

Threshold Effects of Income Diversification, Sukuk, and Banking Risks on Banking System Performance with Emphasis on the Global Health Crisis: Evidence from Banks Listed on the Tehran Stock Exchange



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Abstract: Sustainable growth and development constitute one of the principal economic aspirations of every country. Economists have consistently considered it their responsibility to examine the conditions that encourage economic agents to undertake investment across different times and places. Capital is one of the principal inputs of production. In the past, capital was primarily conceptualized in terms of tools and equipment used in human labor. Today, however, capital is also regarded as the accumulation of liquidity required to initiate or continue an economic activity. Governments and business enterprises require capital to initiate or sustain economic activities. Such capital may be provided through government assets and owners' equity or obtained through the financing process. Financing is one of the major topics in financial economics. Various financing methods and instruments are available, each possessing its own characteristics and properties. Depending on financing needs, financial capacity, the circumstances of economic enterprises, and differences in individuals' investment behavior and risk exposure, these instruments and methods are developed and employed. One important financing method is asset securitization. This study investigates the threshold effects of income diversification, Sukuk, and banking risks on banking system performance, with emphasis on the global health crisis, using banks listed on the Tehran Stock Exchange as the case study. In terms of purpose, the study is applied research, while in terms of nature, it is descriptive-analytical and falls within the category of ex post facto research. The statistical population consists of banks listed on the Tehran Stock Exchange, from which a number of banks were selected for analysis using the Panel Smooth Transition Regression (PSTR) threshold model. The study period is annual and covers 2013–2024 for listed banks. The estimation results for the linear component of the banking performance function based on return on assets (ROA), corresponding to the first regime, indicate that the global financial crisis, liquidity risk, and credit risk negatively affect banking performance. The estimation results for the nonlinear component of the model, corresponding to the second regime, indicate that Sukuk, income diversification, and capital adequacy affect banking performance. The relationships are modeled using a PSTR model in which income diversification serves as the transition variable. The estimation results for the nonlinear component of the banking performance function based on return on equity (ROE), corresponding to the second regime, show that Sukuk, income diversification, and the capital adequacy ratio have positive and statistically significant effects on banking performance. In contrast, the global health crisis, liquidity risk, and credit risk negatively affect banking performance and have contributed to a decline in the performance of the selected banks.

Keywords: Income Diversification; Sukuk; Banking Risks; Banking System Performance; Smooth Transition Model

1. Introduction

Banking systems play a central role in mobilizing financial resources, allocating capital, supporting investment, and facilitating economic growth. The quality of banking performance is therefore closely associated with the stability of financial markets and the broader capacity of an economy to withstand shocks. Banks transform short-term liabilities into longer-term assets, manage liquidity, allocate credit, and provide payment and financing services to households, firms, and governments. These functions, however, expose banks to multiple forms of financial risk, particularly credit risk, liquidity risk, capital adequacy risk, and fluctuations in the composition of income. The importance of these risks becomes more pronounced during periods of systemic disruption, when deterioration in borrowers' financial positions, instability in funding markets, and contraction in economic activity may simultaneously weaken bank profitability and balance-sheet quality. Research on banking stability has therefore increasingly emphasized the interaction between profitability, capitalization, risk exposure, financing structure, and diversification rather than treating these dimensions as isolated determinants of performance. In Islamic and dual banking systems, these relationships are further complicated by the institutional characteristics of Shariah-compliant financing, specific governance requirements, and the growing role of Islamic capital-market instruments such as Sukuk [1, 2].

Bank performance is generally evaluated through accounting-based indicators such as return on assets (ROA) and return on equity (ROE), which represent distinct but complementary dimensions of financial performance. ROA reflects the ability of a bank to generate earnings from the assets under its control, whereas ROE indicates the efficiency with which shareholders' equity is employed to generate net income. Both indicators are influenced not only by operating efficiency and the scale of banking activities but also by risk-taking behavior, capital structure, income composition, and the institutional environment within which banks operate. Capital adequacy is particularly important because sufficient capitalization increases banks' capacity to absorb unexpected losses and may reduce vulnerability to adverse financial conditions. Studies comparing conventional and Islamic banking have demonstrated that bank capital decisions are affected by institutional characteristics and creditor-protection mechanisms, while the structure of Islamic banking introduces additional considerations regarding the composition and quality of capital [2]. Moreover, research on the capital adequacy ratios of Islamic banks indicates that capitalization should not merely be viewed as a regulatory constraint, because it can interact with risk, profitability, and the specific features of Islamic financial intermediation [3]. Consequently, investigating capital adequacy together with other financial and risk-related determinants provides a more comprehensive explanation of banking performance.

Another critical issue concerns income diversification. Banks traditionally rely heavily on interest or financing income generated from lending activities, but developments in financial markets have encouraged them to expand toward fee-based services, investment income, securities transactions, and other nontraditional sources of revenue. Income diversification may reduce dependence on a single business line and potentially stabilize revenue when traditional lending activities weaken. However, diversification can also expose banks to unfamiliar risks, higher operational complexity, and greater sensitivity to financial-market volatility. Therefore, its relationship with performance is not necessarily linear. Evidence from dual banking economies suggests that diversification interacts with competition and financial stability in complex ways and that its effects may differ according to institutional structure and the characteristics of individual banks [1]. This suggests that the effect of income diversification may depend on whether a bank has already reached a particular level of diversification. Before such a threshold,

diversification may offer only limited benefits or may impose additional costs, whereas beyond a certain level it may materially alter the responsiveness of profitability to financial conditions. This possibility provides a strong basis for employing nonlinear and threshold-based econometric models rather than assuming that the marginal effect of diversification remains constant over its entire range.

The expansion of Islamic finance has simultaneously increased the importance of Sukuk as an alternative financing instrument for governments, financial institutions, and corporations. Sukuk differ from conventional debt securities because they are structured on the basis of Shariah-compliant contractual arrangements and generally represent ownership interests or rights associated with specified assets, usufructs, projects, or investment activities. The development of Islamic financing instruments has contributed to greater diversity in financial intermediation and has provided financial institutions with mechanisms for mobilizing funds outside conventional interest-based structures [4]. Sukuk development is also associated with broader economic outcomes. Evidence regarding the relationship between Islamic financial instruments and economic growth suggests that the expansion of Sukuk markets and economic activity may reinforce each other through improved financing opportunities and capital mobilization [5]. Similarly, research on Islamic banking has shown that the expansion of Islamic financial intermediation can contribute to economic growth by supporting productive financing and strengthening the transmission of financial resources to the real economy [6]. Studies examining the relationship between Islamic banking and industrial production further suggest that Islamic financial institutions can play an important role in supporting real-sector activity, although the magnitude of this role depends on the structure and development of the banking sector [7].

At the bank level, Sukuk can influence performance through several channels. Sukuk issuance or investment may provide banks with additional sources of income, facilitate liquidity management, alter asset composition, and enable diversification of funding and investment portfolios. Recent evidence has directly examined how Sukuk issuance affects liquidity, profitability, and asset quality in Islamic banks, highlighting the importance of assessing these outcomes jointly rather than focusing exclusively on financing volume [8]. Likewise, studies of investment in Sukuk have emphasized its potential relationship with the financial performance of Islamic banks, particularly through the contribution of Sukuk holdings to income generation and portfolio structure [9]. Comparative research has also investigated the effect of Sukuk market development on the profitability of Islamic and conventional banks, showing that the relationship between Sukuk development and bank performance may vary according to the institutional characteristics of the banking model [10]. Furthermore, the relationship between Sukuk issuance, financing costs, and abnormal returns indicates that Sukuk may affect not only financial intermediaries but also firms' financing decisions and market valuation, thereby reinforcing the broader importance of Sukuk within capital-market and banking relationships [11].

The versatility of Sukuk continues to expand as researchers and practitioners explore innovative structures and applications. The concept of linking Sukuk with unconventional asset and financing arrangements illustrates the adaptability of Islamic-finance principles to financial structures that may not originally have been designed as Islamic instruments [12]. Similarly, cash waqf-linked Sukuk demonstrate how Sukuk can be integrated with socially oriented Islamic financial mechanisms, although optimizing such instruments requires overcoming institutional, regulatory, governance, and operational barriers [13]. These developments indicate that Sukuk should not be regarded merely as substitutes for conventional bonds. Rather, they constitute a diverse class of financing and investment instruments capable of affecting liquidity, financial inclusion, risk allocation, funding structure, and financial performance. Accordingly, in banking-performance research, the impact of Sukuk may depend on the

extent to which banks can integrate these instruments into their asset-liability management and revenue-generating strategies.

Despite the potential benefits of Islamic financing instruments, their distinctive contractual features also generate specific governance and compliance risks. Islamic banks are required to ensure that their products, investments, and financial practices remain consistent with Shariah principles. Shariah noncompliance may impose financial, reputational, operational, and legal costs on banking institutions. Corporate governance mechanisms and the effectiveness of Shariah supervisory boards therefore have important implications for financial outcomes in Islamic banking [14]. Research from Southeast Asian Islamic banks has further shown that corporate governance mechanisms are relevant to the management of Shariah noncompliance risk, reinforcing the need to incorporate institutional governance into assessments of banking stability [15]. Shariah audit represents another important control mechanism, because effective audit systems can improve the monitoring of compliance and strengthen accountability within Islamic financial institutions [16]. When noncompliance occurs, specialized Islamic dispute-resolution mechanisms may also play a role in mitigating the financial and institutional consequences of Shariah-related disputes [17]. These governance considerations are particularly relevant when analyzing Sukuk and Islamic financing instruments because the performance advantages associated with these instruments may be weakened if compliance, governance, or risk-management structures are inadequate.

Alongside financing structure and diversification, credit and liquidity risks remain fundamental determinants of banking performance. Credit risk arises from the possibility that borrowers or counterparties will fail to meet their contractual obligations and can reduce profitability through loan-loss provisions, nonperforming assets, and impaired cash flows. Liquidity risk reflects a bank's inability to meet financial obligations when they become due without incurring excessive costs or significant losses. Excessive exposure to either type of risk can weaken profitability and threaten solvency, especially when adverse conditions affect multiple institutions simultaneously. Effective risk-management practices can therefore operate as a mechanism through which banks protect financial performance from deteriorating balance-sheet conditions. Evidence concerning banks listed on the Tehran Stock Exchange has emphasized the mediating role of risk-management practices in explaining financial performance, demonstrating the importance of examining financial risks in conjunction with managerial responses rather than as purely exogenous constraints [18]. In the Iranian context, the soundness of Islamic banking has also been identified as an important factor in limiting the contagion of financial crises, underscoring the systemic implications of bank-level risk exposure [19].

The growing complexity of banking risk is also evident in emerging areas such as climate-related financial risk. Contemporary banking research increasingly recognizes that financial institutions face risks generated not only within traditional credit and liquidity channels but also through external environmental, macroeconomic, and systemic shocks. Bibliometric evidence on climate risk in banking reveals the rapid expansion of research examining how environmental exposures can affect asset quality, financial stability, lending behavior, and risk management [20]. Although climate risk differs from the global health crisis examined in the present study, both illustrate a broader principle: external shocks can rapidly alter the financial conditions facing banks and may amplify existing credit, liquidity, and profitability vulnerabilities. Consequently, banking models that incorporate only internal financial indicators may overlook an important dimension of performance. The inclusion of systemic crisis variables is therefore necessary when evaluating how banks respond to conditions that abruptly change economic activity, customer behavior, funding requirements, and the quality of bank assets.

The global health crisis created precisely such an environment. The pandemic constituted a multidimensional shock affecting economic production, labor markets, firm revenues, financial markets, household income, and institutional management. For banks, the crisis could influence performance through reduced loan repayment capacity, increased credit losses, changes in deposit and liquidity behavior, declining business activity, operational disruption, and extraordinary policy interventions. It also required banking institutions to adapt their management systems, organizational routines, and expectations regarding uncertainty. Post-pandemic management research emphasizes that conventional assumptions about leadership and organizational performance may need to be reconsidered when institutions operate under large-scale and persistent disruption [21]. In the banking sector, such changes imply that relationships estimated under normal economic conditions may not adequately represent periods of systemic stress. A variable such as income diversification, for example, may affect profitability differently during a global health crisis than during stable periods, while exposure to credit or liquidity risk may produce considerably larger performance effects after a crisis threshold is crossed.

These circumstances provide an important rationale for nonlinear modeling. Traditional linear regression assumes that the marginal effect of each explanatory variable is constant regardless of the level of the transition variable or the state of the financial system. Such an assumption may be restrictive in banking applications because financial institutions often operate differently across low-risk and high-risk regimes, below and above regulatory thresholds, and during normal and crisis periods. Panel data models provide important methodological advantages because they combine cross-sectional and time-series information and can control for unobserved heterogeneity among institutions. Nevertheless, panel regressions must be specified carefully because endogeneity can arise through simultaneity, omitted variables, measurement error, and dynamic relationships between current performance and previous financial decisions [22]. A threshold-based panel methodology can extend conventional panel analysis by permitting coefficients to change smoothly as an observable transition variable crosses an estimated threshold, thereby providing a more realistic representation of gradual regime shifts in banking behavior.

The Panel Smooth Transition Regression (PSTR) framework is particularly appropriate when changes between regimes are expected to occur gradually rather than abruptly. In the present research context, income diversification can serve as a meaningful transition variable because its effect on performance may depend on the extent to which banks have already diversified their revenue structures. At lower levels of diversification, banks may remain highly dependent on traditional financing activities, and modest changes in nontraditional revenue may have limited effects on profitability. As diversification increases, however, revenue composition may become sufficiently different to alter the way Sukuk, capital adequacy, liquidity risk, credit risk, and systemic shocks affect performance. This nonlinear perspective is consistent with the broader literature showing complex interactions among diversification, competition, and stability [1], as well as with evidence that bank capitalization, governance, and Islamic financial instruments operate through multiple interdependent channels [3, 14]. It therefore enables the analysis to move beyond the simple question of whether a variable has a positive or negative effect and instead examine how that effect changes across financial regimes.

The Iranian banking and capital-market environment provides an especially relevant setting for such analysis. Iran possesses a banking structure based on Islamic financial principles while simultaneously maintaining an active securities market in which listed banks interact with capital-market instruments. The development and use of Sukuk have increased the range of Shariah-compliant financing alternatives available to banks and other institutions [4]. Iranian studies have examined Sukuk from several perspectives, including financial performance [9], bank profitability [10], financing cost and abnormal returns [11], and the relationship between financial risk

management and the performance of listed banks [18]. Moreover, concerns regarding the stability of Islamic banking and its capacity to limit financial-crisis contagion have increased the importance of examining how bank-specific financial characteristics interact with systemic shocks [19]. Nevertheless, these dimensions are frequently studied separately, leaving limited evidence on whether the effects of Sukuk, banking risks, capital adequacy, and income diversification on performance change after an endogenous diversification threshold is reached.

This research gap is important because assuming homogeneous effects across all levels of income diversification can obscure economically meaningful changes in bank behavior. A positive average association between diversification and performance may conceal weak or statistically insignificant effects at lower levels and substantially stronger effects after a threshold is crossed. Similarly, the adverse effects of credit risk, liquidity risk, or a global health crisis may intensify in a different regime, while the contribution of capital adequacy and Sukuk may become more pronounced as banks' revenue structures diversify. Such possibilities are especially relevant when bank performance is measured using both ROA and ROE, because the two indicators capture different aspects of profitability and may respond differently to changes in assets, equity, risk, and financing instruments. Integrating these determinants within a PSTR framework can therefore provide a richer interpretation of the mechanisms linking financial structure and risk to bank profitability.

Accordingly, the aim of this study is to investigate the threshold effects of income diversification, Sukuk, banking risks, capital adequacy, and the global health crisis on the performance of banks listed on the Tehran Stock Exchange, measured by ROA and ROE, using a Panel Smooth Transition Regression model in which income diversification serves as the transition variable.

2. Methods and Materials

In terms of purpose, the present study is applied research, while in terms of nature, it is descriptive-analytical and belongs to the category of ex post facto studies. The study examines the threshold effects of income diversification, Sukuk, and banking risks on banking system performance, with emphasis on the global health crisis, using banks listed on the Tehran Stock Exchange as the case study. For this purpose, a Panel Smooth Transition Regression (PSTR) threshold model is employed. The study period is annual and covers 2013–2024 for listed banks. Following Lee et al. (2022), Rizwan et al. (2022), Chen and Luo (2021), and Asmoya and Goma (2020), the research models are estimated using the PSTR model specified as follows.

Model 1:

$$ROA_{i,t} = \alpha_0 + \beta_1 ROA_{i,t-1} + \beta_2 SMD_{i,t} + \beta_3 DIV_{i,t} + \beta_4 CVD_{i,t} + \beta_5 LR_{i,t} + \beta_6 CR_{i,t} + \beta_7 CAR_{i,t} + (\theta_1 ROA_{i,t-1} + \theta_2 SMD_{i,t} + \theta_3 DIV_{i,t} + \theta_4 CVD_{i,t} + \theta_5 LR_{i,t} + \theta_6 CR_{i,t} + \theta_7 CAR_{i,t})F(S_t, \gamma, c) + u_{i,t}$$

Model 2:

$$ROE_{i,t} = \alpha_0 + \beta_1 ROE_{i,t-1} + \beta_2 SMD_{i,t} + \beta_3 DIV_{i,t} + \beta_4 CVD_{i,t} + \beta_5 LR_{i,t} + \beta_6 CR_{i,t} + \beta_7 CAR_{i,t} + (\theta_1 ROA_{i,t-1} + \theta_2 SMD_{i,t} + \theta_3 DIV_{i,t} + \theta_4 CVD_{i,t} + \theta_5 LR_{i,t} + \theta_6 CR_{i,t} + \theta_7 CAR_{i,t})F(S_t, \gamma, c) + u_{i,t}$$

where the transition function F is defined as:

$$F(\gamma, s_t, c) = (1 + ROA\{-\gamma(s_t - c)\})^{-1}, \gamma > 0 \quad (1)$$

$$F(\gamma, s_t, c) = (1 + ROE\{-\gamma(s_t - c)\})^{-1}, \gamma > 0 \quad (2)$$

To examine the characteristics of the PSTR model with a logistic transition function, based on the model proposed by Van Dijk (1999), it is assumed that the dependent variables, ROA and ROE , are functions only of their own lagged values. Accordingly, assuming a two-regime transition function, the following relationships are obtained:

$$ROA_t = (\theta_0 + \theta_1 y_{t-1} + \dots + \theta_p ROA_{t-p}) + (\theta_0 + \theta_1 y_{t-1} + \dots + \theta_p ROA_{t-p}) G(R, O, A_t, \gamma c) + u_t \quad (3)$$

$$G(R, O, A_t, \gamma c) = \frac{1}{1 + \exp\{-\gamma(ROA_t - c)\}}$$

$$ROE_t = (\theta_0 + \theta_1 y_{t-1} + \dots + \theta_p ROE_{t-p}) + (\theta_0 + \theta_1 y_{t-1} + \dots + \theta_p ROE_{t-p}) G(R, O, E_t, \gamma c) + u_t \quad (4)$$

$$G(R, O, E_t, \gamma c) = \frac{1}{1 + \exp\{-\gamma(ROE_t - c)\}}$$

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

Dependent Variables:

ROA: Bank profitability, measured by dividing net income for the period by total assets.

ROE: Return on equity measures a bank's efficiency in generating net income for its shareholders. In other words, this ratio indicates the amount of net income generated by the economic entity for each unit of shareholders' investment. Accordingly, the ratio is calculated as follows:

$$ROE = \frac{NI}{WE}$$

where NI denotes net income and WE denotes shareholders' equity.

Explanatory Variables:

DIV: Income diversification. Following Lee et al. (2022), income diversification is calculated using the specified measure.

In this measure, **LOAN** denotes loans and credit facilities granted by banks; **EA** denotes the sum of bank loans and credit facilities and other earning assets; and **OEA** denotes other earning assets.

SMD: Sukuk. Guaranteed and tradable securities are used to represent this variable. Sukuk are financial instruments employed to meet the financing needs of companies and institutions by mobilizing idle funds from investors in the market. Islamic financial instruments (Sukuk) are securities of equal financial value that are tradable in financial markets and structured on the basis of contracts recognized under Islamic law. Sukuk holders jointly own, on a pro rata basis, one or more underlying assets and the benefits or returns generated by those assets.

CR: Credit risk.

LR: Liquidity risk.

CAR: Capital adequacy, defined as capital divided by total assets.

CVD: Global health crisis variable. This variable takes the value of 1 during the years of the global health crisis and 0 otherwise and is incorporated into the model as a dummy variable.

The statistical population of this study consists of banks listed on the Tehran Stock Exchange. A number of these banks are selected for the present research and examined using the Panel Smooth Transition Regression threshold model. The study period is annual and covers 2013–2023 for listed banks.

The sample selection criteria, based on the systematic elimination method, are as follows:

The bank must have been listed on the Tehran Stock Exchange before 2013.

All required information must be available.

The bank's fiscal year must end around March 20.

The bank must not have experienced an interruption in operations exceeding three months during any fiscal period.

Based on the above criteria, the banks included in the present study are Eghtesad Novin Bank, Parsian Bank, Pasargad Bank, Karafarin Bank, Saman Bank, Sina Bank, Sarmayeh Bank, Dey Bank, Bank Saderat Iran, Bank Mellat, Bank Tejarat, and Iran Zamin Bank.

In this study, the Panel Smooth Transition Regression (PSTR) approach is employed to estimate the research model.

3. Findings and Results

Before estimating the models using regression techniques and panel data, unit root tests were conducted for all variables to ensure their stationarity over the study period. In the present study, the Levin–Lin–Chu (LLC) panel unit root test was employed. The results are presented in Table 1.

Table 1. Results of the Levin–Lin–Chu Panel Unit Root Test

Variable	LLC Statistic	Probability	Order of Integration
CAR	-4.65816	0.0000	$I(0)$
CR	-6.62308	0.0000	$I(0)$
CVD	-9.57782	0.0000	$I(0)$
DIV	-4.35428	0.0000	$I(0)$
LR	-2.88350	0.0020	$I(0)$
ROA	-2.07718	0.0189	$I(0)$
ROE	-5.53993	0.0000	$I(0)$
SMD	-6.89827	0.0000	$I(0)$

The results presented in Table 1, based on the calculated LLC statistics and their corresponding probability values, indicate that all research variables are stationary at level. Thus, all variables are integrated of order zero, $I(0)$, and no further differencing is required before model estimation.

Most economic theories express long-run relationships among variables in level form. To establish the existence of a long-run relationship among the variables included in a model, the variables should either be stationary or, if nonstationary, integrated of the same order. Accordingly, stationarity and cointegration tests are commonly employed to determine whether a stable long-run relationship exists among the variables. If the residuals obtained from the estimated regressions are $I(0)$, or stationary, the existence of a long-run equilibrium relationship among the variables can be inferred. In the present study, the Kao panel cointegration test was employed to examine the existence of long-run equilibrium relationships.

Table 2. Results of the Kao Panel Cointegration Test

Model	Dependent Variable	Test Statistic	ADF Statistic	Probability
Model 1	ROA	Kao test	-3.135407	0.0009
Model 2	ROE	Kao test	-7.254526	0.0000

As shown in Table 2, the Kao panel cointegration test confirms the existence of cointegration among the variables in both estimated models. The hypotheses of the cointegration test are defined as follows:

H_0 : No cointegration exists among the variables

H_1 : Cointegration exists among the variables

Because the probability values for both models are below 0.05, the null hypothesis of no cointegration is rejected. Therefore, the variables are cointegrated in the long run, confirming the existence of stable long-run relationships among them in both the ROA and ROE models.

To determine whether the relationship among the model variables is linear or nonlinear, the number of regime parameters, m , must be examined. In the tests conducted, the null hypothesis assumes a linear specification, whereas the alternative hypothesis corresponds to either a logistic PSTR model with $m = 1$ or an exponential PSTR model with $m = 2$. The diagnostic results indicate that the null hypothesis of linearity is rejected. Consequently, a nonlinear relationship exists among income diversification, Sukuk, banking risks, and bank performance in the selected banks, and the PSTR approach is therefore appropriate for estimating the model.

For the ROA model, the Wald test yielded an F -statistic of 3.951 with a probability value of 0.000; the Fisher test produced an F -statistic of 3.739 with a probability value of 0.003; and the likelihood-ratio test yielded a statistic of 3.893 with a probability value of 0.001. For the ROE model, the corresponding statistics were 5.236 ($p = 0.000$), 4.598 ($p = 0.000$), and 4.789 ($p = 0.000$), respectively.

Table 3. Results of the Linearity Hypothesis Tests for the ROA and ROE Models

Model	Test	F -Statistic	p -Value	Decision
ROA	Wald	3.951	0.000	Reject linearity
ROA	Fisher	3.739	0.003	Reject linearity
ROA	LRT	3.893	0.001	Reject linearity
ROE	Wald	5.236	0.000	Reject linearity
ROE	Fisher	4.598	0.000	Reject linearity
ROE	LRT	4.789	0.000	Reject linearity

The results confirm that the hypothesis of a linear relationship among the variables must be rejected for both models. Accordingly, the probability of a purely linear relationship among income diversification, Sukuk, banking risks, and bank performance is ruled out, and the PSTR specification based on the selected transition variable is adopted as the appropriate framework for estimating the models.

Following González et al. (2005) and Colletaz and Hurlin (2006), the null hypothesis of a PSTR model with one transition function was tested against the alternative hypothesis of a PSTR model containing at least two transition functions. The results show that the null hypothesis regarding the adequacy of a single transition function cannot be rejected for either the one-threshold or two-threshold specification. Therefore, a single transition function is sufficient to represent the nonlinear relationship among income diversification, Sukuk, banking risks, and bank performance in the selected banks.

Table 4. Residual Nonlinearity Tests for the ROA and ROE Models

Model	Threshold Specification	LM_W	LM_F	LR
ROA	$m = 1$	1.369 (0.745)	1.478 (0.632)	1.439 (0.652)
ROA	$m = 2$	1.423 (0.678)	1.367 (0.756)	1.298 (0.8123)
ROE	$m = 1$	1.012 (0.687)	1.116 (0.612)	1.236 (0.542)
ROE	$m = 2$	1.258 (0.521)	1.239 (0.532)	1.425 (0.489)

Note. $H_0: r = 1$; $H_1: r = 2$. Probability values are reported in parentheses.

After confirming the nonlinear relationship among the variables and establishing that one transition function is sufficient to represent the nonlinear behavior, the optimal specification between a transition function with one threshold and one with two thresholds was determined. For this purpose, the corresponding PSTR models were estimated and compared using the residual sum of squares, Schwarz information criterion, and Akaike information criterion. Based on these criteria, the PSTR specification with one threshold was identified as the optimal model. Therefore, a PSTR model with one transition function and one threshold was selected to examine the nonlinear behavior of the variables.

Using a PSTR model in which income diversification serves as the transition variable, the bank performance function measured by return on assets (*ROA*) was estimated. The results for the linear component of the model, representing the first regime, indicate that the global health crisis, liquidity risk, and credit risk exert negative effects on bank performance. The nonlinear component, representing the second regime, indicates significant effects of Sukuk, income diversification, and capital adequacy on bank performance.

Table 5. PSTR Estimation Results for the ROA Model

Regime	Variable	Coefficient	Standard Error	<i>t</i> -Statistic	<i>p</i> -Value
Linear	Constant	0.666277	0.201960	3.299048	0.0010
Linear	SMD	0.134493	0.080284	1.675214	0.0943
Linear	DIV	0.095415	0.057963	1.646151	0.1001
Linear	CVD	-0.109331	0.050050	-2.184460	0.0292
Linear	LR	-0.046318	0.019267	-2.404060	0.0164
Linear	CR	-0.048372	0.017549	-2.756488	0.0060
Linear	CAR	0.014838	0.006607	2.245690	0.0255
Nonlinear	Constant	0.424104	0.162874	2.603876	0.0094
Nonlinear	SMD	0.188902	0.088416	2.136508	0.0329
Nonlinear	DIV	0.204708	0.076651	2.670643	0.0077
Nonlinear	CVD	-0.489045	0.194501	-2.514356	0.0121
Nonlinear	LR	-0.543096	0.219393	-2.475447	0.0135
Nonlinear	CR	-0.207265	0.071960	-2.880267	0.0041
Nonlinear	CAR	0.214652	0.095978	2.236478	0.0256
Transition parameter	Threshold <i>c</i>	0.964102	0.158623	6.077495	0.0000
Transition parameter	Slope <i>γ</i>	6.675325	2.934622	2.274678	0.0284

$$\bar{R}^2 = 0.84$$

In the linear regime, the coefficient of Sukuk is positive ($\beta = 0.134493$), although its effect is not statistically significant at the 5% level ($p = 0.0943$). Income diversification likewise has a positive coefficient ($\beta = 0.095415$), but its effect is not statistically significant at the conventional 5% level ($p = 0.1001$). By contrast, the global health crisis has a negative and significant effect on ROA ($\beta = -0.109331$ $p = 0.0292$). Liquidity risk also negatively affects ROA ($\beta = -0.046318$ $p = 0.0164$), while credit risk produces a negative and statistically significant effect ($\beta = -0.048372$ $p = 0.0060$). Capital adequacy positively and significantly affects ROA ($\beta = 0.014838$ $p = 0.0255$).

In the nonlinear regime, Sukuk exerts a positive and statistically significant effect on ROA ($\beta = 0.188902$ $p = 0.0329$). Income diversification also has a positive and significant effect ($\beta = 0.204708$ $p = 0.0077$). The global health crisis is associated with a substantial negative effect

($\beta_1 = -0.489045$ $p = 0.0121$), while liquidity risk ($\beta_2 = -0.543096$ $p = 0.0135$) and credit risk ($\beta_3 = -0.207265$ $p = 0.0041$) also exert statistically significant negative effects. Capital adequacy has a positive and significant effect on bank profitability in this regime ($\beta_4 = 0.214652$ $p = 0.0256$).

Comparison of the coefficients across the two regimes is based on the transition variable and its observed values, because the value of the transition variable determines the transition function and consequently the prevailing regime. In the estimated ROA model, income diversification is the transition variable, and its estimated threshold value is $c = 0.964102$. Depending on the position of income diversification relative to this threshold, the model follows two distinct limiting regimes. Comparison of the coefficients indicates that once income diversification exceeds the threshold value of 0.964102, corresponding to transition from the linear to the nonlinear regime, the responsiveness of bank profitability to income diversification increases markedly. This suggests that banking policymakers responded more strongly to changes in income diversification in an effort to improve profitability and prevent its deterioration.

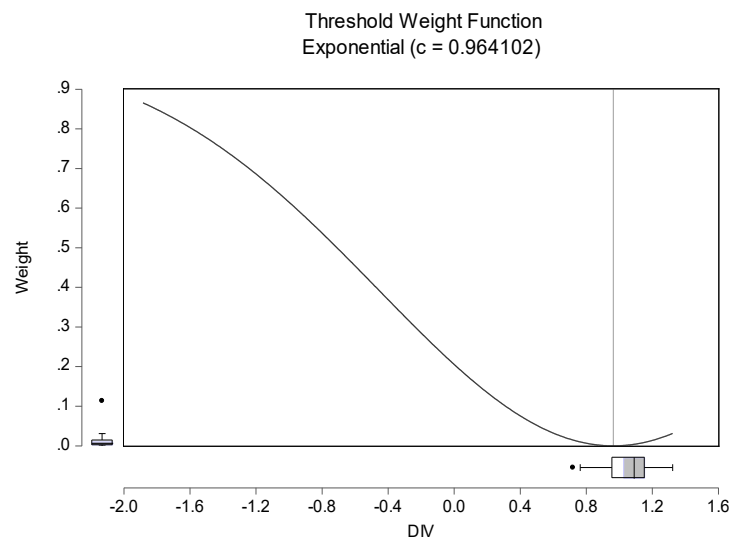


Figure 1. Relationship Between the Transition Function and the Income Diversification Transition Variable

The Durbin–Watson test was used to examine serial correlation. The test produced an F -statistic of 1.458, a probability value of 0.48, and a Durbin–Watson statistic of 2.398. These results indicate that there is no significant autocorrelation among the disturbance terms. Therefore, the classical assumption of no serial correlation among the error terms is not violated, and the estimators retain the required properties of minimum variance and efficiency.

The homoskedasticity assumption was also examined using the Breusch–Pagan–Godfrey test. The test yielded an F -statistic of 0.698, a probability value of 0.812, and a Breusch–Pagan–Godfrey statistic of 1.139. These results indicate the absence of statistically significant heteroskedasticity.

Another criterion for evaluating the adequacy of the estimated model is the stability of the coefficients across the two regimes. If the estimated model provides an appropriate specification, the coefficients are expected to remain stable as the model transitions from one regime to another.

For the smooth-transition parameter stability test, the null hypothesis $b_1 = b_2 = b_3 = b_4 = 0$ generated an F -statistic of 1.236 with $p = 0.653$; the hypothesis $b_1 = b_2 = b_3 = 0$ generated an F -statistic of 1.326 with $p = 0.574$; the hypothesis $b_1 = b_2 = 0$ produced an F -statistic of 1.348 with $p = 0.512$; and the hypothesis $b_1 = 0$ produced an F -statistic of 1.487 with $p = 0.456$. None of these null hypotheses is rejected, indicating that the model coefficients remain stable across the regimes.

To determine whether the relationships among the variables in the ROE model are linear or nonlinear, the same procedure was applied. The null hypothesis assumes a linear model, whereas the alternative hypothesis corresponds to either a logistic PSTR model with $m = 1$ or an exponential PSTR specification with $m = 2$. As reported in Table 3, the Wald, Fisher, and LRT statistics for the ROE model are all statistically significant at $p < 0.001$. Therefore, the hypothesis of linearity is rejected, confirming a nonlinear relationship among income diversification, Sukuk, banking risks, and bank performance.

The selected PSTR specification based on the transition variable was therefore considered the appropriate model for estimation. Following González et al. (2005) and Colletaz and Hurlin (2006), the null hypothesis of a PSTR specification with one transition function was tested against the alternative of a model containing at least two transition functions. As reported in Table 4, the null hypothesis regarding the sufficiency of one transition function cannot be rejected for either the one-threshold or two-threshold specification. Accordingly, one transition function is sufficient to characterize the nonlinear behavior of income diversification, Sukuk, banking risks, and bank performance.

After establishing nonlinearity and confirming the adequacy of one transition function, the optimal number of thresholds was selected by estimating competing PSTR specifications and comparing their residual sum of squares, Schwarz information criterion, and Akaike information criterion. The results supported the PSTR model with one threshold as the optimal specification. Consequently, a PSTR model incorporating one transition function and one threshold was selected for the ROE analysis.

Using a PSTR model in which income diversification serves as the transition variable, bank performance measured by return on equity (ROE) was modeled. The results for the nonlinear component of the model, corresponding to the second regime, indicate that Sukuk, income diversification, and the capital adequacy ratio have positive and statistically significant effects on bank performance. Conversely, the global health crisis, liquidity risk, and credit risk negatively affect bank performance and contribute to a decline in the performance of the selected banks.

Table 6. PSTR Estimation Results for the ROE Model

Regime	Variable	Coefficient	Standard Error	t-Statistic	p-Value
Linear	Constant	0.289564	0.208206	1.390754	0.1664
Linear	SMD	0.139694	0.048299	2.892296	0.0038
Linear	DIV	0.035862	0.014372	2.495362	0.0129
Linear	CVD	-0.023619	0.051341	-0.460055	0.6460
Linear	LR	-0.091310	0.053985	-1.691467	0.0923
Linear	CR	-0.071610	0.029185	-2.453670	0.0147
Linear	CAR	0.023577	0.011754	2.005899	0.0464
Nonlinear	Constant	0.533757	0.307849	1.733825	0.0829
Nonlinear	SMD	0.144645	0.037615	3.845384	0.0002
Nonlinear	DIV	0.265475	0.078286	3.391090	0.0008
Nonlinear	CVD	-0.973491	0.397276	-2.450409	0.0152
Nonlinear	LR	-0.134509	0.025286	-5.319560	0.0000
Nonlinear	CR	-0.104390	0.041223	-2.532328	0.0121
Nonlinear	CAR	0.177326	0.070478	2.516070	0.0126
Transition parameter	Threshold c	-0.211146	0.023650	-8.927949	0.0000
Transition parameter	Slope γ	3.620499	0.723642	5.003163	0.0000

$$\bar{R}^2 = 0.82$$

In the linear regime, Sukuk has a positive and statistically significant effect on ROE ($\beta = 0.139694$ $p = 0.0038$), and income diversification also positively and significantly affects ROE ($\beta = 0.035862$ $p = 0.0129$). The coefficient of the global health crisis is negative but statistically insignificant ($\beta = -0.023619$ $p = 0.6460$). Liquidity risk is negative but does not reach statistical significance at the 5% level ($\beta = -0.091310$ $p = 0.0923$). Credit risk has a negative and significant effect ($\beta = -0.071610$ $p = 0.0147$), whereas capital adequacy has a positive and statistically significant effect ($\beta = 0.023577$ $p = 0.0464$).

In the nonlinear regime, Sukuk positively and significantly affects ROE ($\beta = 0.144645$ $p = 0.0002$). Income diversification has a considerably larger positive and statistically significant coefficient ($\beta = 0.265475$ $p = 0.0008$). The global health crisis negatively and significantly affects ROE ($\beta = -0.973491$ $p = 0.0152$). Similarly, liquidity risk ($\beta = -0.134509$ $p < 0.001$) and credit risk ($\beta = -0.104390$ $p = 0.0121$) exert statistically significant negative effects. Capital adequacy has a positive and significant influence on ROE ($\beta = 0.177326$ $p = 0.0126$).

The estimated threshold value for the income diversification transition variable in the ROE model is $c = -0.211146$. Depending on the distance of bank efficiency from this estimated threshold, the model operates under two limiting regimes. Comparison of the coefficients demonstrates that when income diversification crosses the threshold of -0.211146 , corresponding to transition from the linear to the nonlinear regime, the responsiveness of bank efficiency to income diversification rises substantially. Accordingly, banking policymakers appear to have responded more strongly to changes in income diversification in an effort to improve profitability and prevent deterioration in bank performance.

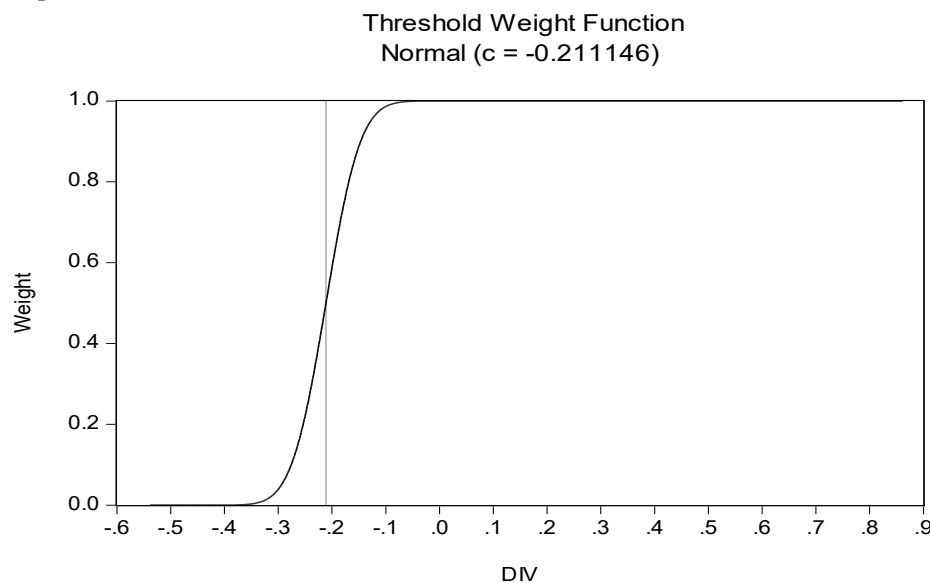


Figure 2. Relationship Between the Transition Function and the Income Diversification Transition Variable

The Durbin–Watson test was employed to assess serial correlation in the ROE model. The F -statistic was 1.458, with a probability value of 0.48, while the Durbin–Watson statistic was 2.398. These findings indicate no significant correlation among the disturbance terms. Therefore, the classical assumption of no autocorrelation among the residuals is satisfied, and the estimators retain the desirable properties of efficiency and minimum variance.

The homoskedasticity assumption was evaluated using the Breusch–Pagan–Godfrey test. The resulting F -statistic was 0.698, with $p = 0.812$, while the Breusch–Pagan–Godfrey statistic was 1.139. Thus, the null hypothesis of homoskedasticity cannot be rejected, indicating that heteroskedasticity is not present.

Table 7. Diagnostic Test Results for the ROA and ROE Models

Diagnostic Test	Statistic	Value	Probability	Result
Serial correlation	<i>F</i> -statistic	1.458	0.480	No serial correlation
Serial correlation	Durbin–Watson	2.398	—	No evidence of problematic autocorrelation
Heteroskedasticity	<i>F</i> -statistic	0.698	0.812	No heteroskedasticity
Heteroskedasticity	Breusch–Pagan–Godfrey statistic	1.139	—	Homoskedasticity supported

Coefficient stability across regimes was also examined for the ROE specification. This test evaluates whether the estimated parameters remain stable as the process shifts between the two regimes. Failure to reject the corresponding null hypotheses indicates that the coefficients do not undergo statistically significant changes as a consequence of regime transition.

Table 8. Smooth-Transition Parameter Stability Test

Null Hypothesis	<i>F</i> -Statistic	Probability
$b_1 = b_2 = b_3 = b_4 = 0$	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

As shown in Table 8, all probability values exceed 0.05. Therefore, the relevant null hypotheses cannot be rejected. The coefficient-stability test consequently indicates that the estimated coefficients remain stable across the two regimes and do not change significantly as a result of regime switching.

4. Discussion and Conclusion

The present study examined the threshold effects of income diversification, Sukuk, banking risks, capital adequacy, and the global health crisis on the performance of banks listed on the Tehran Stock Exchange by employing a Panel Smooth Transition Regression (PSTR) framework. Bank performance was assessed through both return on assets (ROA) and return on equity (ROE), while income diversification was specified as the transition variable. The preliminary econometric tests confirmed that all study variables were stationary at level, and the Kao cointegration tests indicated the existence of statistically significant long-run relationships among the variables in both models. The linearity tests further rejected the null hypothesis of a linear specification for both ROA and ROE, thereby validating the use of a nonlinear PSTR model. In addition, the residual nonlinearity tests showed that a single transition function was sufficient, and the information criteria favored a one-threshold specification. These findings indicate that the relationship between income diversification, Sukuk, banking risks, and banking performance is not constant across all levels of diversification and that the behavior of the selected banks changes after the diversification variable crosses an estimated threshold.

The results of the ROA model showed that, in the first or linear regime, the global health crisis, liquidity risk, and credit risk had negative and statistically significant effects on bank profitability, whereas capital adequacy exerted a positive and significant effect. Sukuk and income diversification also had positive coefficients in this regime, although their effects were not statistically significant at the conventional 5% level. After transition to the second regime, however, Sukuk and income diversification became positive and statistically significant determinants of ROA, while capital adequacy remained positively associated with profitability. At the same time, the negative effects of the global health crisis, liquidity risk, and credit risk became considerably stronger. This

pattern suggests that once the level of income diversification exceeds the estimated threshold of 0.964102, the marginal contribution of diversified revenue sources and Sukuk-related activities to asset-based profitability increases markedly. The nonlinear results therefore imply that diversification may initially provide only limited profitability benefits, but once a sufficiently developed diversification structure is achieved, its contribution to bank performance becomes more pronounced.

The positive effect of income diversification in the nonlinear regime is consistent with the argument that diversification can reduce excessive dependence on traditional lending activities and broaden the revenue base of banks. When banks generate income from a wider range of activities, including securities, fee-based services, investment operations, and Islamic financial instruments, temporary weakness in one line of business can potentially be compensated for by stronger performance in another. This interpretation is broadly consistent with the findings of Azmi et al., who emphasized that diversification interacts with banking stability and competitive conditions and that its effect cannot necessarily be represented by a simple homogeneous relationship [1]. The present results extend this reasoning by demonstrating that diversification itself can operate as a threshold variable. At lower levels, the costs of developing new revenue sources, organizational complexity, and unfamiliar risk exposures may partially offset the benefits of diversification. Beyond the threshold, however, the diversified revenue structure appears to become sufficiently developed to improve the capacity of banks to generate returns from their asset base.

The positive and statistically significant effect of Sukuk on ROA in the second regime is also economically meaningful. Sukuk can provide banks with alternative investment opportunities, additional sources of income, and instruments for managing liquidity and balance-sheet composition. This finding is consistent with evidence showing that Sukuk issuance can influence the liquidity, profitability, and asset quality of Islamic banks [8]. The result is also aligned with research indicating that investment in Sukuk can improve the financial performance of Islamic banking institutions [9]. Furthermore, Samadi et al. reported that the development of Sukuk markets is associated with changes in bank profitability, although the magnitude of the effect can differ between Islamic and conventional banking structures [10]. The stronger Sukuk effect after the income-diversification threshold is crossed may therefore indicate that Sukuk becomes more effective when it is embedded within a broader and more diversified financial strategy rather than being used as an isolated financing or investment instrument.

The positive role of Sukuk is further supported by the wider Islamic-finance literature. Naeimi et al. emphasized the reciprocal relationship between the development of Islamic financial instruments, particularly Sukuk, and economic growth, suggesting that well-developed Sukuk markets can support capital formation and resource allocation [5]. Anwar et al. likewise showed that Islamic banking can contribute to economic growth through financing channels that connect banking activities to the real economy [6]. Bougatef et al. also documented a relationship between Islamic banking development and industrial production, reinforcing the view that Islamic financial intermediation can influence real-sector performance [7]. From this perspective, the positive Sukuk coefficient obtained in the present study may reflect not only direct financial returns but also the broader role of Sukuk in enhancing the efficiency of financial intermediation, diversifying investment portfolios, and linking bank resources with productive economic activities.

The positive and significant effect of capital adequacy on ROA in both regimes indicates that better-capitalized banks are more capable of supporting stable profitability. A higher capital base strengthens loss-absorption capacity, improves resilience to shocks, and can reduce the financial consequences of deterioration in asset quality. This result is consistent with Baldwin et al., who showed that capital adequacy in Islamic banks is shaped by a

complex interaction of financial and institutional factors and plays an important role in maintaining balance-sheet stability [3]. It is also compatible with Bitar and Tarazi, who demonstrated that bank capital decisions differ across conventional and Islamic banking structures and are influenced by the broader institutional environment [2]. In the present study, the fact that the capital adequacy coefficient becomes substantially larger in the nonlinear regime suggests that stronger capitalization becomes particularly valuable once banks expand their income sources and potentially engage in more complex financial activities.

The negative effect of credit risk on ROA in both regimes is consistent with theoretical expectations. Higher credit risk increases the probability of default, raises loan-loss provisions, reduces expected cash flows, and weakens the quality of bank assets. As credit risk increases, a larger share of bank resources must be allocated to risk absorption rather than income generation. The stronger negative coefficient observed in the nonlinear regime indicates that the adverse effect of credit deterioration can intensify when banks operate in a more diversified environment. One possible explanation is that diversification may expand the scope of activities without eliminating the central role of credit exposures, meaning that high credit risk can still erode the benefits generated by other business lines. The importance of effective risk-management practices for the financial performance of Iranian listed banks has also been emphasized by Razmjooei and Adami Fard, who highlighted the mediating role of risk-management practices in bank performance [18]. The present findings similarly suggest that diversification alone cannot compensate for weak credit-risk management.

Liquidity risk was also negatively related to ROA, with the magnitude of its coefficient increasing substantially in the nonlinear regime. This finding indicates that insufficient liquidity can severely constrain banks' ability to convert diversification opportunities into sustainable profitability. Banks facing liquidity pressure may be forced to liquidate assets, reduce lending, obtain expensive short-term funding, or forgo profitable investment opportunities. These consequences can offset the financial advantages of Sukuk and diversified income streams. The findings are consistent with the growing literature emphasizing the importance of multidimensional risk assessment in banking. Bringas-Fernández et al., although focusing on climate-related risks, showed that contemporary banking risk increasingly involves interconnected external and internal sources of vulnerability that can affect liquidity, asset quality, and overall stability [20]. The present results similarly indicate that liquidity risk should be viewed not as an isolated balance-sheet indicator but as a factor capable of changing the effectiveness of broader profitability strategies.

The global health crisis had a negative and statistically significant effect on ROA in both regimes, with the adverse effect becoming much larger after transition to the nonlinear regime. This result is consistent with the disruptive nature of the pandemic period, during which banks faced weaker borrower repayment capacity, economic contraction, changes in customer behavior, increased uncertainty, and operational disruptions. The amplified negative coefficient in the second regime may indicate that banks with more diversified activities were also exposed to a wider range of market and operational channels through which the crisis affected performance. Chandler argued that the post-pandemic environment required organizations to reconsider conventional expectations regarding management, leadership, and organizational adaptation because disruption affected both operational structures and managerial decision-making [21]. In banking, these pressures may have been reflected in greater funding uncertainty, deterioration in loan portfolios, and reduced profitability across different lines of business.

The ROE model produced results broadly consistent with the ROA model but also revealed several important differences. In the linear regime, Sukuk, income diversification, and capital adequacy had positive and statistically

significant effects on ROE, while credit risk exerted a negative and significant effect. The global health crisis and liquidity risk were negative but statistically insignificant at the 5% level. In the nonlinear regime, however, Sukuk, income diversification, and capital adequacy remained positive and significant, whereas the global health crisis, liquidity risk, and credit risk all became negative and statistically significant. These findings show that the transition toward a more diversified income structure does not merely affect asset-based profitability but also changes the sensitivity of shareholder returns to financial risks and financing instruments.

The most notable result in the ROE model is the substantial increase in the coefficient of income diversification from 0.035862 in the linear regime to 0.265475 in the nonlinear regime. This sharp increase indicates that the benefits of diversification for shareholder returns become much stronger after crossing the estimated threshold of -0.211146 . The result again supports a nonlinear interpretation of diversification. Before the threshold is crossed, diversification may generate only incremental gains because traditional banking income remains dominant. Once diversification reaches a more developed stage, however, additional revenue channels can make a much greater contribution to equity-based profitability. This finding aligns with the evidence of Azmi et al. that diversification, competition, and stability are intricately connected within dual banking economies [1]. The present results add to this literature by identifying a specific regime-dependent pattern in which diversification becomes much more strongly associated with performance beyond a threshold.

The positive Sukuk coefficient in both ROE regimes further indicates that Sukuk can contribute directly to shareholder profitability. Baghfalaki and Moradi examined the relationship between Sukuk issuance, financing costs, and abnormal returns, emphasizing that Sukuk can influence financial performance through both financing and market-valuation channels [11]. Hassan et al. likewise demonstrated that Sukuk issuance can affect profitability while simultaneously influencing liquidity and asset quality [8]. In addition, the increasing diversity of Sukuk structures discussed by Kang et al. suggests that Islamic-finance principles can be adapted to a wide range of financing arrangements, thereby expanding the strategic role of Sukuk beyond conventional debt substitution [12]. The current findings are therefore consistent with the view that Sukuk can become an important element of bank profitability when integrated into a diversified financial structure.

At the same time, the effective use of Sukuk depends on governance and Shariah-compliance mechanisms. Darwanto and Chariri emphasized the importance of corporate governance and Shariah supervisory boards in explaining the financial performance of Islamic banks [14]. Basiruddin and Ahmed similarly showed that governance mechanisms influence the management of Shariah noncompliance risk [15], while Isa et al. highlighted the importance of effective Shariah audit practices for improving accountability and compliance within Islamic financial institutions [16]. Bhatti also emphasized that Shariah noncompliance can generate financial and institutional risks that require appropriate dispute-resolution and governance mechanisms [17]. These studies suggest that the positive effects of Sukuk observed in the present analysis should not be interpreted as automatic consequences of issuing or holding Islamic securities. Rather, such benefits are likely to depend on the quality of governance, risk controls, Shariah oversight, and the broader institutional capacity of banks to manage Islamic financial instruments.

The negative and significant coefficients of credit and liquidity risk in the nonlinear ROE regime reinforce the importance of risk management for shareholder returns. High credit risk reduces distributable earnings through expected and realized losses, while liquidity shortages can increase funding costs and restrict profitable investment activities. When combined with diversified financial operations, these risks may become even more consequential because banks simultaneously manage larger and more heterogeneous portfolios. The result is consistent with

Golestani's emphasis on the importance of Islamic banking soundness in limiting the contagion of financial crises [19]. It also supports the argument that risk management is a central mechanism linking financial decisions to banking outcomes [18]. Thus, the beneficial effects of diversification and Sukuk should be considered conditional on adequate risk-control capacity rather than as substitutes for prudent credit and liquidity management.

The positive coefficient of capital adequacy in the ROE model indicates that a stronger capital position is also beneficial for shareholder performance. Although higher capital ratios can theoretically reduce leverage and thereby constrain ROE, sufficient capitalization may improve confidence, reduce financial distress costs, support expansion into diversified activities, and enhance the ability of banks to withstand losses. The observed positive relationship suggests that, in the studied banks, the stabilizing benefits of stronger capitalization outweigh potential reductions in leverage-based returns. This result is consistent with the emphasis placed by Baldwin et al. on the structural determinants of capital adequacy in Islamic banks [3] and with the evidence provided by Bitar and Tarazi regarding the importance of institutional and creditor-related factors in bank capital decisions [2].

Another important aspect of the findings is that the estimated models passed the main diagnostic tests. The Durbin-Watson results indicated no problematic autocorrelation, while the Breusch-Pagan-Godfrey results showed no evidence of heteroskedasticity. In addition, the tests of parameter stability indicated that the coefficients remained stable across the two regimes. These results strengthen confidence in the estimated nonlinear relationships. From a methodological perspective, the use of panel data is also advantageous because it combines interbank and intertemporal variation, although such models require attention to endogeneity and dynamic relationships. Barros et al. emphasized the importance of careful treatment of endogeneity in panel-data corporate-finance research [22]. The PSTR framework employed in the present study contributes to this methodological objective by allowing coefficients to vary smoothly across regimes rather than imposing a restrictive constant-effect assumption.

Overall, the findings demonstrate that income diversification performs a central threshold function in explaining bank performance. Below the estimated threshold, some positive effects of Sukuk and diversification are either weaker or statistically insignificant; beyond the threshold, their profitability effects become stronger. At the same time, the negative effects of credit risk, liquidity risk, and the global health crisis also intensify in the nonlinear regime. This means that diversification is not inherently protective. Rather, it changes the structure of banking performance in such a way that both opportunities and vulnerabilities become more pronounced. The results therefore support an integrated interpretation in which Sukuk, capital adequacy, diversification, and risk management jointly determine banking outcomes. The increasing sophistication of Islamic financing instruments, including socially oriented structures such as cash waqf-linked Sukuk, further reinforces the importance of institutional capacity and strategic integration when such instruments are used to enhance financial performance [13]. Accordingly, banks seeking to benefit from diversification and Sukuk must simultaneously maintain adequate capital, strengthen liquidity buffers, control credit exposures, and develop governance structures capable of managing more complex financial portfolios.

The present study is subject to several limitations. First, the empirical analysis was restricted to selected banks listed on the Tehran Stock Exchange, and therefore the findings may not be directly generalizable to unlisted banks, specialized credit institutions, or banking systems operating under different regulatory and macroeconomic conditions. Second, the study employed annual data, which may conceal short-term fluctuations and rapid changes in liquidity, credit quality, and profitability that occur within a fiscal year. Third, bank performance was measured only through ROA and ROE, while other dimensions such as net interest margin, cost efficiency, nonperforming

loan ratios, market valuation, and risk-adjusted performance were not incorporated. Fourth, the global health crisis was represented by a dummy variable, which captures the occurrence of the crisis but not differences in its intensity across years or institutions. Fifth, although the PSTR approach captures regime-dependent nonlinearities, the estimated relationships may still be influenced by omitted macroeconomic, regulatory, governance, or bank-specific variables not included in the model.

Future studies are recommended to extend the analysis by incorporating a broader sample of banks and financial institutions and by comparing listed and unlisted banks or Islamic and conventional banking systems. Researchers may also employ quarterly or monthly data to capture shorter-term adjustments in liquidity, profitability, and credit risk. Future research could consider alternative performance indicators, including cost efficiency, net interest margin, nonperforming loans, market-based performance, and risk-adjusted returns. It would also be useful to replace the simple crisis dummy with more detailed indicators of systemic stress, such as economic contraction, market volatility, loan moratorium intensity, or changes in monetary and fiscal support. Comparative studies across countries could assess whether the estimated diversification thresholds differ according to regulatory frameworks and financial-market development. Further research may also examine multiple transition variables, dynamic PSTR specifications, interaction effects between Sukuk and capital adequacy, and possible asymmetric effects of increases and decreases in income diversification.

Bank managers and policymakers should treat income diversification as a strategic process whose benefits may depend on reaching an economically meaningful scale rather than merely increasing the number of revenue sources. Banks should develop diversified income activities gradually and in coordination with their risk-management capacity, capital position, and liquidity structure. Sukuk can be incorporated more systematically into asset management, financing, and investment strategies, particularly when banks possess sufficient governance, analytical, and Shariah-compliance capabilities. Credit-risk controls should be strengthened through more rigorous borrower screening, continuous portfolio monitoring, and early-warning systems, while liquidity management should include adequate buffers and contingency funding arrangements. Regulators should also monitor the interaction between diversification and risk, because the findings indicate that both positive and negative performance effects can intensify after the threshold is crossed. Finally, maintaining adequate capital should remain a central policy priority because stronger capitalization can support profitability while improving the resilience of banks during systemic disruptions.

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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