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Factors Affecting Banking Financial Stability in Vietnam's Emerging Economy: A Lasso, Ridge, and Elasticnet Regression Analysis

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Abstract

Background: The COVID-19 pandemic has significantly impacted the stability of the global economy and the banking sector in developing nations such as Vietnam.

Objective: This study examines the variables impacting the Z-score index and uses them to evaluate the stability of commercial banks in Vietnam.

Methodology: The research uses ElasticNet, Ridge, and Lasso regression methods to tackle the problems caused by a large number of independent variables and reduce the likelihood of issues like autocorrelation and multicollinearity. These approaches help adjust the model coefficients within the appropriate thresholds or select important variables to minimise the risk of multicollinearity or autocorrelation as well as in other emerging markets, for the period from 2010 to 2023 based on the regression methods Ridge, Lasso, and ElasticNet. Model performance is evaluated using MSE and R^2 scores.

Result: The results showed that Ridge performs best with an R^2 score of 88.75% and an MSE of 0.002607; ElasticNet performs better than Lasso, though the difference is negligible.

Conclusion: Empirical data demonstrate that several parameters, such as the previous year's Z-score, the ratio of loans to total mobilised capital, total asset growth rate, ROE, competitiveness, market power, or inflation rate, significantly influence the Z-score. In contrast, the Z-score is less affected by the risk provision ratio, income diversification, or bank size.

Unique Contribution: The study uses the Z-score index to measure banking stability and provides empirical information on its influences. This contribution is especially relevant for emerging economies, where the drivers of financial stability are underexplored.

Key Recommendation: The authors suggest several implications that could improve both experimental and operational efficiency for bank managers and maintain financial stability.

Keywords: ElasticNet; Lasso; stability bank; Ridge; Z-score.

Introduction

Banking is the lifeblood of a country's financial foundation, so banking stability plays a crucial role in the sustainable development of an emerging economic market like Vietnam. Determining the impact trends of factors on banking stability is an issue of significant interest to academics.

Specifically, the COVID-19 pandemic has significantly impacted the stability of the global economy and the banking sector in developing nations such as Vietnam. Altman et al. (2017) suggest that utilising the Z-score as a metric for assessing banking stability applies to many prevalent attributes of countries. The researchers also believe combining the Z-score's consideration of stability in the impact relationship with other additional factors is necessary. Because of the suitability of the calculation method and its similarity with organisational characteristics, many domestic and foreign studies currently use the Z-score to measure the level of banking stability. Depending on the characteristics of each country, the Z-score calculation method or the set of indicators representing the factors affecting the Z-score are appropriately selected. However, there is still no consensus on which index or method is best to measure the level of stability and which factors affect a country's banking stability.

Studies in the field of finance often have the problem of a small number of observed samples and a high dimensional set of inputs. One of the major concerns that is difficult to avoid is the existence of a causal relationship and the degree of cross-correlation between factors. This can have potential risks of multicollinearity, autocorrelation, or experimental data overfitting, leading to bias in regression results. Removing or adding variables to the regression model can cause research to face the risk of loss or excess of irrelevant information. At the same time, a model with too many input variables can also cause multicollinearity or spurious regression (Herawati et al., 2018). The ordinary least squares (OLS) regression method is often used to determine the relationship between independent and target variables. However, the OLS method is considered to have some limitations in explaining the correct selection of the subset of variables in the original set of independent variables. When there are numerous independent variables, OLS estimation produces non-unique results, and it is impossible to determine the trend and extent of each independent variable's influence on the dependent variable (Alexandre et al., 2022). To overcome the above limitations, many previous studies have attempted and proposed regression techniques that are considered appropriate in research model situations with many dependent variables, such as the Lasso method, the Ridge method (Sirimongkolkasem & Drikvandi, 2019), or the ElasticNet method. Therefore, the author used the Lasso, Ridge, and ElasticNet regression methods.

Moreover, this study aims to bridge current research gaps by integrating the rigour of sophisticated econometric approaches with the practical reality of Vietnam's expanding banking system. By evaluating data from 30 Vietnamese commercial banks from 2010 to 2023, this study intends to provide valuable empirical evidence and offer actionable recommendations for improving financial stability.

The authors presented the next part of the article in the following order: Part 2 provides a brief overview of the theoretical basis and synthesises results from previous studies; Part 3 introduces and proposes the data set and research methods; Part 4 presents, analyses, and evaluates the experimental results obtained. Finally, it synthesises the results and proposes implications based on the experimental findings. The study goal is to examine the variables impacting the Z-score index and use them to evaluate commercial banks' stability to provide more

experimental evidence on the effectiveness of Lasso, Ridge, and ElasticNet regression methods and determine trends and levels of impact of factors on banking stability.

Theoretical Framework

The Z-score model generally works quite well for most countries, with an accuracy of almost 75%. When the target variable is categorical (the dependent variable has two stable or unstable values) and combined with other observed variables in the model, the prediction performance can reach over 90% (Altman et al., 2017). The nature of the Z-score value represents the correlation between the bank's capital level and changes in profits, which is the basis for determining the frequency of changes in profits that can be absorbed by capital without affecting the bank's solvency. The higher the Z-score value, the more banking stability there is. In many previous studies, the assessment of the instability or stability of a bank needs to be based on many factors and groups of combined indicators, carefully considered on many different economic scales. The Z-score value compares the stability of a bank to that of past years with other banks in the same national system. Many studies use the Z-score to measure banking stability (Coskun & Murat, 2023; Pham et al., 2021; Jeon et al., 2017). The article uses the Z-score to determine the stability level of Vietnamese commercial banks, which aligns with previous studies.

In addition to choosing the appropriate banking stability measurement indicators, the effectiveness and reliability of the regression results depend significantly on the accuracy in identifying the influencing factors. The review results show that the factors affecting banking stability may not be the same in each study, and many aspects were concluded to affect the Z-score results. Furthermore, the use of different sets of indicators varies based on the banking characteristics of each country and the research context. There is no official conclusion about which factors are most appropriate for each country or period of study (Samir et al., 2023).

The Lasso regression method is a proposed multivariate linear regression method. Lasso overcomes the disadvantages of OLS and, at the same time, performs "variable selection" in the model according to the mechanism of "correcting" some estimation coefficients of unimportant variables to zero. When regressing on a dataset with input variables at risk of being polylinear, Lasso will tend to select one variable in the group of polylinear variables and ignore the others. Therefore, the Lasso method is also considered a variable selection technique, removing elements deemed unimportant from the model (Peter et al., 2022).

The Ridge regression method is similar to Lasso because it adjusts the model's parameters. Ridge differs from Lasso because it does not eliminate variables, but all input factors can carry useful information and affect model performance (Samir et al., 2023). This method will convert the output value of a linear function into a probability value between 0 and 1. Ridge's goal is to reduce the estimation coefficients' deviation and variability. In other words, Ridge's goal is to minimise errors during the training process by adjusting the coefficients while matching the training data well. Ridge is considered a very effective method in multivariate models, which can handle multi-collinear problems or data overmatch on even small datasets (Mohammadi, 2022).

The ElasticNet regression method is an enhanced approach that integrates both Ridge and Lasso**.** Lasso can also lose information, while Ridge can keep unnecessary variables. ElasticNet is considered a synthesis method that promotes the advantages and overcomes the disadvantages of Lasso and Ridge, which are to eliminate variables with an estimation coefficient of 0 (after adjustment) and try to retain variables even though they are less correlated with the target variable (Sirimongkolkasem & Drikvandi, 2019).

In this study, three scenarios correspond to three different methods to compare and evaluate the performance of each technique for Vietnamese commercial banks. From there, the study determines the importance and trend of each observed factor's impact on the target value based on the method that performs the best. The authors hope to provide more reliable empirical evidence on applying Lasso, Ridge, or ElasticNet methods to multivariate linear regression problems in particular or fields in economics in general.

Research Data and Methodology

We looked at the regression findings to see how the independent variables affected the Z-score index and in what direction. Each component was assigned four levels of influence: no, moderate, small, and significant impact. By merging these methodological approaches thoroughly, the study offers insights and recommendations for scholars and practitioners.

Research Data: The dataset was compiled from 30 Vietnamese commercial banks from 2010 to 2023. In particular, the bank's characteristics and macroenvironmental factors are collected from reliable sources such as consolidated financial statements, the State Bank, and the World Bank. The authors standardise the dataset before conducting regression experiments.

Methodology: The authors approach this article using qualitative and quantitative research methods. The authors synthesise factors to build a research model, drawing on the theoretical basis and empirical evidence from previous research. The authors identified many factors that impact bank stability after briefly reviewing and synthesising previous research, as detailed in Table 1. The authors collect, calculate, and pre-process the dataset based on these factors before putting it into experiments. As a result, the research approaches Hafeez et al. (2022) method of calculating the Z-score value based on the mean of the ROA (ROAA) and the standard deviation over the sampling period to the present. Therefore, the Z-score_{it} index evaluates the stability of bank i in year t, as determined by the following formula:

$$Z\_score_{it} = \frac{ETA_{it} + ROAA_{it}}{\partial_{ROAA_i}}$$

In which *i* is the representative variable of the bank, *t* is the time, *ETA* is the ratio of equity to total assets, *ROAA* is the return on average total assets, and the standard deviation of return on average total assets of bank *i* in the research period. The higher the Z-score value, the more banking stability there is. The multivariate linear regression model is constructed in the following general form:

$$\textbf{Z-score}_{it} = \beta_0 + \beta_1\{\text{Comp}_{it}\} + \beta_2\{\text{Bank}_{it}\} + \beta_3\{\text{Macrot}\} + e_{it}.$$

In which: e_{it} is a random error; $\beta_0 \dots \beta_3$ are the parametric vectors that must be estimated. Comp, Bank, and Macro are vectors representing competitive factors, banking characteristics, and

the macro environment, respectively. In addition, the COVID-19 pseudo variant will be included in the research model to consider the impact of COVID-19 on bank stability in recent years (since 2019). Summarizing from previous studies, the factors that affect the Z-score index include:

Table 1: ***Summary of factors affecting Z-score from previous studies***

Variable	Meaning	Calculation formula	Expectation Signs	Citation source
Z-score	Banking stability index	$Z\_score_{it} = \frac{EAT_{it} + ROAA_{it}}{\partial_{ROAA_i}}$		
Lerner	Competitiveness	$Lerner_{it} = (P_{it} - MC_{it})/P_{it}$ *In this case, P is the output price calculated by the total revenue per total assets, and* MC is the marginal cost of the bank.	+	(Jeon et al., 2017; Pham et al., 2021; Peter et al., 2022)
FS1	Ratio of the number of foreign banks	FS1 = Total number of foreign bank branches/ Total number of Vietnamese banks	-	(Jeon et al., 2017; Pham et al., 2021)
FS2	Proportion of assets of the foreign banks	FS2 = Total assets of foreign banks/Total assets of Vietnam's credit system	+	
ETA	Equity size on total assets	ETA = Equity / Total assets	+	(Pham et al., 2021; Samir et al., 2023)
SIZE	Bank size	Ln (Total assets)	+	(Pham et al., 2021; Sirimongkolkasem & Drikvandi, 2019)
LTA	Loan Rates	LTA = Total Loans / Total assets	+	(Maria et al., 2022; Pham et al., 2021)
HDV	Capital Mobilization Rate	HDV = Total Capital Mobilization / Total assets	+	(Pham et al., 2021; Jeon et al., 2017)
LDR	Efficiency of using mobilized capital	LDR = Total Capital Mobilization/ Total Loans	+	(Pham et al., 2021; Mohapatra et al., 2023)
ROE	Return on Equity	ROE = Profit After Tax/Equity	+	(Pham et al., 2021; Albaity et al., 2019)
CTI	Cost-efficiency	CTI = Total Operating Expenses/ Total Income	-	(Pham et al., 2021; Rakshit & Bardhan, 2019)
LLP	Credit risk provision ratio	LLP = Total Credit Risk Provision / Total Outstanding Loans	-	(Pham et al., 2021; Prakash et al., 2022)
HHI	Ability to diversify income	$HHI = 1 - [(NON/NI)^2 + (NET/NI)^2]$ *In which:* NON: non-interest income; NET: net interest income; NI = NON + NET.	+	(Srivastava et al., 2023; Pham et al., 2021)
MS	Market Power	MS = Bank Total assets/ Total assets of VN Credit System	-	(Pham et al., 2021; Srivastava et al., 2023)
Growth	TTS Growth Rate	$(TTS_i - TTS_{(i-1)})/TTS_{(i-1)}$	-	(Pham et al., 2021; Bayeh et al., 2021)
GDP	GDP growth rate	$(GDP_i - GDP_{(i-1)})/GDP_{(i-1)}$	+/-	(Albaity et al., 2019; Pham et al., 2021)
INF	Inflation rate		+/-	(Jeon et al., 2017; Pham et al., 2021; Srivastava et al., 2023)

Covid	Influenced by Covid_19	0 - Covid-free year 1 - Year of Covid	-	(Srivastava et al., 2023; Mohapatra et al., 2023)

Source: Summary of the authors

Starting from the research idea, we develop a situation-based experimental scenario: adjusting the coefficient and removing non-important variables (Lasso); not removing the variable but only adjusting the most suitable set of model parameters (Ridge); combining both Lasso and Ridge methods to both change the model coefficient and remove variables that are considered to be few related to the target variable.

Study Results

Analyse the results of descriptive statistics and correlation matrix of factors in the research model. Some results were obtained by summarising the data of 30 Vietnamese commercial banks from 2010 to 2023. Regression results of the research model based on an experimental study on the dataset of 30 Vietnamese commercial banks in 2010 - 2023 using the Lasso, Ridge, and ElasticNet methods obtained the following results. The results show the degree of variation of the estimated parameters in the model when the value λ change corresponds to each Lasso, Ridge, and ElasticNet method (performed by cross-valuation method). Accordingly, the value $\lambda = 0.000295$ is considered the most optimal. Results in Table 2 show that the Lasso and ElasticNet methods have similar variation levels of the estimated parameter set. The set of estimation parameters selected when training with each method yields the following results.

Table 2: ***Regression results using Lasso, Ridge, and ElasticNet methods***

Order Number	Independent variables	Estimation coefficient Lasso	Estimation coefficient Ridge	Estimation coefficient ElasticNet
1	Z-score_1	**0.2302**	**0.2286**	**0.2360**
2	FS1	-0.0369	-0.1041	-0.0644
3	FS2	-0.0838	-0.0920	-0.0849
4	SIZE	0.0394	0.0494	0.0419
5	ETA	0.0017	0.0684	0.0083
6	ROE	0.5281	0.5735	0.5375
7	LTA	*0.0000*	0.2583	0.0557
8	HDV	0.0487	-0.1661	0.0005
9	LDR	-0.0575	-0.4051	-0.1443
10	CTI	-0.0882	-0.1805	-0.1335
11	LLP	-0.0319	-0.0705	-0.0511
12	HHI	*0.0000*	0.0165	*0.0000*
13	GrowTA	-0.0338	-0.0661	-0.0537
14	MS	*0.0000*	-0.0403	*0.0000*
15	Lerner	0.0312	0.0322	0.0386
16	GDP	*0.0000*	0.0047	0.0017
17	INF	-0.2243	-0.2102	-0.2190
18	Covid_0.0	0.0401	0.0225	0.0380
19	Covid_1.0	*0.0000*	-0.0225	-0.0023
Training Performance	MSE	0.002776	0.002607	0.002725
	R^2_score	87.73%	88.75%	87.96%

Source: Calculation and synthesis results in Python by the authors

The extent and direction of the impact of input factors on the Z-score value based on the regression coefficient results in Table 2 of each method is visualised as follows.

Results on the impact of factors on stability at the Bank of Vietnam

Based on the results of the regression estimation coefficient obtained (Table 3), the authors divide it into 4 evaluation levels according to the following corresponding value ranges:

Table 3: ***How factors affect Z-score by Lasso, Ridge, ElasticNet***

Impact on Z-score	Lasso	Ridge	ElasticNet
No Impact (~0.0000)	LTA, HHI, MS, GDP, Covid_1.0		HHI, MS
Minimal impact (0.0001 - 0.0099)	ETA	GDP	ETA, HDV, GDP, Covid_1.0
Have an impact (0,0100 - 0,0999)	FS1, FS2, SIZE, ETA, HDV, LDR, CTI, LLP, GrowTA, Lerner, Covid_0.0	FS2, SIZE, ETA, LLP, HHI, GrowTA, MS, Lerner, Covid_0.0, Covid_1.0	FS1, FS2, SIZE, HDV, LLP, GrowTA, Lerner, Covid_0.0
Many impacts (0,1000 - 0,9999)	Z-score_1, ROE, INF	Z-score_1, FS1, ROE, LTA, HDV, LDR, CTI, INF	Z-score_1, ROE, LDR, CTI, INF

Source: Author's summary results

Table 3 shows all three regression methods yield similar results regarding the correlation between independent variables and the Z-score target variable. The study model may exclude factors with small estimation coefficients. However, the Ridge regression method's performance measurement results yielded the best results on the MSE and R2-score indicators, indicating its suitability for the study dataset.

Discussion of Findings

The regression coefficient for the result bears a positive sign, implying that the previous year has a positive impact on the current year's stability.

The presence of foreign banks is reflected in the regression coefficients of the two variables, FS1 and FS2, which show negative signs. This suggests that an increase in the number of SBV branches and total assets harms the stability of Vietnamese commercial banks. SBVs have capital and operating capacity advantages and are strong enough to apply modern financial technology. Pham et al., 2021). Besides, bank size (SIZE) based on the regression coefficient with a positive sign indicates that the bank size is acting in the same direction as the bank stability. This result is similar to the study of (Jeon et al., 2017; Kumar & Mallika, 2021; Bayeh et al., 2021).

Equity to Total Assets (ETA): The result shows a positive regression coefficient, indicating that banks with higher equity are more stable. This is consistent, as banks with a higher proportion of equity face less borrowing pressure and can proactively expand and increase development investments. Moreover, when banks have higher equity, their profits tend to be better because this equity can be used for investments without incurring interest costs or other expenses associated

with borrowed capital. This result aligns with expectations and other studies (Prakash et al., 2022; Pham et al., 2021). Besides, the Gross Asset Growth Rate (GrowTA) is a regression coefficient that has a negative sign, suggesting that an increase in the asset growth rate will negatively impact bank stability. For an emerging economic market like Vietnam, along with the entry of foreign organisations, the trend of comprehensive digital transformation in management and operation is focused on drastic investment by bank leaders (Pham et al., 2021; Rakshit & Bardhan, 2019).

Market share strength (MS): When considering the size of the bank's assets compared to the whole market, MS gives a regression coefficient result with a negative sign (Ridge) and almost no impact (Lasso, ElasticNet). The implication is that if MS impacts bank stability, it will affect the opposite direction of stability. Competitiveness (Lerner): The regression coefficient of the Lerner variable is meaningful and carries a positive sign, implying that competitiveness positively impacts bank stability. The results of this study are precisely as expected initially, similar to many previous studies (Kumar & Mallika, 2021; Pham et al., 2021; Mohapatra et al., 2023).

Credit scale (LTA and HDV): The regression coefficient result for LTA bears a positive sign, implying that the ability to lend has the same impact as bank stability. The results are similar to the study of (Pham et al., 2021). On the other hand, the ability to mobilise capital from 2010 to 2023 during the research period negatively affects the bank's stability. Besides, the efficiency of the use of mobilised capital (LDR) based on the regression coefficient result for LDR bears a negative sign, implying that the efficiency of using mobilised capital is inversely correlated with bank stability (Kumar & Mallika, 2021; Pham et al., 2021).

Return on equity ratio (ROE): The regression coefficient is statistically significant and bears a positive sign. This implies that profitability has a positive impact on bank stability.
Income diversification (HHI): The results show that HHI correlates in the same direction as the Z-score. This proves that the ability to diversify income in recent years has positively impacted bank stability. This result is in line with expectations and similar to the research results of Pham et al. (2021) and contrary to the research of (Jeon et al., 2017). Besides, cost efficiency (CTI): the regression coefficient of the CTI variable has a negative sign, implying the efficiency of cost use in the study period has the opposite impact on bank stability. This result is similar to the study of (Mohapatra et al., 2023) when they believe that the cost increase is more significant than the bank's income will affect financial efficiency, leading to decreased bank stability.

Provision to credit risk ratio (LLP): The regression coefficient of LLP variables has a negative sign, which is the opposite of bank stability. This shows that the higher the provision ratio, the more unstable it is; bad debts are always a worrying problem for Vietnamese banks, especially after Covid-19. The bad debt ratio increasingly negatively impacts financial performance (Maria et al., 2022; Pham et al., 2021).

Macro factors (GDP and INF): Different macro factors impact bank stability differently. Accordingly, the GDP growth rate has a positive impact on bank stability; this result is similar to the study of (Jeon et al., 2017; Pham et al., 2021) and the opposite (Kumar & Mallika, 2021); the inflation rate has the opposite effect on bank stability, this result is similar to (Jeon et al., 2017) in

contrast to (Pham et al., 2021). This shows that for an emerging economic market such as Vietnam, the level of banking stability will increase in a suitable growth environment where inflation is well controlled. Finally, the COVID-19 epidemic harms bank stability; the opposite result is for years without the epidemic. This result is reasonable with the actual situation and the aggregate results mentioned earlier (Srivastava et al., 2023; Mohapatra et al., 2023).

While unique to Vietnamese commercial banks, the study's findings have more significant implications for banking systems in emerging nations and beyond due to advanced regression techniques. Furthermore, the Lasso, Ridge, and ElasticNet regression methods effectively tackle multicollinearity and overfitting in high-dimensional datasets, making them applicable to banking stability studies worldwide. These methodologies offer a strong foundation for studying financial stability in many economic circumstances.

Conclusion and Recommendations

The study's outcomes have met most of the initial objectives. As a result, the study's findings provide empirical evidence that the Ridge regression method yields the highest performance, with the results of Lasso and ElasticNet showing significant similarities. Based on the research results, the authors suggest several implications that could improve both experimental and operational efficiency for bank managers.

First, choosing a suitable regression method is extremely important. There is currently no official conclusion on which method is best to use. Adjusting the model coefficients only between the inputs (according to the idea of the Ridge method) can limit the loss of necessary information, but at the same time, it may not eliminate the information that is not necessary for the model. On the other hand, removing factors based on regression results for approximate estimation coefficients of 0 (as the idea of the Lasso and ElasticNet methods) can cause potential information loss in the model. The results showed that the performance of the three differential methods was negligible. Therefore, choosing the most suitable method for the research dataset must be carefully considered. It should be regarded as following each bank's management perspective, evaluation system, and individual policies.

Second, the results show that the two methods of Lasso and ElasticNet have highly similar results. The results of the estimated parameter set and the performance of the regression methods depend significantly on the selection of the appropriate adjustment factor (coefficient). Therefore, it is necessary to research, test, and combine more methods of determining the value of the adjustment coefficient to achieve the best efficiency. All three methods should use the same value to ensure consistency in model estimation coefficient adjustment and increase reliability for research results. In this study, uniform use value $\lambda = 0{,}00005$. At the same time, the research results need to be controlled regularly to promptly detect anomalies in the dataset and avoid affecting the accuracy of regression results.

Third, factors pointing in the same direction suggest that development should be the primary focus for strengthening bank stability. Bank managers must regularly monitor and

implement appropriate improvement solutions for factors negatively impacting bank stability. However, it is necessary to be flexible in regulating and considering the index from many angles. For example, the growth rate of the total assets of 30 Vietnamese commercial banks studied in 2010–2023 shows the opposite impact on bank stability. This is not necessarily negative because additional investment in assets can cause temporary instability, take time to exploit and recover, and have positive effects in the future. The impact of income diversification (HHI) activities has been consistent with that of the Z-score in previous periods. Therefore, promoting and focusing on rational cost allocation for product and service diversification activities is necessary.

Fourth, the presence of foreign banks shows a negative impact on the stability of Vietnamese commercial banks. However, expanding market size and capital scale is inevitable as international integration expands. For a country with an emerging economy like Vietnam, the banking industry needs an appropriate strategy to turn challenges into opportunities by taking advantage of cooperation, learning, exchanging, and absorbing robust strategies from competitors to enhance its competitiveness. Therefore, banks must develop a reasonable approach to increase market share following a specific roadmap to improve the brand and position in domestic and foreign markets. In the context of increasing international integration and financial liberalisation, banks in emerging economies such as Vietnam must also keep up with technological trends and global financial management standards.

Finally, determine the extent and trend of each factor's influence on bank stability. This will be the basis for bank administrators to develop new strategies or adjust current operating methods to suit the bank's characteristics and policies. To achieve this, banks should create a transparent policy system and clear legal corridors for bank activities. The bank leader's ingenious, flexible, and wise leadership and the employees' consensus and smooth coordination are also essential.

Limitations and future research: The dataset is substantial, but its limitations, based on 30 Vietnamese commercial banks across 13 years, may not capture all aspects affecting banking stability in different economic conditions. The study did not include geopolitical issues and financial technology improvements, which assessed some critical factors. Finally, ElasticNet, Ridge, and Lasso regression models assume linear relationships between variables. This study didn't examine nonlinear dependencies. Future research could include banks from other developing economies to improve generalizability. Additionally, advanced machine learning approaches like neural networks and decision tree nonlinear models can be employed to detect nonlinear relationships. Cybersecurity, Fintech integration, and consumer happiness are other exciting research fields.

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