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Business Complexity and Risk in Banks: A Static and Dynamic Analysis in an Emerging Economy

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ABSTRACT

This study investigates how multiple facets of corporate complexity influence risk exposure in the Iranian banking sector, using a panel data sample from 21 banks spanning the years 2009 through 2022. Complexity is assessed through two key metrics: non-core assets (nonbank assets) and revenue generated from non-interest activities. Findings from the static model suggest that a greater proportion of non-core assets correlates with lower levels of bank risk. In contrast, non-interest revenue exhibited no meaningful relationship with risk. Additional tests determined that the risk mitigation observed from non-core assets does not operate via increased non-interest income, leading to a rejection of the hypothesized mediating effect. Additionally, it was discovered that bank size, which was included as a moderator, had no discernible impact on this association. In contrast, a dynamic assessment using the System GMM approach produced conflicting results. The key discovery here is proof that bank risk has inherent persistence. Once dynamic variables were properly controlled, the impact of non-core assets on risk was statistically insignificant. This finding shows that the complexity-risk link is less direct than static techniques suggest, as long-run risk features tend to outweigh the effect of specific components. The study improves understanding of the complexity-risk nexus by presenting empirical data from a rising market and emphasizes the importance of using dynamic methodological frameworks in future research.

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1. Introduction

Banks' transition from their traditional roles has led to the diversification of their activities. Changes in business models, expansion of geographical scope, establishment of ownership links, exposure to modern technologies, and heightened competition have created challenges, resulting in an increase in their size and complexity. This complexity introduces a balancing challenge for risk management: on the one hand, diversification benefits, which may arise from various income sources and the deco-movement of macroeconomic shocks (Ho et al., 2023), can contribute to stability (Cetorelli and Goldberg, 2016). However, we must balance these benefits against agency frictions and supervisory costs that arise from distinct legal entities and complex internal organizations. Higher risk-taking tendencies in banks have been attributed to complexity, which often intensifies agency conflicts (Correa and Goldberg, 2022), which is coupled with the loss of effective control over all organizational units (Acharya et al., 2006). This increases the risk of a bank failure that could affect the entire financial system (systemic risk) (Luciano and Wihlborg, 2018; Bonfim and Félix, 2022; and Correa and Goldberg, 2022). One of the key factors influencing this process is the role of regulatory constraints and requirements (Correa and Goldberg, 2020). The purpose of these regulations is to protect deposit-taking institutions from potential problems arising in affiliated companies.
An accurate assessment of complexity and risk is imperative, given that a robust and stable banking infrastructure is fundamental to achieving sustained economic development, a point highlighted by the Basel principles (2013). This paper investigates the role of business complexity dimensions (diversification of activities and income sources) on risk within the Iranian banking group. By expanding the conceptual scope of complexity, this study provides the first multidimensional analysis in the Iranian banking system. In addition to the diversification of income sources (non-interest income), it focuses on the diversification of asset structure (investment in nonbank assets) as a deeper and more capital-intensive dimension of complexity.

Initial results derived from this research highlight the multidimensional nature of the relationship between corporate complexity and bank risk. Specifically, a key finding is that decreased holdings of non-core assets (nonbank assets) correlate with an escalation in the risk profile of banks. This means that as a banking organization diversifies into different activities and invests a greater share of its resources in the nonbank asset sector, it achieves better risk management against the risks it faces, or in other words, it becomes more resilient to risks. On the other hand, examining banks' business complexity through income source diversification (non-interest income ratio) reveals no effect on bank risk. Conversely, the variability of bank risk is not dependent on their income sources. This result is in full alignment with the evidence provided by Kamalian et al. (2021). Beyond this, the results of advanced analyses revealed new layers of this complex relationship. While previous studies have generally focused on static analysis, this research makes a serious attempt to accurately control for bank risk autocorrelation and endogeneity of variables by employing the System GMM model. Initially, mediation and moderation tests showed that the risk-reducing effect of nonbank assets is not transmitted through an increase in non-interest income, and this relationship is not influenced by bank size. More importantly, however, dynamic analysis using the GMM model indicated that static model results are essentially a statistical illusion arising from the lack of dynamic control, and the impact of nonbank assets on risk becomes statistically insignificant. Consequently, previous findings lose their validity in the long-term context. This discovery goes beyond measuring a relationship; it challenges the methodological validity of the initial static findings of the research. This suggests that the relationship between activity diversification and risk may not be as simple as it appears, and the influence of a single variable in a complex banking system may be obscured by long-term risk dynamics. These results remained robust even after robustness checks and underscore the necessity of using advanced models to achieve a more accurate understanding of risk dynamics.

This study expands the existing literature concerning bank complexity and risk, a domain characterized by conflicting theoretical and empirical findings regarding the link between these two variables. The subsequent sections of this document are logically arranged. Section 2 explores the diverse scholarly works on complexity and risk, which culminates in the formulation of the hypotheses. Section 3 then provides a comprehensive description of the data sources, sample, and variables utilized. The methodological framework is presented in Section 4. Following this, Section 5 offers an in-depth discussion of the empirical results, and Section 6 provides the concluding remarks.

2. Literature Review

The concept of bank complexity is a pivotal topic in the financial literature, possessing multiple dimensions. This research primarily concentrates on two central elements: non-core assets and revenue derived from non-interest activities. Although a wealth of research has been conducted, the evidence regarding the complexity-risk linkage within the banking sector is frequently contradictory and lacks clarity, stemming from divergent theoretical viewpoints and varied methodological approaches. Driven by these existing inconsistencies, this paper proposes the subsequent hypotheses for investigation within the specific context of Iran's developing economy. The body of theoretical work on the direct relationship between complexity and risk is organized around two key assertions. To begin, the Diversification Theory, often known as the Portfolio Hypothesis, proposes that increasing economic complexity by diversifying revenue streams reduces overall risk. This happens because non-interest income frequently has no association with typical lending income. This notion is supported by a large body of empirical evidence; for example, Wu et al. (2020) found that business complexity reduces bank risk and promotes stability. Similarly, Berger et al. (2017) demonstrated that internationalizing bank operations reduces risk and dampens the impact of regional shocks (Kraus et al., 2017), particularly

under new regulatory conditions (Berger et al., 2023). Furthermore, the disclosure of risk management information leads to reduced bank risk (Wang and Wang, 2025). Domestic studies also confirm this finding; for example, Shahchera and Jozdani (2016) and Ebrahimi et al. (2016) found that income diversification reduces risk and improves bank performance, respectively. Additionally, better asset quality, liquidity, and capital buffers are linked to a decrease in risk, whereas a larger bank size tends to increase it (Tabatabaie et al., 2024). Conversely, certain studies demonstrated that diversifying income streams can enhance market performance, and the provision of voluntary data reinforces the positive correlation between income diversification and performance (Parsaei et al., 2024) and market power (Gholizadeh et al., 2022). In contrast, the agency theory posits that greater complexity increases bank risk due to intensified agency problems and supervisory difficulties (Luciano and Wihlborg, 2018; Bonfim and Félix, 2022; and Correa and Goldberg, 2022). According to this theory, management with complex business lines may engage in riskier behavior. Demirgüç-Kunt and Huizinga (2010) and Argimón and Rodríguez-Moreno (2022) found evidence that an increase in complex activities leads to higher risk, particularly in the absence of effective controls. Furthermore, income diversification can impact credit risk efficiency and cost efficiency (Farhang et al., 2025). In addition, Wang and Kang's (2024) study on Chinese banks indicates that increasing financial interconnectedness elevates bank risk-taking, with factors like monetary policy and economic policy uncertainty exacerbating this effect. Similarly, Amini et al. (2023) state that political crises worsen banks' operational risk and negatively affect the economy. Other research, using machine learning approaches, has identified key features such as volatility and stock beta as significant factors in predicting bank systemic risk (Kumar et al., 2024) and the transition of asset growth into systemic risk (Irwan et al., 2025). Additionally, Correa and Goldberg (2022) showed that business, geographic, and organizational complexities can increase systemic risk.

2.1. Hypothesis Development

Given this contradiction, the first research hypothesis (H1) assesses the role of banks' business complexities on their overall risk, and it is examined through the following two sub-hypotheses:

H1a: Investment in nonbank assets leads to a reduction in bank risk.

H1b: An increase in income diversification reduces bank risk.

This study extends beyond a direct impact analysis to look at the mechanisms of effect transmission. This investigation is carried out to determine whether the effect of complexity is transmitted through certain channels or is influenced by other factors. The second hypothesis (H2), which considers mediation effects, investigates whether the impact of one complexity variable is passed to another. This hypothesis states that:

H2a: Nonbank assets positively influence bank income diversification by creating stable income streams. Studies like that of Ahn and Choi (2020) in Asia show that investing in nonbank sectors can provide new income sources to counter the volatility of the lending market.

H2b: Investment in nonbank assets reduces risk through increased income streams (non-interest income). This hypothesis specifies the transmission path and is based on the idea that nonbank assets can be converted into liquidity to provide income sources when needed and prevent liquidity shocks (Stiroh and Goldberg, 2016).

H3, the moderation hypothesis, explores how bank size moderates the relationship. The financial literature suggests that the benefits of complexity may be greater for larger banks. Correa and Goldberg (2022) showed that complexities can reduce specific and liquidity risks by creating diversification benefits, and these benefits are more pronounced in larger banks. Therefore, this hypothesis is proposed as follows:

H3: Given the existence of economies of scale, the advantages derived from business complexity tend to be more pronounced for larger banks compared to their smaller counterparts.

Finally, given the dynamic nature of bank risk, this study goes beyond static analyses. Literature emphasizes that risk is an autoregressive phenomenon that persists over time. This justifies the necessity of using dynamic models to properly measure the persistence of risk and the delayed impact of variables. The findings of Hertrampf et al. (2024), Li et al. (2025), and Chen et al. (2025) also emphasize that managerial characteristics, financial technologies, and liquidity regulations can affect the structure of assets and liabilities over time, and consequently, bank risk. Furthermore, Miraskari and Hosseini. (2017) report the dynamic effect of financial market development on macroeconomic indicators, and in another study, they state that inflation and economic growth lead to increased bank failure risk in the long run (Miraskari et al., 2019). Additionally, An et al. (2025) highlight that climatic risks can also influence bank risk over both short and long time horizons. Consequently, the fourth hypothesis (H4) is put forth:

H4: Examining short- and long-run timeframes reveals a significant distinction in how non-bank assets affect bank risk. These hypotheses offer a comprehensive analytical framework to accurately assess how business complexity impacts bank risk across the Iranian banking sector.

3. Data and Variable Definitions

This section provides a complete and precise definition of every variable necessary for the subsequent investigation.

3.1. Data and Sample

In this paper, complexity and risk data are defined at the bank level, primarily gathered manually from their financial statements. This study utilizes a balanced panel dataset comprising annual financial information for 21 Iranian state-owned, quasi-private, and private banks over the period 2009 to 2022. The selection of these banks was based on the maximum availability of complete and continuous financial data throughout the examination period. The fourteen-year time span with 21 banks was chosen

because several banks, particularly in the private sector, are young, and this duration ensures all are active within the range, mitigating the heterogeneity of different founding periods. The bank-level data were primarily collected manually from their financial statements. The information sources are divided into two main categories: CODAL.ir (Comprehensive Database of All Listed Companies) and the Tehran Stock Exchange Library, for private and quasi-private banks listed on Iran's capital market, and for state-owned banks after 2020. The other category is the Central Bank of Iran's (CBI.IR) official website and the Higher Education Institute of Banking of Iran's website, for data related to state-owned banks prior to 2020. Furthermore, to account for the influence of broader macroeconomic conditions, indicators such as the economic growth rate, inflation rate, and exchange rate were sourced from the Central Bank of Iran's official portal.

3.2. Definition and Measurement of Variables

This research investigates how business complexity affects the banks' overall risk exposure. Drawing from the literature, the definition, measurement method, and rationale for selecting each variable are detailed below:

Dependent Variable:

Bank Risk (Ln Z-Score): The bank's total risk exposure is quantified by the Z-Score, a widely accepted indicator applied by various researchers, including Lepetit et al. (2008), Berger et al. (2017), and Cetorelli and Goldberg (2022). This measure serves as a specific proxy for a bank's overall stability against both volatility of returns and potential losses, thereby holding a direct correlation with its probability of failure (insolvency risk).The main advantage of this metric is its combination of profitability (ROA), financial leverage (equity/assets), and risk (SD ROA) into a single index, providing a comprehensive picture of bank stability. Higher Z-score values indicate lower risk and greater stability. The dependent variable's statistical distribution is transformed using its natural logarithm to achieve

greater smoothness and to mitigate issues related to heteroskedasticity within the regression models:

$$Ln\ Z - Score i,t = Ln \frac{\left(ROAi,t + \left(\frac{Assets i,t}{Equity i,t}\right)\right)}{\text{SD ROAi,t}}$$

Independent Variables:

Business Complexity (Nonbank Asset Ratio): Business complexity is measured using the ratio of nonbank assets to a bank's total assets. This measure follows studies by Chernobai et al. (2021) and Demirgüç-Kunt and Huizinga (2010). This criterion reflects the diversification of the bank's non-traditional activities and includes investments and securities intended for long-term holding or sale.

Non-Interest Income Ratio: This variable is also used as a mediating variable to test the hypothesis that nonbank assets influence risk through the diversification of income sources. The second measure is the banks' non-interest income. This factor includes income earned from advisory services, underwriting, asset management, brokerage activities, etc. This metric is derived from the banks' income statements and is measured as the ratio of non-interest income to the bank's total income (income statement diversification).

Control Variables: To reduce the likelihood of omitted variable bias, the model includes a set of firm-level and macroeconomic control factors. This set includes the following: bank size (LnTA), return on assets (ROA), return on equity (ROE), liquidity ratio (Cash to TA), sales growth (Sales growth), and excessive growth of liabilities. The macroeconomic variables, included to account for external conditions, are: inflation rate, economic growth rate, and exchange rate. Furthermore, mediators and moderators are used to obtain a better understanding of the mechanisms of influence, to examine the differences in the effect of nonbank assets on risk across different bank sizes, and to validate the hypothesis. These variables will be derived from the main explanatory and control variables. Table 1 contains a full definition of each variable.

Table 1. Variable definitions

Variables	Definitions
Bank Complexity	
Complexity : Business	
Nonbank Asset Ratio	The non-bank assets to total assets ratio quantifies the portion of a financial statement that includes available-for-sale transactions and securities, including a variety of short-term investments and assets held for sale, as well as those with low liquidity kept for long-term storage.
Non-Interest Income Ratio	The annual non-interest income to annual total income ratio includes those incomes reflected in the bank P&L, which are achieved through underwriting, advisory services, brokerage activities, asset management, and the like.
Bank Risk	
Z-Score	Z-Score i,t= (ROA i,t + (Equity i,t/ Assets i,t))/SD ROA i,t
Bank Level Characteristics	
Ln TA	Total assets of the bank. Unit: Ln (millions IRR)
Excessive Growth	Excess debt growth is recognized as a dummy variable, taking the value of 1 when the bank's current liabilities grow year-over-year at a rate exceeding the growth of its current assets, and 0 otherwise.
ROA (%)	Net annual profit (loss) to total assets ratio (net profit and loss divided by total assets)
ROE (%)	Net annual profit (loss) to total equity ratio (net profit and loss divided by total equity)
Cash To TA	Total cash and cash equivalents to total assets ratio
Sales growth	Year-on-year operational income growth rate-(Total operating income during year t-1/(Total operating income during year t-1-Total operating income during year t)).
Macro-Economic Indicators	
GDPgrowth (%)	Official GDP growth rate reported by the Central Bank of Iran (year-on-year change in GDP)
Inflation (%)	Official inflation rate reported by the Central Bank of Iran.
Exchange Rate (%)	Iranian Rial to US Dollar Exchange Rate, reported by the Central Bank of Iran (year-on-year change in USD rate).

4. Research Methodology and Model Specifications

This section first presents the methodology and specifications of the panel regression models used to test the study's hypotheses, and then the empirical results are analyzed.

4.1. Estimation Strategy and Model Specifications

4.1.1. Baseline Model Specification

The regression model presented below is utilized to evaluate the first hypothesis of this study, which concerns the direct effect of complexity on bank risk (H1a and H1b). Furthermore, this framework serves as the foundation for all subsequent analyses:

$$Y_{i,t} = \alpha + \beta X_{i,t-1} + \phi Controls_{i,t-1} + \delta_i + \omega_{i,t} \quad (1)$$

Within this framework, the subscript 'i' denotes the cross-sectional unit (the bank), while't' captures the temporal dimension (the year). $Y_{i,t}$ on the left-hand side, is the measure for the dependent variable in the model, representing the bank's overall risk (Ln Z-Score). On the right-hand side, $X_{i,t-1}$ represents each of the primary measures for banks' business complexity. These variables are the Nonbank Asset $Ratio_{i,t-1}$ and Non-interest Income $Ratio_{i,t-1}$, which denote the ratio of nonbank assets and the ratio of non-interest income to total assets, respectively. The use of a lagged value (t−1) is because the impact of these assets on risk is not an instantaneous process and may manifest over time. Additionally, using a lagged variable helps mitigate the potential problem of endogeneity. $Controls_{i,t-1}$ reflect some of the bank-level characteristics and are controlled for due to their potential role in explaining changes in bank risk (these variables were fully introduced in Section 3.2). Furthermore, to account for individual or group effects of banks, δi is included in the model, representing the average of the unobserved heterogeneity or differences among banks. These fixed effects pertain to correlations that banks have individually or in groups with the explanatory variables; they are unobserved, specific to each

group, and do not change over time. However, these differences may be random in relation to the explanatory variables since many factors contribute to them. Consequently, the initial step involves conducting the Hausman Test to determine the suitability of the estimation approach (fixed effects versus random effects). If the fixed-effects model is chosen, classical assumptions such as heteroscedasticity and autocorrelation of errors are checked using relevant tests (such as the Wooldridge test). Should these issues persist, the model estimation employs either Robust Standard Errors or Clustered Standard Errors to mitigate their effects, thereby confirming the reliability and statistical soundness of the coefficients.

4.1.2. Mediation Effects Analysis

To examine the study's second hypothesis (H2), which states that the effect of nonbank assets as a component of business complexity on risk is transmitted through the mediating variable of income diversification, we use the three-step approach developed by Baron and Kenny (1986). This approach includes the following three models:

Model (1) - Direct Effect: This is the same model introduced in Section 4.1.1, which examines the direct impact of nonbank assets on risk.

Model (2) - Effect on Mediator: The subsequent model is deployed to examine the influence of nonbank assets on the mediating variable (non-interest income) (H2a):

$$\text{Noninterest\_Income\_Ratio}_{i,t-1} = \alpha + \beta \text{Nonbank Asset Ratio}_{i,t-1} + \phi Controls_{i,t-1} + \delta_i + \omega_{i,t} \quad (2)$$

Model (3) - Mediating Effect: This model simultaneously examines the effect of the independent variable and the mediating variable (nonbank assets and non-interest income) on bank risk (H2b):

$$\text{Ln Z} - \text{Score}_{i,t} = \alpha + \beta \text{Nonbank Asset Ratio}_{i,t-1} + £\text{Noninterest\_Income\_Ratio}_{i,t-1} + \phi Controls_{i,t-1} + \delta_i + \omega_{i,t} \quad (3)$$

By comparing the coefficients in the above models, we can analyze the mediating role of non-interest income and nonbank assets on a reciprocal basis. This analysis is performed only if the first two conditions (Model 1 and 2 showing a significant relationship) are met.

4.1.3. Moderation Effects Analysis

This section addresses the moderation hypothesis (H3) and examines whether bank size changes the effect of nonbank assets on risk.

$$\text{Ln Z} - \text{Score}_{i,t} = \alpha + \beta \text{Nonbank Asset Ratio}_{i,t-1} + £\text{LnTA}_{i,t-1} + \rho(\text{Nonbank Asset Ratio} \times \text{LnTA})_{i,t-1} + \phi Controls_{i,t-1} + \delta_i + \omega_{i,t} \quad (4)$$

Here, the significance of the ρ coefficient indicates the moderating effect of bank size.

4.1.4. Analysis of Dynamic and Long-Term Effects

This section explores the temporal dynamics and the difference between short-term and long-term effects (addressing the fourth hypothesis). To investigate this difference, a Dynamic Panel Model is used (H4):

$$\text{Ln Z} - \text{Score}_{i,t} = \alpha + \rho \text{Ln Z} - \text{Score}_{i,t-1} + \beta \text{Nonbank Asset Ratio}_{i,t-1} + \phi Controls_{i,t-1} + \delta_i + \omega_{i,t} \quad (5)$$

In this model, ρ represents the persistence of risk over time. The short-term effect is determined by the β coefficient, while the long-term effect is calculated using the formula $\beta/(1-\rho)$. To solve the endogeneity problems

common in dynamic models, advanced methods such as the Generalized Method of Moments (GMM) are employed.

5. Empirical Analysis of Results

5.1. Preliminary Panel Data Tests

5.1.1. Unit Root (Stationarity) Test

Despite the relatively short study period (T=14) making panel unit root tests non-mandatory, the Levin, Lin, and Chu (LLC) test was nevertheless conducted to bolster methodological robustness and preempt the issue of spurious regression (non-stationarity). As documented in Table 2, the primary dependent variable (Ln Z-Score) and nearly all explanatory variables exhibit stationarity at the level. This provides the necessary initial assurance regarding the non-occurrence of spurious regression. The remaining non-stationary variables (Excessive Growth and SIZE) were included in the models at their level and lagged forms. Nevertheless, the use of robust estimation models such as Driscoll-Kraay and especially System GMM ensures the statistical accuracy and validity of the results across all estimations.

Table 2. Panel Unit Root Test (LLC) Outcomes for Study Variables

Variables	Adjusted t-statistic	p-value	Conclusion
Nonbank Asset	-3.848	0.0001	Stationary
Non-Interest Income Ratio	-10.570	0	Stationary
Excessive Growth	0.663	0.746	Non-stationary
ROA	-10.942	0	Stationary
ROE	-5.020	0	Stationary
Ln TA	2.875	0.998	Non-stationary
Cash To TA	-3.198	0.0007	Stationary
Ln Z-Score	-2.572	0.005	Stationary
Sales growth	-27.355	0	Stationary
GDPgrowth	-13.105	0	Stationary
Inflation	-5.576	0	Stationary

Exchange Rate	-5.002	0	Stationary

5.1.2. Statistical Description of Variables

The descriptive statistics for the variables employed in this study are summarized in Table 2, covering the time frame from 2009 to 2022. This summary outlines the essential properties of the data and sheds light on the condition of the banks under investigation. As shown in the table, the mean Nonbank Asset Ratio is 0.115, while the mean Non-Interest Income Ratio is 0.203. These values indicate that while the share of nonbank assets on banks' balance sheets is small, income diversification through their income statements has been more prominent. Despite the large size of the banks (with a mean Ln TA of 19.796), their performance is evaluated as very poor. This reality is underscored by the negative mean values for Return on Assets (ROA) at -0.488 and Return on Equity (ROE) at -0.208, as well as low sales growth (with a mean of 0.420). Furthermore, the results show that the mean Z-Score for the banks under review is 1.646, which indicates a high level of risk. This is confirmed by other descriptive statistics; the relatively high growth of liabilities (with a mean of 0.602) and a very low liquidity ratio (with a mean of 0.037) have added to the intensity of their risk. Finally, it can be concluded that Iranian banks, operating in a small and non-competitive economy and under the influence of political sanctions (such as SWIFT banking sanctions), have been deprived of the greater benefits of diversification. This, in turn, has fueled the increase in their risk.

Table 3. Descriptive statistics

	2009-2022						
Variables	**Mean**	**Median**	**P10**	**P90**	**SD**	**N**	**Num Obs**
Ln Z-Score	1.646	1.767	0.472	2.638	0.976	21	294
Nonbank Asset Ratio	0.115	0.098	0.033	0.215	0.082	21	294
Non-Interest Income Ratio	0.203	0.166	0.052	0.398	0.160	21	294

	2009-2022						
Variables	**Mean**	**Median**	**P10**	**P90**	**SD**	**N**	**Num Obs**
Ln TA	19.796	19.929	17.714	21.646	1.530	21	294
Excessive Growth	0.602	1.000	0.000	1.000	0.490	21	294
ROA٪	-0.488	0.367	-1.892	2.556	7.092	21	294
ROE٪	-0.208	6.096	-27.024	29.077	76.715	21	294
Cash To TA	0.037	0.019	0.004	0.093	0.047	21	294
Sales growth	0.420	0.283	0.000	0.754	1.359	21	294
SDROA (%)	2.659	1.284	0.788	3.112	4.849	21	294
Ln Z-Score1	-1.082	-0.629	-3.772	0.852	1.827	21	294
GDPgrowth (%)	1.055	2.229	-6.510	5.727	5.111	21	294
Inflation (%)	26.300	26.000	9.600	46.500	14.485	21	294
Exchange Rate (%)	12.373	6.071	0.000	24.731	18.587	21	294

5.2. Hypothesis Testing

5.2.1. Direct Effects

This segment analyzes the direct influence of business complexity on bank risk. The analyses were conducted utilizing a balanced panel dataset encompassing 21 banks across a 14-year timeframe. Based on the results of the Hausman test, researchers selected the random-effects model to perform the final estimation for the non-interest income ratio component of complexity. Conversely, the fixed-effects model was ultimately employed for the component involving the nonbank asset ratio. Subsequently, diagnostic checks on the fixed-effects model detected both heteroscedasticity (Wald Test, Prob>chi2=0.000) and autocorrelation (Wooldridge Test, Prob>F=0.0003). Therefore, the final model was estimated using Driscoll-Kraay standard errors, a measure necessary to establish the result's validity. The resulting estimates are displayed in Table 4. Specifically, Column (1) reports the outcomes for the nonbank asset ratio measure, while Column (2) documents the outcomes for the non-interest income ratio measure. As detailed in Column (1), the regression estimates unequivocally indicate a significant, inverse relationship between the nonbank asset ratio and banking

risk within Iran. This outcome substantiates the Portfolio Hypothesis, suggesting that diversification into nonbank activities substantially aids in reducing risk and enhancing stability across the Iranian banking sector. The significant and negative coefficient observed for the primary variable (nonbank asset ratio) verifies that an expansion of these activities corresponds to an increased Z-Score (the stability index) (β=−15.109, std. err=4.110).

Conceptually, this finding aligns with the portfolio hypothesis and the benefits of diversification in financial markets. It indicates that Iranian banks have successfully reduced their dependency on income concentrated in lending by expanding their activities into non-traditional sectors. This result is particularly significant in the context of Iran's emerging economy, which faces economic volatility and systemic risks. In contrast, the results in Column (2) show that the coefficient for the non-interest income ratio is 1.937; however, this effect is not statistically significant (P-value=0.249). This finding suggests that non-interest income does not have a meaningful impact on bank risk. Overall, these findings indicate that investing in nonbank assets is a more effective strategy for risk reduction in the studied banks than increasing non-interest income. Furthermore, important insights are obtained from a thorough examination of the control variables: An increase in bank size greatly lowers risk and increases stability, as evidenced by the negative and highly significant coefficients of bank size (Ln TA) in both models (−1.617 in Column (1) and −2.257 in Column (2)). Regardless of the kind of company complexity, this link exists. Furthermore, the model's explanation relies heavily on the Return on Assets (ROA) in both models, liquidity (Cash to TA) in Column (1), and inflation in Column (2), all of which are strongly correlated with bank risk. Nevertheless, none of the models include other variables like sales growth, economic development, or the exchange rate as significant.

Table 4. Regression Results of Business Complexity on Bank Risk

Dependent variable:	**Ln Z-Score**	**Ln Z-Score**
	(1)	**(2)**
Nonbank Asset Ratio i,t-1	-15.109***	
	(4.110)	
Non-Interest Income Ratio i,t-1		1,937
		(1.680)
Ln TA i,t-1	-.1.617***	-2.257***
	(0.111)	(0.302)
Excessive Growth i,t-1	-2.998***	-0.560
	(0.865)	(0.740)
ROA i,t-1	0.384***	0.309***
	(0.046)	(0.045)
ROE i,t-1	0.005	0.003
	(0.003)	(0.003)
Cash To TA i,t-1	26.736***	-8.191
	(8.060)	(5.600)
Sales growth i,t-1	-0.382***	-0.242
	(0.099)	(0.172)
GDPgrowth i,t-1	-0.012	0.029
	(0.047)	(0.048)
Inflation i,t-1	-0.070	0.103***
	(0.018)	(0.023)
Exchange Rate i,t-1	-0.001	-0.017
	(0.012)	(0.012)
N	21	21
R-Squared: Within	-	0.393
R-Squared: Overall	0.307	-
Observations	273	273
F-Limer Test (P-value)	0.000	0.000
Hausman Test (Chi2)	0.009	0.454
Reg	Fixed-Effects	Random-Effects

Note: This table summarizes the outcomes from the panel data model estimation designed to investigate the influence of business complexity on bank risk. The dependent variable is the Ln Z-Score, which serves as the metric for assessing overall bank risk. Business complexity is gauged by the Nonbank Asset Ratio (Column 1) and the Non-Interest Income Ratio (Column 2). All explanatory variables were incorporated into the model using a one-period lag (t−1).

The figures enclosed in parentheses represent the standard errors. Statistical significance is denoted by the symbols ***,, and * for the 1%, 5%, and 10% thresholds, respectively.

5.2.2. Mediation Analysis

This section examines the mechanism through which business complexity, based on the nonbank assets component, affects risk, focusing on the mediating role of non-interest income. The study's hypothesis (H2), which posits that the risk-reducing effect of nonbank assets is transmitted through an increase in non-interest income, was tested using the three-step approach developed by Baron and Kenny (1986).

Step 1: The initial requirement for mediation—a significant relationship between the independent and dependent variables—is met, as indicated by the statistically significant and negative coefficient of the nonbank asset ratio in Column (1) of Table 4.

Step 2: Influence of the Independent Variable on the Mediator In the subsequent step, Model 2 was deployed to assess the influence of the nonbank asset ratio on the mediator (non-interest income ratio). As documented in Column (1) of Table 5, the nonbank asset ratio yields a coefficient of −0.104 (with a standard error of 0.157). Significantly, the findings demonstrate that the association between nonbank assets and non-interest income is not statistically significant. This lack of significance suggests that bank investment in nonbank assets fails to generate a marked increase in non-interest income, consequently invalidating the mediation process via the non-interest income channel.

As the second necessary condition for mediation (a significant link between the independent and mediating variables) was not met, the mediation hypothesis is consequently invalidated. This outcome negates the requirement for executing the third step in the analysis.

This discovery is significant because it goes against diversification theory, which holds that non-interest income is the main route for risk mitigation: an increase in non-interest income does not channel the positive

effect of nonbank assets on lowering risk. Due to the market structure or the nature of the operations, this conclusion might suggest that non-interest income is not a good way for Iranian banks to transfer the risk-reducing benefits of nonbank assets. This finding enables researchers to concentrate on other risk-reduction strategies.

5.2.3. Moderation Analysis

This section addresses the moderation hypothesis (H3), which examines whether bank size alters the effect of nonbank assets on risk. This analysis is conducted based on Model 4.

The moderation hypothesis is not supported by the findings. As shown in Column (2) of Table 5, the interaction term yields a coefficient of −2.880 (standard error: 2.150). This result suggests that the moderating influence of bank size on the link between business complexity and risk lacks statistical significance. This means that the benefits of business complexity operate independently of bank scale, and there is no significant interaction effect between them. This finding could point to an important aspect of Iran's banking structure and has significant implications for policy and risk management, suggesting that these two factors should be considered separately.

Table 5. Results of Mediation and Moderation Analyses of Business Complexity on Bank Risk

Dependent variable:	Non-Interest Income Ratio i,t-1	Ln Z-Score i,t
	(1)	(2)
Nonbank Asset Ratio i,t-1	-0.104 (0.157)	47.561 (42.523)
Ln TA i,t-1	-0.026*** (0.010)	-1.943*** (0.409)
(Nonbank Asset Ratio*Ln TA) i,t-1		-2.880 (2.150)
Excessive Growth i,t-1	0.063** (0.026)	-0.190 (0.734)

Dependent variable:	Non-Interest Income Ratio i,t-1	Ln Z-Score i,t
	(1)	(2)
ROA i,t-1	-0.006***	0.261***
	(0.001)	(0.048)
ROE i,t-1	0.000	-0.002
	(0.000)	(0.003)
Cash To TA i,t-1	-0.029	-8.237
	(0.209)	(5.644)
Sales growth i,t-1	0.015**	0.274
	(0.006)	(0.182)
GDPgrowth i,t-1	0.002	0.022
	(0.002)	(0.047)
Inflation i,t-1	0.002	0.102
	(0.000)	(0.023)
Exchange Rate i,t-1	0.000	-0.017
	(0.000)	(0.012)
N	21	21
R-Squared: Within	0.163	0.405
Observations	273	273
F-Limer Test (P-value)	0.000	0.000
Hausman Test (Chi2)	0.396	0.998
Reg	Random-Effects	Random-Effects

Note: This table presents the regression outcomes for the mediation and moderation analysis models. The dependent variable is the Non-Interest Income Ratio in the mediation model, while Bank Risk (Ln Z-Score) is utilized in the moderation model. Column 1 displays the mediation model's results (using the Non-Interest Income Ratio as the mediating variable), and Column 2 reports the moderation model's results (featuring the Nonbank Asset Ratio × Ln TA interaction variable). The Random Effects (RE) method was employed for estimating all models, with every explanatory variable included at a one-period lag (t-1). The coefficient is provided for each variable, with the corresponding standard error presented directly beneath it in parentheses. The symbols ***, **, and * indicate statistical significance at the 1%, 5%, and 10% thresholds, respectively.

5.2.4. Analysis of Dynamic and Long-Term Effects

This segment investigates the temporal relationship (short-term and long-term) between business complexity and bank risk, employing a Dynamic

Panel Model (System GMM). The corresponding outcomes are displayed in Table 6. The estimation results from the System GMM panel model yield crucial insights into the dynamic relationships between variables. As evidenced in Table 6, the model's appropriateness is verified by diagnostic checks: Both the Arellano-Bond AR(2) test and the Hansen test register insignificant P-values. This confirms the robustness of the instruments utilized and the adherence of the model's underlying assumptions, thereby establishing a firm methodological basis for drawing conclusions. Analyzing the coefficients reveals the most compelling finding: the intrinsic, long-term persistence of bank risk. The lagged dependent variable (Ln Z-Score$_{i,t-1}$) demonstrates a significant coefficient of 0.999 (at the 1% level). This outcome validates bank risk as a dynamic, persistent phenomenon strongly tied to the preceding period's risk, underscoring the necessity of incorporating this dynamic nature in subsequent research. The study's main hypothesis suggests that the nonbank asset ratio coefficient (a measure of business complexity) is -8.741, although this does not reach statistical significance. This conclusion is a major finding, implying that, contrary to original expectations and after thorough adjustment for dynamic effects and endogeneity, the impact of nonbank activities on risk is statistically unreliable within this complicated framework. This result poses a significant challenge to findings that have focused on static data or simpler methods. It suggests that the relationship between activity diversification and risk may not be as simple as it appears; in a complex banking system, multiple factors simultaneously affect risk, and therefore, the influence of a single variable, such as nonbank activities, may be obscured by other factors or act nonlinearly. This finding underscores the necessity of using advanced models to achieve more accurate results and a deeper understanding of risk dynamics.

Table 6. Results of Dynamic Panel Model Estimation (System GMM)

Dependent variable:	**Ln Z-Score**
	(1)
Ln Z-Score i,t-1	0.999***
	(0.272)
Nonbank Asset Ratio i,t-1	-8.741
	(17.474)
Excessive Growth i,t-1	-2.245
	(4.048)
ROA i,t-1	-0.368
	(0.354)
ROE i,t-1	-0.009
	(0.014)
Ln TA i,t-1	0.029
	(1.433)
Cash To TA i,t-1	9.589
	(8.460)
Sales growth i,t-1	0.702
	(0.681)
GDPgrowth i,t-1	-0.016
	(0.061)
Inflation i,t-1	0.067
	(0.063)
Exchange Rate i,t-1	-0.021
	(0.027)
N	21
Observations	252
Test AR(1)	0.013
Test AR(2)	0.284
Hansen Test	1.000

Note: This table displays the estimation outcomes derived from the dynamic panel model, employing the System GMM methodology. This specific model was chosen to assess the dynamic and long-run associations between the study variables, while appropriately addressing crucial concerns like endogeneity and risk persistence. Bank risk (Ln Z-Score) is featured as the dependent variable in Column 1. The coefficients and their standard errors for

all explanatory variables, which were incorporated into the model with a one-period lag, are included in the table. Furthermore, the outcomes of essential diagnostic checks—including the AR (2) and Hansen tests—are presented at the bottom of the table to verify the validity of the methodology and the instruments utilized in the model.

5.3. Robustness Checks

To ensure the validity and stability of the main findings, two key robustness checks were performed. The objective of these tests was to determine whether the findings were specific to the choice of instruments. For the first robustness check, we used the instrument substitution technique (changing instruments) and re-estimated the original GMM model using a different set of instruments. In this model, the lagged dependent variable and the main variable (both lagged) were chosen as GMM instruments. Table 7 displays the corresponding results yielded by this test. As shown in the table, the statistical results of this model are fully valid, as the diagnostic tests for AR (1), AR (2), and Hansen all satisfy the necessary conditions. However, the coefficient for business complexity, with a value of −8.901, is insignificant. The second robustness test was performed by re-running the initial analyses but with only one control variable: bank size (Ln TA). As the results in Table 8 (Columns 1 and 2) show, similar to the initial findings, the relationship between business complexity and bank risk is strong and significant in the static models (Column 1), but in the dynamic model, this relationship is overshadowed by the intrinsic persistence of bank risk (Column 2). The results from both robustness checks provide a very strong and consistent argument. These findings clearly indicate that the relationship between business complexity and bank risk is insignificant within a rigorous dynamic framework. This emphasizes that the intrinsic persistence of bank risk is the most important factor in risk dynamics, overshadowing the influence of other factors like business complexity.

Table 7. Results of the Robustness Check with Instrumental Variables in the Dynamic Panel Model (System GMM)

Dependent variable:	**Ln Z-Score**
	(1)
Ln Z-Score i,t-1	0.925***
	(0.219)
Nonbank Asset Ratio i,t-1	-8.901
	(13.429)
Excessive Growth i,t-1	3.212
	(4.622)
ROA i,t-1	-0.304
	(0.590)
ROE i,t-1	-0.011
	(0.012)
Ln TA i,t-1	0.003
	(0.976)
Cash To TA i,t-1	1.283
	(9.715)
Sales growth i,t-1	0.782
	(0.661)
GDPgrowth i,t-1	-0.062
	(0.059)
Inflation i,t-1	0.027
	(0.052)
Exchange Rate i,t-1	-0.019
	(0.011)
N	21
Observations	273
Test AR(1)	0.008
Test AR(2)	0.946
Hansen Test	1.000

Note: The outcomes of the robustness check are provided in this table; this analysis employed the System GMM approach with an alternative configuration of instrumental variables. Both the lagged dependent variable (bank risk) and the primary explanatory variable (business complexity)

served as instruments. Bank risk (Ln Z-Score) is designated as the dependent variable, and business complexity (Nonbank Asset Ratio) functions as the key independent variable. The symbols ***, **, and * indicate statistical significance at the 1%, 5%, and 10% thresholds, respectively.

Table 8. Robustness Test Results with a Single Control Variable (Bank Size)

Dependent variable:	**Ln Z-Score i,t**	**Ln Z-Score i,t**
	(1)	**(2)**
Ln Z-Score i,t-1		0.911***
		(0.067)
Nonbank Asset Ratio i,t-1	-18.329***	-11.366
	(3.999)	(7.000)
Ln TA i,t-1	-1.739***	0.621
	(0.220)	(0.395)
Othere Controls	No	No
N	21	21
R-Squared: Within	0.270	-
Observations	273	273
AR(1) Test	-	0.003
AR(2) Test	-	0.219
Hansen Test	0.379	1.000
F-Limer Test (P-value)	0	-
Reg	Random-Effects	GMM

Note: The outcomes of a robustness check are shown in this table; the main models were re-estimated using a restricted group of control variables, which exclusively included bank size. Bank risk (Ln Z-Score) is designated as the dependent variable, and business complexity (Nonbank Asset Ratio) functions as the key independent variable. The coefficient is provided for each variable, with the corresponding standard error presented directly beneath it in parentheses. The symbols ***, **, and * indicate statistical significance at the 1%, 5%, and 10% thresholds, respectively.

6. Conclusion and Policy Implications

This study conducted an empirical analysis utilizing panel data from 21 Iranian banks, spanning the period 2009 to 2022, to investigate how business complexity influences risk in the Iranian banking sector. The primary

findings yield significant insights into the complex nexus between complexity and risk within an emerging economy, thus providing a valuable contribution to the extant literature. Furthermore, the results indicate that distinct dimensions of business complexity affect banks' overall risk differently. Specifically, an increased ratio of nonbank assets on the balance sheet is correlated with a corresponding decrease in a bank's risk exposure. This aligns with diversification theories, demonstrating that capital allocation toward non-traditional activities may bolster a bank's resilience against systemic and unexpected shocks. The outcome corroborates the findings of earlier studies, including Wu et al. (2020) and Shahchera and Jozdani (2016), within the specific context of the Iranian economy. On the other hand, over the reviewed period, there was no statistically significant influence of complexity resulting from revenue diversification (the percentage of non-interest income to total income) on bank risk. This result deviates from some earlier research that supports the advantages of income diversification while also being inconsistent with studies that highlight the risky nature of these endeavors (e.g., Demirgüç-Kunt and Huizinga, 2010). This outcome can be the consequence of the particulars of the Iranian banking system, where regulatory and structural elements may negate the possible advantages of income diversification. Additionally, other study findings demonstrated that the risk-reducing benefit of nonbank assets is not communicated through an increase in non-interest income, which runs counter to some hypotheses and deviates from the mediation theory put out in the literature (e.g., Ahn and Choi, 2020). The unique non-interest revenue structure of the Iranian banking system, which could not be solid enough, could be the cause of this disparity. Furthermore, the moderation hypothesis was also disproved, which suggested that larger banks would profit more from complexity (Correa and Goldberg, 2022). This suggests that business complexity has advantages in Iran that are not influenced by a bank's size, and that both big and small banks can profit from this approach. The most compelling and novel insight arises from the dynamic analysis conducted via

the System GMM model. This estimation reveals that when persistence and endogeneity effects are meticulously addressed, the influence of nonbank assets on risk lacks statistical verification within this temporal and dynamic framework. This finding challenges the validity of many static studies that ignore these dynamics. This result is consistent with more recent literature (e.g., Hertrampf et al., 2024) that emphasizes the intrinsic persistence of risk and the need for dynamic analyses. In essence, this finding suggests that in a complex and self-correlated banking system, the effect of a single variable like business complexity may be obscured by other factors. This research has significant implications for policymakers and bank managers in Iran, indicating that the approach to complexity should be tailored to the nature of the activities and the time horizon. It is essential for the supervisory authority to adopt a risk-complexity and transparency-focused approach; specifically, they should establish a clear permissible limit for the diversification of nonbank activities and increase regulatory capital requirements for banks with high business complexity. This ensures the need for a stronger capital and regulatory buffer to absorb potential losses arising from more complex activities. Furthermore, bank management is advised to conduct a conditional reassessment of their diversification strategy; since the moderation analysis showed that the success of a complexity strategy depends on the bank's internal conditions, the move toward increased activity diversification is justified only when the bank has high operational profitability or a high liquidity level. Finally, risk management units must update their internal models by accounting for the dynamic effects of business complexity. It is suggested that future studies investigate the more precise and dynamic mechanisms between these variables and use other measures to assess complexity, although access to accurate and comprehensive data in Iran's economic and political environment remains a major challenge.

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All authors had contribution in preparing this paper.

Conflicts of interest

The authors declare no conflict of interest

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