possibility of using cryptocurrencies as collateral further illustrates the growing intersection between digital assets and traditional banking activities. If cryptocurrencies become accepted as collateral for loans, banks may gain access to new customer segments and asset classes, but they may simultaneously become more directly exposed to cryptocurrency price volatility, valuation uncertainty, liquidity risk, and legal ambiguity. The feasibility of pledging cryptocurrencies as collateral has therefore become an important banking and regulatory question, particularly because operational and legal barriers may limit their effective integration into conventional lending

practices [15]. In parallel, the legal classification of cryptocurrencies remains contested in several jurisdictions, and the extension of conventional concepts of money or currency to cryptoassets has generated significant legal and regulatory debate [16]. These uncertainties affect banks because the enforceability, accounting treatment, capital requirements, custody obligations, and liquidation procedures associated with digital assets depend substantially on their legal status. Research on the nature of cryptocurrencies and digital currencies likewise indicates that these assets are contributing to the evolution of monetary technologies and reshaping conceptual boundaries between money, digital value, and financial innovation [17]. Consequently, institutional quality and regulatory effectiveness may critically determine whether cryptocurrency integration creates manageable innovation or amplifies financial-sector vulnerabilities.

Institutional quality is especially important in Islamic and emerging economies, where banking systems may differ in legal structures, supervisory capacity, financial depth, and the coexistence of Islamic and conventional banking institutions. Strong institutions can improve transparency, regulatory enforcement, governance, investor protection, and risk management, thereby reducing the likelihood that financial innovations generate destabilizing effects. Conversely, weak governance and corruption can encourage excessive risk-taking and weaken supervisory effectiveness. Evidence from dual banking systems demonstrates that corruption is associated with bank risk-taking behavior, highlighting the relevance of institutional quality for the stability of banking systems in which Islamic and conventional institutions coexist [18]. Comparative research on Islamic and conventional banking has also shown that the two systems may exhibit differences in performance, financing mechanisms, and resilience, reinforcing the need to consider the institutional structure of Islamic economies when evaluating banking outcomes [19]. The operation of Islamic banking systems is also closely linked to monetary-policy transmission, profit-rate determination, and the distinctive principles governing financing contracts. In the Iranian context, studies of the response of inflation to contractionary monetary policy in an Islamic banking framework have demonstrated the importance of banking-sector mechanisms in transmitting macroeconomic policy [20]. Similarly, the mechanism for determining bank profit rates in the monetary and banking system has important consequences for bank behavior and financial intermediation [21], while critiques of the theory of bank interest in Islamic banking have emphasized the role of money creation and institutional arrangements in interest-rate determination [22]. These characteristics suggest that cryptocurrency expansion may interact with Islamic banking structures differently depending on institutional quality and financial development.

Financial development itself may serve as a key conditioning variable in determining the extent to which cryptocurrencies affect banks and financial stability. In more developed financial systems, deeper markets, diversified sources of funding, more sophisticated regulatory frameworks, improved technological capacity, and stronger risk-management systems may help absorb shocks associated with digital assets. Conversely, in less developed financial systems, cryptocurrency expansion may place greater pressure on banking liquidity, capital flows, monetary control, and financial intermediation. Therefore, the effect of cryptoassets is unlikely to remain constant across different levels of financial development. The broader literature on financial connectedness supports this argument by showing that spillover relationships depend on market structure, asset characteristics, and time horizon. For example, time-frequency analyses of global ESG stock markets demonstrate that return and volatility connectedness varies across investment horizons, indicating that financial integration is multidimensional and dynamic [23]. Similar methodological evidence from oil-price shocks and sectoral returns shows that connectedness and spillovers can vary considerably over time and across frequency domains [24]. Although these studies do not focus directly on cryptocurrencies and banking, they support the broader conceptual argument that

financial-market transmission is state-dependent and may change as the underlying financial environment evolves. The literature on connectedness among other asset classes likewise demonstrates the importance of dynamic spillovers for portfolio and risk management [25]. Such findings provide a methodological and theoretical foundation for investigating financial development as a threshold variable rather than simply as an additive explanatory factor.

Macroeconomic conditions can further influence the interaction between cryptocurrencies and banking performance. Inflation, economic growth, and monetary instability shape the incentives of households and firms to hold bank deposits, domestic currency, foreign currency, or digital assets. During periods of high inflation or weak confidence in the national currency, cryptoassets and stablecoins may become more attractive as alternative stores of value or transaction instruments, potentially accelerating deposit substitution and weakening conventional bank funding. Evidence on cryptocurrency resilience during inflation and financial instability suggests that major digital assets display heterogeneous responses across market conditions, reinforcing the view that macroeconomic shocks can reshape their role within financial portfolios [7]. Geopolitical shocks may also alter investor demand for cryptocurrencies as perceived safe-haven or alternative assets. Research on the Russia–Ukraine war, for example, indicates that anchoring and safe-haven perceptions influenced cryptocurrency-market responses during a major geopolitical event [26]. These effects are particularly relevant for emerging and Islamic economies, many of which face episodes of inflation, exchange-rate pressure, financial sanctions, capital-flow restrictions, and institutional uncertainty. Under such circumstances, cryptocurrencies may become more deeply integrated into household and corporate financial decisions, thereby increasing their potential impact on banking liquidity and financial stability.

Trust is another critical factor linking cryptocurrency use to financial-system outcomes. Consumer adoption of cryptocurrencies is influenced not only by technological utility but also by perceptions of market volatility, security, reliability, and environmental conditions. Evidence from cryptocurrency use in the travel sector demonstrates that consumer trust is strongly shaped by market-environment volatility, showing that instability can affect willingness to adopt crypto-based payment solutions [27]. This insight has broader implications for banking because shifts in trust between banks and digital-asset platforms may influence where households hold liquidity and conduct transactions. If trust in cryptocurrency platforms grows while confidence in banks declines, deposits may migrate away from the banking sector. Conversely, strong institutional protection, transparent regulation, and reliable banking services may limit such displacement. The interaction between technology adoption and financial behavior is therefore central to understanding whether cryptocurrencies operate primarily as complementary financial innovations or as substitutes for traditional banking services.

The strategic challenge for banks is not limited to managing financial risk; it also involves adapting to technology-driven structural change. Cryptocurrency markets are closely linked to technological innovation, digital infrastructure, blockchain development, and changing consumer preferences. Evidence suggests that cryptocurrency activity, technological developments, and broader market dynamics are mutually connected rather than independent processes [2]. This creates strategic pressure on banks to invest in digital infrastructure, redesign payment services, strengthen cybersecurity and compliance systems, and evaluate whether to offer custody, trading, tokenization, or digital-asset-related services. At the same time, greater engagement with cryptocurrency markets may increase direct exposure to market risk, legal risk, reputational risk, liquidity risk, and operational risk. Thus, the strategic question is not merely whether banks should interact with cryptoassets, but under what

institutional and financial conditions such interaction can be managed without undermining profitability and stability.

From a capital-market perspective, the performance of banks is also influenced by their exposure to market risk and the pricing of banking-sector securities. Empirical applications of the capital asset pricing model to selected banking stocks on the Istanbul Stock Exchange illustrate the importance of systematic market risk for bank equity performance [28]. Cryptocurrency expansion introduces an additional source of market uncertainty that may affect bank valuations through direct exposure, competitive threats, shifts in investor expectations, and broader risk sentiment. At the same time, the heterogeneity of cryptocurrency risk across market states implies that average linear effects may conceal important differences between low-risk and high-risk regimes. The observed asymmetry of cryptocurrency spillovers under geopolitical and financial stress [8], the time-varying causal influence between cryptocurrencies and conventional markets [4], and the changing network structure of crypto volatility [3] all suggest that threshold-based modeling may provide a more realistic representation of the relationship between cryptocurrency activity and banking outcomes.

Despite the rapidly expanding literature, several important gaps remain. Much of the existing research focuses on cryptocurrency price behavior, portfolio diversification, investor sentiment, volatility forecasting, or spillovers between cryptocurrencies and other financial assets. Comparatively less attention has been given to the direct implications of cryptocurrency activity for banking performance and financial stability, particularly in Islamic economies. Furthermore, existing studies often assume homogeneous or linear effects, even though the literature increasingly demonstrates nonlinear, asymmetric, state-dependent, and time-varying relationships across financial markets. The role of financial development as a regime-changing factor remains especially underexplored. If the effect of cryptocurrency market expansion changes after financial development crosses a critical level, conventional linear estimates may provide incomplete or misleading conclusions. Similarly, institutional quality may determine the extent to which banking systems can regulate, absorb, and manage crypto-related shocks. These gaps are particularly important in the D-8 countries—comprising Iran, Türkiye, Pakistan, Bangladesh, Indonesia, Malaysia, Egypt, and Nigeria—because these economies differ considerably in financial depth, institutional capacity, banking-sector structure, inflation experience, regulatory development, and exposure to digital financial innovation.

Accordingly, the aim of this study is to examine the threshold effects of financial development on the relationship between cryptocurrency activity, financial stability, and banking performance in selected D-8 Islamic countries, with particular emphasis on the moderating role of institutional quality.

2. Methods and Materials

Following the studies of Heitmann et al. (2025), Afzal (2025), Al-Saadi (2025), and Bouri (2024), the present article evaluates the impact of cryptocurrencies on financial stability and banking performance in Islamic markets. The general specification of the PSTR model, considering financial stability and banking performance as the dependent variables and cryptocurrency market capitalization, Bitcoin price volatility, cryptocurrency trading volume relative to GDP (Crypto Trading Volume/GDP), bank size, financial development, and institutional quality as explanatory variables, is specified as follows:

Model 1: Financial Stability

$$Z\text{-score}_t = \alpha_0 + \beta_1 MC_t + \beta_2 BV_t + \beta_3 CT_t + \beta_4 FD_t + \beta_5 INF_t + \beta_6 SIZE_t + \beta_7 IQ_t + \beta_8 GROWTH_t + (\theta_1 MC_t + \theta_2 BV_t + \theta_3 CT_t + \theta_4 FD_t + \theta_5 INF_t + \theta_6 SIZE_t + \theta_7 IQ_t + \theta_8 GROWTH_t)F(S_t, \gamma, c) + u_t \quad (1)$$

Model 2: Banking System Performance

$$BP_t = \alpha_0 + \beta_1 MC_t + \beta_2 BV_t + \beta_3 CT_t + \beta_4 FD_t + \beta_5 INF_t + \beta_6 SIZE_t + \beta_7 IQ_t + \beta_8 GROWTH_t + (\theta_1 MC_t + \theta_2 BV_t + \theta_3 CT_t + \theta_4 FD_t + \theta_5 INF_t + \theta_6 SIZE_t + \theta_7 IQ_t + \theta_8 GROWTH_t)F(S_t, \gamma, c) + u_t \quad (2)$$

Dependent Variables

Financial Stability (Z-score): Financial stability is evaluated using the banking stability index commonly known as the Z-score. In this measure, banking stability and resilience are defined as the sum of the capital adequacy ratio and return on assets divided by the standard deviation of return on assets. The higher the value of this index, the lower the probability of bank instability or failure; in other words, a higher Z-score indicates a more stable banking condition.

$$\text{Bank Stability} = \ln(\text{Z-score}) = \ln\left(\frac{ROA + \text{Capital Ratio}}{\sigma(ROA)}\right)$$

Banking System Performance (BP): Return on assets, defined as profit divided by total assets, is used as an indicator of banking system performance.

Independent and Control Variables:

Market Capitalization of Cryptocurrencies (MC): The aggregate market value of all active cryptocurrencies over a specified period, measured as the total cryptocurrency market capitalization in U.S. dollars for each year. An increase in this variable indicates expansion of cryptocurrency market activity and a potential threat to banks' liquidity and funding resources (Afshari et al., 2025).

Bitcoin Volatility (BV): The magnitude of changes in the price of Bitcoin over a specified period, measured by the standard deviation of Bitcoin's annual returns. Higher volatility indicates greater risk for banks exposed directly or indirectly to digital asset markets.

Cryptocurrency Trading Volume Relative to GDP (CT): The ratio of total cryptocurrency trading volume to a country's gross domestic product. It is calculated as the total cryptocurrency trading volume over a specified period divided by GDP for the same period. This indicator reflects the intensity of cryptocurrency activity relative to the overall economy and indicates the potential pressure of such activity on bank liquidity.

FD: Financial development index, measured using bank credit extended to the private sector.

SIZE: Bank size, measured as the logarithm of total bank assets.

INF: Inflation.

GROWTH: Gross domestic product growth rate; GDP refers to the market or monetary value of all final goods and services produced within a country's borders over a specified period.

IQ: Institutional Quality. Institutional quality refers to the degree of transparency, effectiveness, and efficiency of a country's legal and regulatory framework in the financial and banking sectors. It is measured using World Bank indicators or Doing Business indicators related to institutional quality and banking-system efficiency. Higher institutional quality enhances bank stability and mitigates the adverse effects of cryptocurrencies (Miro et al., 2025).

To examine the properties of the PSTR model with a logistic transition function, following van Dijk (1999), it is assumed that the dependent variable is solely a function of its own lagged values. Accordingly, assuming a two-regime transition function, the following relationships are obtained:

$$Z\text{-score}_t = (\theta_0 + \theta_1 Z\text{-score}_{t-1} + \dots + \theta_p Z\text{-score}_{t-p}) + (\phi_0 + \phi_1 Z\text{-score}_{t-1} + \dots + \phi_p Z\text{-score}_{t-p})G(B, V_t, \gamma c) + u_t$$

$$BP_t = (\theta_0 + \theta_1 BP_{t-1} + \dots + \theta_p BP_{t-p}) + (\phi_0 + \phi_1 BP_{t-1} + \dots + \phi_p BP_{t-p}) G(B, V_t, \gamma c) + u_t \quad (6)$$

The resulting specification is referred to as a two-regime PSTR model. The location parameter c identifies the point of transition between the two limiting regimes, $G(B, V_t, \gamma c) = 0$ and $G(B, V_t, \gamma c) = 1$, at which $G(B, V_t, \gamma c) = 0.5$. The parameter γ represents the speed of transition between regimes, with larger values of γ indicating a more rapid regime transition.

The statistical data used in the study cover the period from 2013 to 2024. The statistical population of the present study consists of the Islamic countries belonging to the D-8 group, namely:

Iran, Türkiye, Pakistan, Bangladesh, Indonesia, Malaysia, Egypt, and Nigeria.

3. Findings and Results

The empirical analysis first examined the stationarity properties of the study variables using panel unit root tests. Testing stationarity is an essential prerequisite for model estimation because nonstationary variables may lead to spurious regression results and unreliable statistical inference. Accordingly, the Levin–Lin–Chu (LLC) panel unit root test was applied to all variables. As reported in Table 1, the null hypothesis of a unit root was rejected for all variables at conventional significance levels. Thus, all variables were stationary at level, $I(0)$, and no differencing was required before estimating the models.

Table 1. Panel Unit Root Test Results for the Study Variables

Variable	LLC Statistic	p -value	Order of Integration
BV	-10.8057	0.0000	$I(0)$
CT	-2.27434	0.0115	$I(0)$
FD	-5.20847	0.0000	$I(0)$
GROWTH	-3.51163	0.0002	$I(0)$
INF	-1.73897	0.0410	$I(0)$
IQ	-2.35623	0.0092	$I(0)$
MC	-3.16458	0.0008	$I(0)$
SIZE	-13.8433	0.0000	$I(0)$
ZSCORE	-3.09157	0.0010	$I(0)$
BP	-4.60222	0.0000	$I(0)$

After establishing the stationarity of the variables, the existence of long-run equilibrium relationships among the variables included in the two regression models was examined using the Kao panel cointegration test. The Kao test was conducted separately for the financial stability and banking performance specifications. The results are presented in Table 2.

Table 2. Kao Panel Cointegration Test Results

Model	Kao Test Statistic	p -value	Conclusion
Financial stability model	-7.461764	0.0000	Cointegration confirmed
Banking performance model	-1.948672	0.0257	Cointegration confirmed

According to Table 2, the null hypothesis of no cointegration was rejected for both models at the 95% confidence level. Therefore, the alternative hypothesis indicating cointegration among the variables was supported. These results demonstrate that the explanatory variables and the corresponding dependent variable in each specification move together in the long run and that a stable long-run equilibrium relationship exists among them.

Before estimating the financial stability model, it was necessary to determine whether the relationship among the variables was linear or nonlinear. The null hypothesis in the relevant tests assumes a linear model, whereas the alternative hypothesis implies either a logistic PSTR model with $m = 1$ or an exponential PSTR model with $m = 2$, where m denotes the number of location parameters in the transition function.

The Wald, Fisher, and likelihood-ratio tests strongly rejected the null hypothesis of linearity. Accordingly, the relationship between cryptocurrency activity and financial stability in the selected Islamic countries was nonlinear, providing empirical justification for estimating a Panel Smooth Transition Regression model.

Following González et al. (2005) and Colletaz and Hurlin (2006), an additional test was performed to determine whether one transition function was sufficient to capture the nonlinear structure of the model or whether at least two transition functions were required. The null hypothesis was $H_0: r = 1$, indicating one transition function, against $H_1: r = 2$, indicating at least two transition functions.

Table 3. Linearity and Remaining Nonlinearity Tests for the Financial Stability Model

Panel / Test	Statistic	<i>p</i> -value
Panel A. Linearity Tests		
Wald test	3.785	0.000
Fisher test	2.638	0.001
Likelihood-ratio test	2.957	0.012
Panel B. Remaining Nonlinearity Test: $m = 1$		
LMw	1.352	0.743
LMf	1.471	0.630
LR	1.432	0.654
Panel C. Remaining Nonlinearity Test: $m = 2$		
LMw	1.425	0.675
LMf	1.362	0.751
LR	1.297	0.802

The results in Table 3 indicate that, although the hypothesis of overall linearity was decisively rejected, the null hypothesis that one transition function was sufficient could not be rejected under either the one-threshold or two-threshold specification. Therefore, one transition function was adequate to represent the threshold behavior of the relationship between cryptocurrencies and financial stability.

After confirming nonlinearity and establishing the adequacy of a single transition function, the optimal number of threshold parameters had to be determined. PSTR models corresponding to one and two threshold parameters were therefore compared using the residual sum of squares, Schwarz information criterion, and Akaike information criterion. These model-selection criteria identified the specification containing one transition function and one threshold parameter as the optimal model. Consequently, a PSTR model with one logistic transition function and one threshold value was selected for the financial stability analysis.

Financial stability was modeled using a PSTR specification in which the financial development index served as the transition variable. Given the confirmation of nonlinear behavior, both the linear and nonlinear components of the estimated model were examined.

The results show that cryptocurrency market capitalization, Bitcoin volatility, and cryptocurrency trading volume relative to GDP negatively affected financial stability. In the nonlinear component, all three cryptocurrency indicators remained statistically significant at the 5% level. In contrast, financial development, bank size,

institutional quality, and economic growth had statistically significant positive effects on financial stability. Inflation exerted a statistically significant negative effect.

Table 4. PSTR Estimation Results for the Financial Stability Model

Component	Variable	Coefficient	Standard Error	<i>t</i> Statistic	<i>p</i> -value
Linear component	Constant	0.329059	0.136048	2.418698	0.0234
	MC	-0.158886	0.075984	-2.091051	0.0419
	BV	-0.582868	0.239013	-2.438644	0.0149
	CT	-0.096233	0.026454	-3.637702	0.0003
	FD	0.496421	0.175702	2.825358	0.0069
	INF	-0.212527	0.090308	-2.353357	0.0356
	SIZE	0.393667	0.142781	2.757139	0.0201
	IQ	0.642607	0.230948	2.782475	0.0200
	GROWTH	0.097980	0.028983	3.380603	0.0008
Nonlinear component	Constant	0.016839	0.006021	2.796881	0.0049
	MC	-0.110132	0.055542	1.982849	0.0491
	BV	-0.016559	0.007091	2.335214	0.0355
	CT	-0.012901	0.004822	-2.675502	0.0077
	FD	0.089278	0.027937	3.195642	0.0015
	INF	-0.053752	0.022425	-2.396934	0.0165
	SIZE	0.022717	0.010298	2.205968	0.0274
	IQ	0.197885	0.085146	2.324058	0.0201
	GROWTH	0.235516	0.085117	2.762255	0.0053
Transition parameters	Threshold parameter, <i>c</i>	-0.211146	0.043521	-4.851588	0.0000
	Slope parameter, <i>γ</i>	0.735776	0.215697	3.411155	0.0007

Note. Adjusted $R^2 = 0.95$.

The negative relationship between cryptocurrency activity and financial stability can be explained through several transmission mechanisms. Cryptocurrencies are an emerging component of the financial system that can create new economic opportunities while simultaneously introducing new sources of financial vulnerability. Their implications for financial stability can be considered through three broad dimensions: risk-transmission channels through which shocks originating in cryptocurrency markets spread to conventional finance, potential opportunities for financial stability through more efficient payment infrastructure and enhanced financial inclusion, and regulatory and policy challenges associated with the management of digital assets by central banks and financial regulators.

Under current conditions, cryptocurrency markets in many countries are not yet sufficiently large to independently threaten global financial stability. Nevertheless, the rapid growth of cryptoasset markets, the expansion of stablecoins, their increasing interconnectedness with banks and capital markets, and the development of decentralized finance have substantially increased their relevance for policymakers. From the Financial Stability Board perspective, the associated risks become more consequential as the cryptoasset ecosystem increases in scale, develops structural vulnerabilities, and becomes more interconnected with the conventional financial system.

One important transmission channel is extreme price volatility and the resulting spillover of losses. Unbacked cryptocurrencies such as Bitcoin are characterized by considerable price volatility. A sudden decline in their market value can generate substantial losses for retail and institutional investors, investment funds, cryptocurrency firms,

and lenders. When banks, financial institutions, or institutional investors have direct or indirect exposure to such markets, these losses may subsequently be transmitted to conventional financial markets.

A second channel concerns the risk of runs on stablecoins. Although stablecoins are designed to maintain relatively stable values, their stability ultimately depends on the quality and liquidity of reserve assets, issuer transparency, and user confidence. If a large number of holders simultaneously seek redemption, issuers may be compelled to liquidate reserve assets rapidly. Such a process may cause the stablecoin to lose its target value, trigger forced sales of securities and other reserve assets, and generate liquidity pressure in conventional financial markets. The International Monetary Fund (IMF, 2025) identified fluctuations in value and redemption runs, disruptions to reserve-asset markets, and interconnectedness with the traditional financial system as important macro-financial risks associated with stablecoins.

A third mechanism is the weakening of conventional financial intermediation. If households and businesses transfer a substantial proportion of their bank deposits into stablecoins or other digital assets, banks experience a contraction in their deposit funding base. Such deposit substitution can reduce banks' capacity to extend credit while increasing their funding costs. This risk may be particularly pronounced in countries characterized by limited confidence in the domestic currency or banking system.

Another potential source of instability is the substitution of cryptocurrencies or foreign-currency-denominated stablecoins for national currencies. Widespread use of such digital assets can result in the "cryptoization" of an economy, whereby residents increasingly use digital or foreign-currency-linked assets instead of the domestic currency. Potential consequences include reduced monetary policy effectiveness, weaker demand for the national currency, greater difficulty in controlling liquidity, increased exchange-rate volatility, facilitated capital outflows, and greater opportunities for circumventing foreign-exchange restrictions.

Leverage and liquidity risk constitute another major channel. Cryptocurrency exchanges and digital-asset platforms frequently provide leveraged trading and lending facilities. When cryptoasset prices fall, leveraged positions may be liquidated automatically, generating successive rounds of forced sales and accelerating market declines. This mechanism can amplify an initial shock and produce dynamics resembling financial accelerator effects in conventional markets.

Risks may also originate from multifunction cryptocurrency intermediaries. Some cryptoasset firms simultaneously provide custody, trading, lending, token issuance, and investment services. The concentration of numerous financial functions within the same institution can intensify conflicts of interest, create uncertainty regarding the adequacy and composition of reserves, and complicate the management of insolvency and resolution procedures.

At the same time, the estimated model demonstrates that financial development, bank size, institutional quality, and economic growth positively and significantly contribute to financial stability. More developed financial systems tend to possess deeper markets, more diversified funding structures, stronger supervisory capacities, and more sophisticated risk-management mechanisms. Larger banks may also benefit from greater diversification and enhanced capacity to absorb shocks. Similarly, higher institutional quality strengthens regulatory effectiveness, transparency, and enforcement mechanisms, thereby reducing vulnerability to shocks originating in cryptoasset markets. Economic growth improves the financial position of households and firms, enhances debt-servicing capacity, and consequently contributes to banking-system resilience.

Comparisons between the two regimes are determined by the value of the transition variable and the associated transition function. Financial development was used as the transition variable, and its estimated threshold value

was $c = -0.211146$. The model therefore operates between two limiting regimes according to the position of the financial development index relative to this threshold. Comparison of the coefficients indicates that when financial development crosses the threshold of approximately -0.211 , thereby moving from the linear toward the nonlinear regime, the response of financial stability changes considerably. As financial development improves beyond the threshold, financial stability becomes more responsive to changes in the financial development environment.

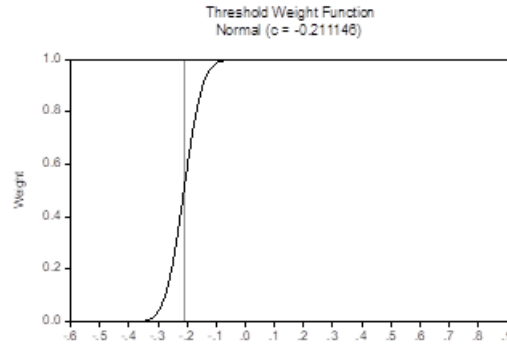


Figure 1. Relationship Between the Transition Function and the Financial Development Transition Variable

Several diagnostic tests were performed to assess the adequacy and statistical reliability of the estimated financial stability model. The Durbin–Watson statistic was used to assess serial correlation, while the Breusch–Pagan–Godfrey test was employed to evaluate heteroskedasticity. In addition, parameter stability across regimes was examined to determine whether the estimated coefficients remained stable as the model moved between regimes.

Table 5. Diagnostic and Parameter Stability Tests for the Financial Stability Model

Diagnostic Test	Null Hypothesis / Statistic	Value	<i>p</i> -value
Serial correlation	F statistic	1.235	0.690
	Durbin–Watson statistic	2.236	—
Heteroskedasticity	F statistic	1.298	0.556
	Breusch–Pagan–Godfrey statistic	1.327	—
Parameter stability	$b_1 = b_2 = b_3 = b_4 = 0$	0.745	0.754
	$b_1 = b_2 = b_3 = 0$	0.798	0.712
	$b_1 = b_2 = 0$	0.821	0.695
	$b_1 = 0$	0.836	0.674

The Durbin–Watson statistic of 2.236, together with the corresponding test results, indicates no evidence of serial correlation among the disturbance terms. Therefore, the classical assumption of no autocorrelation was not violated, supporting the statistical efficiency of the estimated coefficients.

The Breusch–Pagan–Godfrey results likewise indicate no evidence of heteroskedasticity. Thus, the variance of the disturbance term can be regarded as approximately constant across observations.

Finally, the parameter stability tests reported in Table 5 yielded statistically insignificant results in all specifications. Accordingly, the null hypotheses of parameter stability could not be rejected, indicating that the estimated coefficients remained stable across the two regimes.

The same sequence of specification tests was conducted for the banking performance model. The null hypothesis assumed a linear relationship among the variables, whereas the alternative hypothesis implied a logistic PSTR specification with $m = 1$ or an exponential PSTR specification with $m = 2$.

The Wald, Fisher, and likelihood-ratio statistics all strongly rejected the null hypothesis of linearity. Therefore, the relationship between cryptocurrency activities and banking performance in the selected Islamic countries was nonlinear, justifying the use of the PSTR framework.

Following González et al. (2005) and Colletaz and Hurlin (2006), the adequacy of one transition function was subsequently examined against the alternative of at least two transition functions. The null hypothesis of one transition function could not be rejected under either the $m = 1$ or $m = 2$ specification.

Table 6. Linearity and Remaining Nonlinearity Tests for the Banking Performance Model

Panel / Test	Statistic	<i>p</i> -value
Panel A. Linearity Tests		
Wald test	5.236	0.000
Fisher test	4.598	0.000
Likelihood-ratio test	4.789	0.000
Panel B. Remaining Nonlinearity Test: $m = 1$		
LMw	1.012	0.687
LMf	1.116	0.612
LR	1.236	0.542
Panel C. Remaining Nonlinearity Test: $m = 2$		
LMw	1.258	0.521
LMf	1.239	0.532
LR	1.425	0.489

The findings therefore confirm that a single transition function is sufficient to characterize the nonlinear relationship between cryptocurrency activity and banking performance. The competing one-threshold and two-threshold specifications were subsequently compared using the residual sum of squares, Schwarz information criterion, and Akaike information criterion. On the basis of these criteria, the PSTR model containing one transition function and one threshold parameter provided the preferred specification. Consequently, this model was selected for the analysis of banking performance.

A PSTR model was estimated in which financial development served as the transition variable and banking performance was the dependent variable. The results of the nonlinear component indicate that cryptocurrency market capitalization, Bitcoin volatility, and the ratio of cryptocurrency trading volume to GDP exerted negative and statistically significant effects on banking performance at the 95% confidence level.

Banks, as traditional financial intermediaries, face several challenges arising from the rapid expansion of cryptoassets that can directly threaten elements of their conventional business models.

The first mechanism concerns the loss of low-cost funding, particularly customer deposits. One of the principal foundations of banking profitability is the collection of deposits at relatively low funding costs and the subsequent extension of loans at higher rates. The development of stablecoins and decentralized finance platforms may encourage some depositors to shift funds from bank accounts into stablecoins that can be used as payment instruments or placed in digital-asset platforms offering higher yields. Such deposit outflows represent financial disintermediation and reduce the liquidity available to banks for lending, potentially compressing their interest margins and profitability.

The second mechanism concerns higher compliance and operating costs. Banks are subject to extensive Know Your Customer (KYC) and Anti-Money Laundering (AML) requirements. When they interact with cryptocurrency markets or provide digital-asset-related services to customers, they become exposed to additional legal,

compliance, cybersecurity, and regulatory risks. Banks may consequently be required to make substantial investments in information technology infrastructure, compliance systems, transaction-monitoring capabilities, and specialized legal teams to remain compliant with rapidly evolving digital-asset regulations. These expenditures can directly increase operating costs.

A third mechanism is the erosion of traditional cross-border payment revenues. A considerable proportion of fee income at large banks has historically been generated through international transfers, correspondent banking, SWIFT-based payments, and interbank fees. Because blockchain networks and cryptocurrencies facilitate peer-to-peer transfers of value across borders, often at lower cost and higher speed than conventional mechanisms, they may reduce banks' fee-generating opportunities and intensify competitive pressure on traditional payment services.

A fourth channel relates to credit, market, and volatility risks when banks become directly exposed to cryptoassets. If a bank holds cryptocurrency assets on its balance sheet or extends credit to cryptocurrency firms, substantial declines in digital-asset prices may rapidly weaken its balance sheet and adversely affect regulatory capital ratios. Moreover, because cryptocurrency markets operate continuously and experience high volatility, risk management may become more complex and costly for banks whose traditional risk-control systems were developed for more structured and less continuously traded financial markets.

The fifth challenge is competition from decentralized finance. DeFi seeks to replicate services traditionally supplied by banks, including lending, saving, asset exchange, and liquidity provision, without requiring conventional financial intermediaries. Smart contracts can automate financial transactions that previously depended upon bank personnel or centralized institutions. The expansion of such services may therefore weaken the competitive position of traditional banks, especially in attracting younger and more technologically oriented customers.

A sixth channel operates through monetary policy. In economies where cryptocurrencies become substitutes for domestic money, a process of cryptoization may weaken the transmission of central bank monetary policy. Traditional tools such as interest-rate adjustments may become less effective in influencing savings, borrowing, and aggregate demand. Reduced monetary policy effectiveness may indirectly impair commercial banks because their lending, liquidity management, and balance-sheet planning depend heavily on the predictability and credibility of the monetary environment.

The empirical estimates are presented in Table 7.

Table 7. PSTR Estimation Results for the Banking Performance Model

Component	Variable	Coefficient	Standard Error	<i>t</i> Statistic	<i>p</i> -value
Linear component	Constant	0.521556	0.300193	1.737401	0.0823
	MC	-0.139694	0.048299	-2.892296	0.0038
	BV	-0.666277	0.201960	-3.299048	0.0010
	CT	-0.214652	0.095978	-2.236478	0.0256
	FD	0.237879	0.061631	3.859691	0.0001
	INF	-0.289564	0.208206	-1.390754	0.1664
	SIZE	0.035862	0.014372	2.495362	0.0129
	IQ	0.164212	0.061974	2.649681	0.0092
	GROWTH	0.050223	0.020435	2.457766	0.0142
	Constant	0.454951	0.260162	1.748721	0.0937
Nonlinear component	MC	-0.109331	0.050050	-2.184460	0.0292
	BV	-0.489045	0.194501	-2.514356	0.0121

	CT	-0.543096	0.219393	-2.475447	0.0135
	FD	0.481983	0.157276	3.064575	0.0022
	INF	-0.236612	0.084965	-2.784825	0.0055
	SIZE	0.252209	0.084143	2.997371	0.0028
	IQ	0.366688	0.113132	3.241241	0.0012
	GROWTH	0.540769	0.199902	2.705173	0.0082
Transition parameters	Threshold parameter, c	0.139098	0.025936	5.363124	0.0000
	Slope parameter, γ	0.177326	0.070478	2.516070	0.0126

Note. Adjusted $R^2 = 0.88$.

The results further indicate that financial development, bank size, institutional quality, and economic growth improve banking performance. In the nonlinear regime, the coefficient of financial development was positive and statistically significant ($\beta = 0.481983$ $p = 0.0022$), as were the coefficients of bank size ($\beta = 0.252209$ $p = 0.0028$), institutional quality ($\beta = 0.366688$ $p = 0.0012$), and economic growth ($\beta = 0.540769$ $p = 0.0082$). Inflation had a negative and statistically significant nonlinear effect ($\beta = -0.236612$ $p = 0.0055$), although its coefficient in the linear component was not statistically significant ($p = 0.1664$).

Comparison of coefficients across regimes depends on the financial development transition variable and its position relative to the estimated threshold. The estimated financial development threshold for the banking performance model was $c = 0.139098$. Accordingly, the model shifts progressively between two limiting regimes depending on whether the financial development index lies below, around, or above this value.

Comparison of the coefficients suggests that once financial development exceeds the threshold of 0.139098, corresponding to a transition from the linear toward the nonlinear regime, banking performance becomes considerably more responsive to financial development. The stronger positive coefficient of financial development in the nonlinear component indicates that, at higher levels of financial development, the banking system may have greater capacity to adapt to cryptocurrency-related pressures. In this regime, banking-sector policymakers and institutions appear better positioned to respond to structural changes, strengthen risk management, and limit deterioration in banking performance.

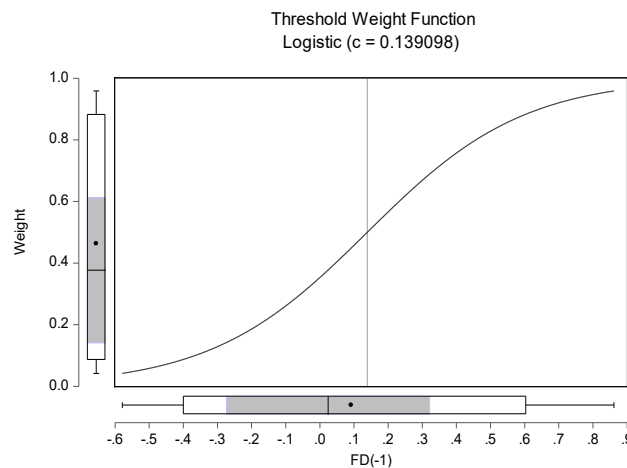


Figure 2. Relationship Between the Transition Function and the Financial Development Transition Variable

Diagnostic tests were also performed for the banking performance specification. Serial correlation was assessed using the Durbin–Watson statistic, heteroskedasticity was examined using the Breusch–Pagan–Godfrey test, and parameter stability across regimes was evaluated through smooth-transition parameter stability tests.

Table 8. Diagnostic and Parameter Stability Tests for the Banking Performance Model

Diagnostic Test	Null Hypothesis / Statistic	Value	<i>p</i> -value
Serial correlation	F statistic	1.458	0.480
	Durbin–Watson statistic	2.398	—
Heteroskedasticity	F statistic	0.698	0.812
	Breusch–Pagan–Godfrey statistic	1.139	—
Parameter stability	$b_1 = b_2 = b_3 = b_4 = 0$	1.236	0.653
	$b_1 = b_2 = b_3 = 0$	1.326	0.574
	$b_1 = b_2 = 0$	1.348	0.512
	$b_1 = 0$	1.487	0.456

The Durbin–Watson statistic of 2.398, together with the corresponding probability value, indicates no evidence of serial correlation among the disturbance terms. Thus, the classical assumption of no autocorrelation was not violated, and the estimators retained the desirable properties associated with efficient estimation.

The Breusch–Pagan–Godfrey test likewise provided no evidence of heteroskedasticity. The relatively large probability value indicates that the null hypothesis of homoskedastic disturbances could not be rejected.

Finally, all parameter stability tests produced statistically insignificant results. Therefore, the null hypotheses of coefficient stability across the two regimes could not be rejected. The estimated parameters can consequently be regarded as stable across regime transitions, providing additional support for the adequacy and reliability of the estimated PSTR banking performance model.

4. Discussion and Conclusion

The findings of the present study demonstrate that cryptocurrency activity has a statistically significant adverse effect on both financial stability and banking performance in the selected D-8 Islamic countries, while financial development and institutional quality play important protective roles in moderating these effects. The PSTR estimates showed that cryptocurrency market capitalization, Bitcoin volatility, and the ratio of cryptocurrency trading volume to GDP exerted negative and significant effects on the banking Z-score and return on assets. These results indicate that as cryptocurrency markets expand, banking systems may face greater instability and reduced profitability, particularly when digital asset activity becomes large relative to the domestic economy. The nonlinear structure of the estimated relationships is also important because the Wald, Fisher, and likelihood-ratio tests rejected linearity in both models, while the model-selection procedures supported the use of a single transition function with one threshold parameter. Accordingly, the effects of cryptocurrency activity on financial stability and bank performance are not constant across all levels of financial development. This result is consistent with recent evidence emphasizing the time-varying and state-dependent nature of cryptocurrency risk transmission. Cryptocurrency markets exhibit dynamic volatility networks and changing interconnections across market states [3], while the relationship between cryptocurrencies and conventional financial markets is characterized by time-varying causality and influence rather than a stable linear structure [4]. Similarly, quantile-based evidence indicates that cryptocurrency spillovers differ across market conditions and can become more pronounced in regulated environments during periods of stress [5]. These findings support the present study's use of a threshold framework and suggest that nonlinear estimation provides a more realistic representation of the interaction between cryptoassets and banking systems.

The negative effect of cryptocurrency market capitalization on financial stability suggests that a larger cryptocurrency ecosystem may increase the exposure of the banking sector to new forms of market, liquidity, and

intermediation risk. As cryptocurrency markets expand, households and firms may increasingly shift funds from conventional deposits toward digital assets, reducing banks' stable funding base and weakening their traditional role in financial intermediation. This mechanism is consistent with qualitative evidence that digital currencies are changing banking business models and potentially altering the structure of monetary and financial intermediation [13]. Kouti also argues that cryptocurrency expansion creates substantial challenges for conventional banking by affecting payment services, intermediation, regulatory compliance, and banks' competitive position in international finance [12]. The present results provide empirical support for these concerns by showing that a greater market presence of cryptocurrencies is associated with weaker financial stability and lower bank profitability. The findings are also compatible with studies examining the legal and operational integration of cryptocurrencies into banking activities. The feasibility of accepting cryptocurrency as collateral remains constrained by legal, valuation, and institutional barriers [15], and uncertainty regarding whether cryptocurrencies can be treated as conventional currency adds further complexity to financial-sector risk management [16]. Such uncertainty may increase compliance costs and operational burdens for banks, thereby contributing to the observed negative association between cryptocurrency expansion and banking performance.

Bitcoin volatility was found to have a particularly strong negative effect on both financial stability and bank performance. This result is theoretically plausible because highly volatile cryptocurrency prices can generate abrupt wealth losses, margin calls, liquidity shocks, and deterioration in the balance sheets of exposed investors and institutions. The finding aligns closely with research showing that volatility is a fundamental feature of cryptocurrency markets and requires specialized stochastic modeling because of its persistence and instability [9]. It is also consistent with evidence that the cryptocurrency market exhibits dynamic network structures in which volatility can propagate rapidly among digital assets [3]. In a banking context, such volatility can affect institutions through several direct and indirect channels, including lending to cryptocurrency firms, custody services, holdings of digital assets, collateral exposure, and customer losses that subsequently affect loan quality. The behavioral characteristics of cryptocurrency investors may further amplify these mechanisms. Almishhal and Bulut show that cryptocurrency markets are strongly influenced by behavioral factors that can intensify price fluctuations and destabilizing market responses [1]. Transaction-level evidence of herding behavior in cryptocurrency markets also indicates that investors often react collectively, thereby magnifying market movements and increasing the likelihood of abrupt price corrections [10]. The negative coefficient of Bitcoin volatility obtained in the present study is therefore consistent with the broader literature demonstrating that cryptocurrency risk is amplified by both market structure and investor behavior.

The negative effect of cryptocurrency trading volume relative to GDP further suggests that the systemic significance of digital assets depends not merely on their absolute market size but also on their intensity relative to the domestic economy. A high cryptocurrency trading volume relative to GDP indicates that digital assets occupy a substantial share of financial transactions and investment activity, which can increase the possibility of spillovers into conventional financial markets. This interpretation is in line with M'Bakob, who finds that sequential attention cycles among cryptocurrency investors can produce spillover effects that affect broader financial market stability [6]. Similarly, the dynamic connectedness literature indicates that financial spillovers are stronger when markets are highly integrated and shocks are transmitted through multiple channels. Evidence from cryptocurrency and conventional markets confirms that these links vary over time and market conditions [4], while research on other asset classes has shown that return and volatility connectedness may differ substantially across time horizons and frequencies [23]. Although Wan et al. focus on global ESG stock indexes, their findings support the broader

proposition that financial connectedness is multidimensional and state dependent. Comparable evidence from oil-price shocks and sectoral returns also demonstrates that spillovers vary over time and across frequencies [24]. Consequently, the negative effect of cryptocurrency trading intensity observed in this study may reflect deeper channels of financial interconnectedness that increase the vulnerability of domestic banking systems to digital-asset shocks.

The findings also showed that financial development had a positive and significant effect on both financial stability and banking performance. More importantly, the estimated PSTR models identified significant financial development thresholds, indicating that the effects of the explanatory variables change after the financial system crosses a critical level of development. In the financial stability model, the threshold parameter was estimated at $c = -0.211146$, while in the banking performance model it was $c = 0.139098$. The significance of these thresholds indicates that financial development acts not only as a direct determinant of banking outcomes but also as a regime-changing variable. As financial systems become more developed, banks may benefit from deeper markets, better diversification opportunities, improved infrastructure, enhanced regulatory capacity, and more sophisticated risk-management practices. This can reduce their vulnerability to cryptocurrency-related shocks. The result is consistent with the broader literature emphasizing that the impact of financial shocks depends on the structure and depth of financial systems. Ijaz et al., although examining connectedness among uranium stocks and metals, show that dynamic linkages between markets have important implications for risk diversification and portfolio management [25]. Similarly, the state-dependent spillovers documented in the cryptocurrency literature indicate that market structure influences the transmission of financial risk [8]. The present findings extend this logic to the banking sector by showing that financial development itself conditions the magnitude and form of cryptocurrency-related effects.

Institutional quality also exerted a positive and statistically significant effect on both financial stability and banking performance. This result highlights the importance of regulatory effectiveness, transparency, legal enforcement, governance quality, and institutional capacity in managing the risks created by cryptocurrency markets. Strong institutions can reduce information asymmetry, improve supervisory enforcement, enhance investor protection, and facilitate the development of clearer rules for digital assets. The finding is consistent with evidence from dual banking systems showing that corruption and weak governance are associated with greater bank risk-taking [18]. In Islamic and dual banking environments, where conventional and Sharia-compliant institutions may coexist, institutional quality may be particularly important because regulatory complexity is already relatively high. The positive role of institutional quality also aligns with comparative research showing that Islamic and conventional banking systems may differ in performance and resilience, making governance and supervisory effectiveness central to banking stability [19]. In the context of Islamic banking, monetary and institutional arrangements also influence the transmission of macroeconomic policy. Evidence from Iran shows that the banking system plays a significant role in transmitting contractionary monetary policy to inflation [20], while institutional mechanisms governing bank profit rates affect the operation of the banking system [21]. These studies support the current finding that stronger institutional structures improve banks' capacity to absorb technological and financial disruptions.

Bank size was another variable that had a positive and significant relationship with both financial stability and banking performance. Larger banks may have greater resources for technological investment, compliance, risk management, diversification, and shock absorption. This can be particularly important in the cryptocurrency context because engaging with or monitoring digital-asset markets requires substantial investment in cybersecurity,

legal compliance, data analytics, and specialized human capital. Larger banks may also have more diversified revenue streams, making them less dependent on any single activity affected by cryptocurrency competition. At the same time, their capital-market position may provide them with greater access to external funding. Evidence from selected banking stocks on the Istanbul Stock Exchange confirms that bank performance is closely connected to systematic market risk and capital-market conditions [28]. The current findings suggest that bank size can provide additional resilience in a financial environment characterized by technological innovation and new forms of market risk.

Economic growth was positively associated with both financial stability and banking performance, which is consistent with conventional banking theory. Stronger economic growth generally improves household and corporate incomes, reduces default probabilities, strengthens loan demand, and enhances banks' asset quality and profitability. In contrast, inflation had a negative effect, particularly in the nonlinear regimes. Inflation can weaken banking performance by increasing uncertainty, reducing the real value of financial assets, affecting interest margins, and changing the demand for domestic money. These effects may be especially relevant in economies where households view cryptocurrencies as alternative stores of value. Gaies et al. demonstrate that the resilience of Bitcoin and Ethereum varies under inflation and financial instability, suggesting that macroeconomic uncertainty can alter the role of cryptocurrencies in investor portfolios [7]. Popova et al. similarly show that geopolitical shocks can alter safe-haven perceptions and cryptocurrency-market behavior [26]. These findings support the interpretation that macroeconomic instability can strengthen the interaction between cryptocurrencies and conventional banking systems.

The negative effect of cryptocurrency activity on banking performance can also be interpreted through the erosion of traditional banking revenue channels. Cryptocurrencies and decentralized financial platforms can compete with banks in payments, transfers, lending, saving, and asset exchange. DeFi platforms, in particular, use smart contracts to perform functions traditionally conducted by financial intermediaries. Gadzinski and Liuzzi show that liquidation dynamics affect lending behavior in decentralized finance [14], demonstrating that alternative lending systems are developing their own mechanisms of credit allocation and risk. The expansion of such platforms may place competitive pressure on banks by diverting customers and transactions away from conventional channels. This pressure may be especially pronounced for younger and more technology-oriented customers. Evidence on consumer trust in cryptocurrency transactions also indicates that adoption depends strongly on perceptions of volatility and market conditions [27]. If consumers increasingly trust crypto-based payment and investment systems, conventional banks may face further pressure on deposits and fee-based services.

The findings also have implications for the broader evolution of financial technology. Cryptocurrencies are increasingly intertwined with technological innovation, digital market infrastructure, and changing patterns of financial activity. Vlachou et al. show that cryptocurrency activity, technological developments, and market dynamics are mutually connected [2]. Similarly, Nejad Moghadam emphasizes that cryptocurrencies and digital currencies are reshaping monetary technologies and contributing to the transformation of financial systems [17]. These developments suggest that the banking sector cannot treat cryptocurrencies merely as speculative assets. Instead, digital assets represent part of a wider technological transformation in which financial institutions must adapt their infrastructure, products, governance mechanisms, and risk-management frameworks. At the same time, such adaptation should be cautious because increased exposure may create new channels of risk transmission.

The results concerning the nonlinear nature of the relationships also correspond with evidence that financial-market spillovers are asymmetric. Kazouz and Yousfi show that risk spillovers between green and conventional

cryptocurrencies vary across quantiles and depend on geopolitical and financial risks [8]. Gu et al. similarly find quantile-specific spillovers between cryptocurrencies and conventional financial markets [5]. These findings suggest that average linear coefficients may conceal important regime-dependent effects. The threshold structure identified in the present study therefore provides an important contribution by showing that the impact of cryptocurrency activity on banking outcomes depends on the stage of financial development. This is particularly relevant in the D-8 countries, where substantial differences exist in financial depth, institutional capacity, technological adoption, regulatory maturity, and macroeconomic stability.

Overall, the empirical evidence supports the conclusion that cryptocurrency expansion creates measurable risks for both financial stability and banking performance in Islamic economies, but these effects are not uniform. More developed financial systems and stronger institutional frameworks appear better able to absorb or mitigate the disruptive effects of digital assets. The findings are consistent with a growing body of literature showing that cryptocurrency markets are characterized by volatility, behavioral amplification, spillovers, dynamic connectedness, and technological disruption [11]. Although Goh and Jeon focus on investor behavior around earnings announcements, their evidence that different investor groups contribute differently to the correction of mispricing reinforces the broader point that market participants are heterogeneous and can shape price adjustment processes in different ways. In the cryptocurrency context, such heterogeneity may further contribute to nonlinear market behavior and the transmission of risk to banking institutions.

The present study has several limitations that should be considered when interpreting the findings. First, the analysis is limited to eight D-8 Islamic countries and therefore may not be directly generalizable to all Islamic, emerging, or developed economies. Second, the study relies on annual data for the period from 2013 to 2024, which restricts the number of observations and may obscure higher-frequency dynamics in cryptocurrency markets that evolve on a daily or intraday basis. Third, cryptocurrency market capitalization, Bitcoin volatility, and cryptocurrency trading volume relative to GDP capture important dimensions of digital-asset activity but do not fully reflect the diversity of the crypto ecosystem, including stablecoins, decentralized finance, central bank digital currencies, tokenized assets, and country-specific regulatory exposure. Fourth, institutional quality is measured using broad institutional indicators that may not fully capture the specific quality of cryptocurrency regulation, banking supervision, cybersecurity governance, or enforcement capacity. Finally, although the PSTR framework effectively captures nonlinear threshold behavior, it does not explicitly identify all potential channels of causality or account for unobserved structural breaks, geopolitical shocks, or regulatory regime changes that may affect the relationship between cryptocurrencies and banking outcomes.

Future studies should extend the analysis by incorporating a larger sample of Islamic and non-Islamic economies and comparing the threshold effects across different institutional and financial systems. Researchers could also employ quarterly, monthly, or daily data to capture short-term volatility transmission and improve the identification of dynamic spillovers. Additional cryptocurrency variables, such as stablecoin market capitalization, decentralized finance activity, exchange inflows and outflows, institutional holdings, and central bank digital currency adoption, could provide a more comprehensive representation of digital financial activity. Future research could also distinguish between conventional and Islamic banks to determine whether the effects of cryptocurrency exposure differ according to banking model, risk-sharing structure, or Sharia-compliant financing principles. Methodologically, subsequent studies may combine PSTR with quantile regression, time-varying parameter models, dynamic panel estimators, network analysis, or regime-switching approaches. It would also be useful to

examine whether regulatory quality, financial literacy, cybersecurity capacity, monetary instability, and capital controls alter the threshold relationship between cryptocurrencies and banking outcomes.

Policymakers and banking regulators should develop differentiated cryptocurrency regulatory frameworks that are aligned with the level of financial development and institutional capacity of each country. Rather than applying uniform restrictions or broad prohibitions, supervisory authorities should adopt risk-based approaches that distinguish between speculative cryptoassets, stablecoins, decentralized finance, and regulated digital financial services. Banks should strengthen liquidity management, cybersecurity infrastructure, stress-testing frameworks, and compliance systems to address potential exposures arising from crypto-related activities. Regulators should also improve reporting requirements for banks and financial institutions with direct or indirect exposure to digital assets, while developing clear standards for custody, collateral valuation, capital adequacy, and customer protection. In addition, institutional reforms that improve transparency, legal certainty, regulatory coordination, and supervisory effectiveness can reduce the vulnerability of the banking system to cryptocurrency-related shocks. Finally, banks should respond strategically to technological competition by improving digital payment services, reducing transaction costs, and developing secure and regulated digital financial products without assuming excessive exposure to highly volatile cryptoassets.

Authors' Contributions

Authors equally contributed to this article.

Ethical Considerations

All procedures performed in this study were under the ethical standards.

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Conflict of Interest

The authors report no conflict of interest.

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