

Does Stability Imply Efficiency in the Banking System? [Killing Two Birds with a Stone]**David Iheke Okorie¹, Akweny Andrew², Dak-Adzaklo Cephas Simon-Peter³, Geoffrey Bentum-Micah⁴**¹Wang Yanan Institute for Studies in Economics (WISE), Xiamen University, China²School of Management, Xiamen University, China³Institute for Finance & Accounting Studies, Xiamen University, China⁴School of Economics & Management, Hubei University of Technology, China***Corresponding author***David Iheke Okorie***Article History***Received: 22.10.2017**Accepted: 26.10.2017**Published: 30.11.2017***DOI:**

10.21276/sb.2017.3.11.1



Abstract: This paper examines the likelihood of efficiency given stability in a competitive market (banking system). Apparently, a financial crisis emanates from instability and inefficiency in the financial system(s) wherein the banking system is a key institution. Therefore, our concern geared towards maintaining both stability and efficiency in the banking system to avoid global financial crisis (contagion effect) using Bayesian Techniques. We deciphered a 1-1 mapping between the stability & efficiency indexes. We also discovered variant forms of relationships existing between stability and efficiency indexes (scores). Our findings identified levels of Stability that are highly predictive of certain levels of efficiency. Sequel to these findings we recommend contingent planning; which makes plans considering possible actions, consequences, and objectives towards achieving the desired levels of stability and efficiency in the system.

Keywords: Financial System; Banking System Stability & Efficiency; Likelihood

INTRODUCTION

Financial system consists of closely related services, markets, and institutions, which are to provide effective and efficient link between the surplus units (lenders) and the deficit units (borrowers). Financial system is the collection of financial institutions, financial markets, financial services and financial instruments. Financial system operates at global levels, national levels, and firm levels.

Overtime, this system has proved to be a crucial part of every economy as it has the capacity to drive an economy into boom or recession. This has drawn much attention from researchers into studying the dynamics of this system. Just as a stable and efficient financial system drives the economy to a boom, inefficient and unstable financial system drives the economy to recession and crisis. It's no news that financial crisis can spread from an economy to another till it becomes a global crisis. This had happened couple of times and policy makers have channelled lots of efforts toward understanding financial crisis. The understanding of this phenomenon has made financial efficiency and stability a critical factor in every economy as their absence in the system breeds crisis coupled with contagion effects, which trickles to other sectors in the economy and to other economies of the world, resulting in a global financial crisis. This crisis is associated to banking panics, recessions, stock market crashes, bursting bubbles, currency crises, and sovereign defaults, etc. It is vital to understand every global financial crisis often starts in an economy.

There are microeconomic and macroeconomic consequences which are inevitable during financial crisis. These may include, welfare lose; which reduces the availability of the minimum well-being and social support provided for all the citizens, lose of jobs due to a recession cause by the financial crisis, etc. the currency crisis; which is a function of the fear and doubt about whether the apex bank of an economy has enough foreign reserve to maintain the economy's fixed exchange rate. Sovereign default; is also one of the negative outcomes of financial crisis, making sovereign governments refuse to pay or completely pay back its debt. These consequences cannot be over emphasized however, after the 2007-08 global financial crisis, the United States enacted the Consumer Protection Act in 2010, which brought into existence the Consumer Financial Protection Bureau (CFPB) which is purposely set to protect the consumers in the financial sector against crisis. Other economies have also taken some critical actions to ensure that consequences of financial crisis are not highly felt in their economy. For instance, the impact of the 2007-08 financial crisis was not greatly felt in Peoples Republic of China owing to the fact that she operated a closed financial sector which is not open to investors from the rest of the world and subsequently lunched the Economic Stimulus Plan (ESP) to specifically deal with the crisis through increase in affordable houses, easing credit restrictions for SMEs and mortgages, lower taxes, increase public

investments into infrastructural development, etc. A world wide form of these anti financial crisis is that of Financial Stability Board (FSB) established in London at the G-20 summit in 2009.

Scholars have made efforts towards addressing the issue of banking system stability and efficiency by mostly examining the nature of the relationship between stability & efficiency, and establishing their trade-offs, etc. These studies showed that banking system stability has significant impact on efficiency in the system while the direction of this impact could be positive or negative. As such, researchers seek to find a balance between stability and efficiency in the banking system to avoid the consequences of instability and inefficiency in the system [1-8].

Banks' Stability therefore is the measure of banks' ability to meet its financial obligations and the overall possibility of default. While Banks' efficiency is the productivity of the banks, it measures how capable banks can turn assets into revenue and minimize the required costs. In clear terms, the banking system is stable and efficient when it can function effectively, resilient to financial stresses, assessing risks, managing risks, efficient resource allocation, maintain monetary and employment stability, mitigate adverse and unforeseen shocks, fulfill basic functions smoothly, maintain functional balances such that, improving a function makes another at least worse off, etc. There are developed variables to quantify and measure the efficiency and stability of the banking system in an economy. For instance, the World Bank (WB) defined measures to capture most characteristics in the financial system of an economy such as efficiency, stability, depth, access, etc. for financial institutions (Banks, insurance companies, etc.), financial markets (stocks and bond markets), and others such as competition and concentration in the banking sector. This database is termed the Global Financial Development Database (GFDD). This study uses the measures of banking system stability and efficiency as developed by the World Bank to capture the objectives of this work while adopting the techniques of Factor Analysis, Basic & Proportional odds Cumulative Logit model, and the Additive Nonparametric model.

This paper examines figuratively, if we could kill two birds with a stone. In other words, we set out to establish the balance between stability and efficiency in the banking system using probability predictions thus, achieving both factors concurrently. This classification analyses use the logistic distribution (cumulative and marginal density functions of efficiency given stability). We conduct a broader study of efficiency and stability in the banking system given that different measure of these variables does not give consistent conclusion [9]. The banking system is the key in every economy hence, instabilities and inefficiencies in this system are most likely to trickle down to a financial crisis, which definitely cuts across other economies of the world. Emphasis is on the fact the banking system cuts across the financial institutions, financial markets, financial services and financial instruments in the financial system. The banking system plays a crucial role in all the blocks (i.e. financial institutions, markets, services, and instruments) therefore; the role of the banking system in an economy is paramount and key in maintaining financial system stability and efficiency. Suffice to say; the financial system is stable and efficient mostly if the banking system is stable and efficient.

Moreover, to establish this balance in the banking system, we employ the maximum likelihood techniques, which produces the estimates (log-odd ratios) that maximize the success likelihood (conditional distribution) of the response factor given the predictor(s). Given that efficiency is the response variable while stability is the independent variable [10], we thereby predict the success likelihood of efficiency conditioned on stability in the banking system. Our choice of methodology accounts for internal validity threats in forms of: inconsistent standard errors, omitted variable bias, sampling errors, error in variables, simultaneous classification bias, and wrong functional form. Thus, largely, our results are also externally valid. Invariably, this work sets the platform and basis on which policy makers in every economy will make concrete decisions regarding the stability and efficiency of their banking system such that the likelihood of financial crisis tends to zero. The nonparametric additive model establishes the true data driven form of relationship between banking system stability and efficiency without any form of functional form restrictions (both linear and nonlinear). Negative and Positive log odd-ratios does not really imply a negative and positive relationship between efficiency and stability rather higher and lower chances of success respectively. The positive and negative log odd ratios translate to positive odd ratios when the exponential function is applied. This is the justification on finding the direction of the relationship between efficiency and stability using a nonparametric data driven approach.

Efficiency measures have taken variant forms in literature including parametric, non-parametric, Bayesian, duality theory, analysis of sampling asymptotic properties, bootstrapping techniques etc. [11-13]. However, researchers have assessed the banking system efficiency using parametric frontier techniques like logistic likelihood [14-20]. In addition, nonparametric frontier techniques like the data envelopment analysis have also been utilized [21-25].

Fragility of the Financial System (mostly the Banking Industry) breeds concern on the payment-system risks unique to the banking industry, with little known about its efficiency and risk properties. The argument being that efficiency in the form of increased competition is most likely to cause financial instability in the whole system due to the

contagion and ripple effects. Implying that financial efficiency and stability are inversely related using partial equilibrium analysis [26-28].

Although competition in the banking sector (efficiency) is complicated by the need to maintain financial stability hence, a balance should be sought, such that will maintain financial efficiency and financial stability concurrently. Different models disclosed different results, denoting the complexity of the relationship between efficiency and banking stability even though it is certain that competition harnesses banking efficiency [26]. In the same light, Freixas & Parigi [5] tried defining the trade off between efficiency and stability given they are inversely related through studying how an effective payment system should be designed such that would capture efficiency and stability in the banking system considering the gross and net types of payment systems. They established the trade off between these two means using the interbank payment systems which maintains equilibrium in terms of safety and efficiency. Evidence from emerging economies on maintaining a balance between stability and efficiency in the banking system is not financial liberalization but on the degree of competitiveness with incorporated high level of financial depth and macroeconomic factor evolution [6]. Amongst others, Sharma [10] discovered that bank size and profitability are most predictive of efficiency in the Indian banking system using the nonparametric data envelopment Analysis and the logistic regression model.

In opposing view, there are empirical evidences not only in the United States, validating that efficiency (competition) and banking stability are positively related. Using data from 79 economies showed that financial instability is less likely in a more concentrated and efficient system of banking i.e. economies with few regulations and restrictions on competition in the financial institutions, and supports private property rights [4]. Moreover, looking at efficiency and stability of banks and financial markets concurrently, Allen [26] noted that financial systems have in the past been bank or/and market based which are subject to crises. He suggested that changing to a financial intermediary based system would help reduce shocks and links efficiency to risk sharing, information provision, corporate governance, funding new industries, law and finance, etc.

METHODS

Objectively, this work seeks to establish the probability of efficiency while assessing stability. That is, what is the likelihood of efficiency given stability? To capture likelihood, we adopt binary choice model(s) without systematic problems and assume the error term is logistically distributed. We also have to guarantee that the response variable follows Binary Distribution thus; derive the likelihood function to maximize with respect to the parameter estimates. In other to establish this framework, we follow the group average classification techniques [29-30]. The definition is on the use of central tendency in identifying and classifying units into successes and failures. Thus, efficiency transforms systematically into binary and ordinal variables using the average and groups-within-group definition respectively. The *Average Definition*; under this definition of efficiency, we adopt a central tendency (arithmetic mean) of the efficiency factor scores to form the benchmark on which economies or data points are classified into success (efficient banking system) or failure (inefficient banking system). The *Groups-Within-Group Definition*; the average definition groups the efficiency scores into two broad groups. We further use the within group arithmetic mean to split the two broad groups into four groups. Thereby, generating four ordinal groups (from most efficient to least efficient banking system), which follows multinomial distributions. This affords us the opportunity to distinguish economies further based on their levels of banking system efficiency. The likelihood of ordered efficiency provides the most likely level of efficiency given stability. Therefore, we employ the proportional odds cumulative logit model for efficiency, which captures the probability that efficiency falls at or below a particular threshold given levels of stability. For outcome category j , the cumulative probability given

$$\left(\text{Stability}_i, W_i, \text{Efficiency}_i \right)_{i=1}^n \quad \text{is:} \\ P(\text{Efficiency} \leq j) = \frac{\exp(\alpha_j + \text{Stability}^T \beta + W^T \gamma)}{1 + \exp(\alpha_j + \text{Stability}^T \beta + W^T \gamma)} \quad (1)$$

When the j – categories of the response variable reduces to 2; which in most cases are binary outcomes, the proportional odd cumulative logit model reduces to the basic logit model. The basic logit model is a special case of the proportional cumulative logit model and used for likelihood estimation and classification purposes. We adopt the Deviance techniques to examine the models' adequacy. Nonparametric data driven relationship estimation techniques are to validate the forms and directions of the relationships between efficiency and stability. There is no parametric functional form restriction (both linear and nonlinear) as to the form or nature of relationship between these characteristics. We model the relationship non-parametrically using the Additive Model as stated in equation2:

$$\text{Efficiency}_{qi} = \omega + \sum_{j=1}^m g_j(\text{Stability}_j) + \varepsilon_i \quad (2)$$

For identification purposes, $E(\text{Efficiency}_i) = \omega$ and $E(g_j(\text{Stability}_j)) = 0$, $j = 1, 2, \dots, m$. Efficiency_{q_i} is the q th efficiency measure where q represents the latent factors of Efficiency, ε_i is the error term, and $g_j(\text{Stability}_j)$ represents the unknown functional form of efficiency relationship(s) which is a function of stability. We adopt the nonparametric Spline estimations because we do not interact term(s) in the Additive model. The tuning parameter (Effective Degrees of Freedom) is as penalized regression splines. Adopting the Ridge Penalty of Spline estimation, which shrinks irrelevant estimates close to zero in estimating the model?

In estimating the multivariate distribution, we try to capture the dependence structure among Efficiency and Stability variables thus, using the copula density function. While selecting the optimal bandwidth consider the performance of the Rule of Thumb, and Cross Validation techniques. The copula density approach is preferred mostly because it captures the dependency structure between variables unlike the normal density approach, which assumes variable independence. Copula approach is like a generalized approach. The copula function in estimating the joint distribution of independent variables, takes a unit value (one) i.e. reducing the joint distribution to an independent distribution. Otherwise, the copula function takes on values which are data driven with respect to the nature of the dependency structure between or among the variables. Sklar's theorem [31] with respect to change of variables shows we can represent the joint distribution as:

$$F(x_1, x_2, \dots, x_k) = C(F_1(x_1), F_2(x_2), \dots, F_k(x_k)) \quad (2.1)$$

$F(x_1, x_2, \dots, x_k)$ is the joint distribution for $x = [x_1, x_2, \dots, x_k]$ with density $f(x_1, x_2, \dots, x_k)$ and distribution $F_j(x_j)$, where $C(F_1(x_1), F_2(x_2), \dots, F_k(x_k))$ is the copula function taking any value between 0 and 1 with both limits included. Partially differentiating equation (2.1) with respect to x_1 and x_2 gives:

$$f(x_1, x_2) = f_1(x_1)f_2(x_2) \dots f_k(x_k)c(F_1(x_1), F_2(x_2), \dots, F_k(x_k)) \quad (2.2)$$

The dependency structure captured by copula density is scale free and invariant to monotone transformations, capturing both linear and non-linear dependency structures. In cases of independence $c(F_1(x_1), F_2(x_2), \dots, F_k(x_k)) = 1$ and the copula decomposition of the joint density is reduced to $f(x_1, x_2) = f_1(x_1)f_2(x_2) \dots f_k(x_k)$. The copula density function is estimated using kernel method which is data driven instead of the parametric methods like Gaussian copula, Frank copula, Clay copula, etc. which are to an extent not flexible enough relative to data driven methods like kernel. To reduce the boundary bias drawback of kernel method, we use the boundary kernel method and adopt the two-step estimation strategy to mitigate the curse of dimensionality.

According to the World Bank 2013, there are developed series used to capture among others the levels of stability, efficiency, depth, and access of the financial systems in an economy, covering about 203 economies. Therein, some measures of the banking system efficiency are: Bank cost to income ratio, Bank lending-deposit spread, Bank net interest margin, Bank noninterest income of total income, Bank overhead cost to total assets, Banks return on assets (before & after tax), Bank return on equity (before & after tax) etc. Stability measures includes, Bank capital to total assets, Bank credit to bank deposits, Bank nonperforming loans to gross loans, Bank regulatory capital to risk-weighted assets, Bank Z-score, Liquid assets to deposits and short term funding, Provisions to nonperforming loans, etc.

These variables rigorously measure efficiency and stability in the banking systems, which are of interest to us. In other to investigate and empirically validate our hypotheses, we employ the factor analysis, which is as attributed to Karl Pearson [29] and Charles Spearman [32]. It aims to explain the covariance relationship among variables using few unobservable, random, and underlying values known as factors. In factor analysis, one of the critical things to do is to establish systematically the factor scores using appropriate methods. In describing the covariance relationships among variables by few unobservable random factors, we must guarantee that high correlation exists within than between groups. The orthogonal factor model is

$$[X - \mu]_{(p \times 1)} = L_{(p \times m)}F_{(m \times 1)} + \varepsilon_{(p \times 1)} \quad (3)$$

This is the equation for centralized random vector X of the original p random variables with the mean vector μ , on the matrix of Factor Loadings L , Common Factors F to explain entirely all the correlation structure between p variables with the individual Specific Factors ε explaining the unique factor features. The link between factor analysis and principal component analysis is on getting the unobserved and random quantities. The Factor PCA models seeks to model the relationships among variables in terms of few latent quantities (Factor Score) while the PCA provides a method to calculate factor loadings on the few latent and random quantities which is used to develop the factor scores.

RESULTS AND DISCUSSIONS

Summary statistics of the variables are in Table 1a & 1b (see appendix). The PCA is primarily a data reduction mechanism used to derive uncorrelated indexes from highly correlated random variables such that there are little or no correlation amongst the principal components and mainly approximates total variances while factor analysis maximizes correlation that exists among random variables. By definition, efficiency covariates i.e. Bank cost to income ratio is the ability, ease, and quickness of the institutions to convert resources into revenue. Bank net interest margin captures the change on income made from the interest paid to lenders to the interest earning assets of the institution. Bank noninterest income is fees charged by the institutions mainly the deposit and transaction fees. Banks overhead cost to total asset is the comparison of the operating expenses of the institution to its assets held. Bank return on assets or equity is the institutions' net income on the average annual total assets or equity. Stability variables i.e. banks' capital to asset ratio is the ratio of banks' capital and reserve to total assets. Banks' credit to deposit is the ratio of the total credit provided by the banks to the total deposits. Banks nonperforming loan to gross loan compares default loans and total gross loans in ratios; provisions are for these loans. Regulatory capital to risk weighted assets compares regulatory capital and assets weighted on risk levels in ratios. Banks' Z-score is the probability of default in the banking system as it compares capitalization and return to the volatility of those returns. Liquid assets to deposits and short term funding are the ratio of liquid assets to the sum of funding and total deposits.

In calculating the factor scores for efficiency, the null hypothesis that $m - factors$ is/are sufficient is/are rejected until $m = 4$ factors. The factor loadings are also rotated using the varimax rotation before calculating the scores. The factor loadings have high communalities as well as very small residual matrix (close to zero). Using the Maximum Likelihood methods, the four factors capture approximately 81% of the total variations in the original eight random variables while approximately 91% captured using the Principal Component method. On this note, we have four factors, which can adequately explain efficiency in the banking system without loss of much information. We employ the factor scores from the PCA method because it captures greater variations. In same vein, the null hypotheses that $m - factors$ is/are sufficient is/are rejected until at $m = 4$ factors, which is sufficient and captures 76% of the total variations in the original stability measures using the PCA method. In nutshell, the factor scores capture 91% and 76% of the total banking system efficiency and stability measures respectively. The four factor equations for efficiency and Stability are:

$$\begin{bmatrix} CIR - \mu_1 \\ NIM - \mu_2 \\ OCTA - \mu_3 \\ NITI - \mu_4 \\ ROAa - \mu_5 \\ ROAb - \mu_6 \\ ROEa - \mu_7 \\ ROEb - \mu_8 \end{bmatrix} = \begin{bmatrix} -.36 & .16 & -.57 & -.56 \\ .20 & -.18 & -.85 & .32 \\ .04 & .98 & -.11 & .05 \\ .04 & .31 & -.90 & .03 \\ .97 & .03 & -.04 & .23 \\ .93 & .04 & -.09 & .33 \\ .23 & .05 & -.06 & .87 \\ .27 & .04 & -.14 & .89 \end{bmatrix} \begin{bmatrix} Efficiency_1 \\ Efficiency_2 \\ Efficiency_3 \\ Efficiency_4 \end{bmatrix} + \begin{bmatrix} .20 \\ .10 \\ .03 \\ .09 \\ .01 \\ .01 \\ .19 \\ .12 \end{bmatrix} \quad (3.1)$$

with communalities = [.80 .90 .97 .91 .99 .99 .81 .88]'

$$\begin{bmatrix} CTA - \mu_1 \\ CBD - \mu_2 \\ NLGL - \mu_3 \\ RCRWA - \mu_4 \\ ZS - \mu_5 \\ LADF - \mu_6 \\ PNPL - \mu_7 \end{bmatrix} = \begin{bmatrix} -.84 & .23 & .01 & .14 \\ -.11 & .64 & .14 & -.04 \\ -.28 & .21 & -.77 & .17 \\ -.73 & -.45 & -.05 & -.23 \\ .01 & .13 & .00 & -.94 \\ -.09 & -.78 & .18 & .09 \\ -.30 & .24 & .68 & .22 \end{bmatrix} \begin{bmatrix} Stability_1 \\ Stability_2 \\ Stability_3 \\ Stability_4 \end{bmatrix} + \begin{bmatrix} .22 \\ .20 \\ .26 \\ .21 \\ .10 \\ .35 \\ .34 \end{bmatrix} \quad (3.2)$$

with communalities = [.78 .80 .74 .79 .90 .65 .66]'

CIR - Bank cost to income ratio (%), *NIM* - Bank net interest margin (%), *OCTA* - Bank overhead costs to total assets (%), *NITI* - Bank noninterest income to total income, *ROAa* - Bank return on assets (%), after tax), *ROAb* - Bank return on assets (%), before tax), *ROEa* - Bank return on equity (%), after tax), and *ROEb* - Bank return on equity (%), before tax). To measure the system stability (*Xs*), we use *CTA* - Bank capital to total assets (%), *CBD* - Bank credit to bank deposits (%), *NLGL* - Bank nonperforming loans to gross loans (%), *RCRWA* - Bank regulatory capital to risk-weighted assets (%), *ZS* - Bank Z-score, *LADF* - Liquid assets to deposits and short term funding (%), and *PNPL* - Provisions to nonperforming loans (%). The factor scores $Efficiency_i$, $Stability_i$, $i = 1, \dots, 4$ are such that satisfy the two equations respectively using the least squares method to minimize individual specific residuals. From the loading matrix and the communalities, it is vital to note that mega information in the p original sets of random variables where captured by the m sets of factors. Efficiency Factor ($Efficiency_1$) - represents mostly the Bank Return on Assets (before & after tax). Efficiency Factor ($Efficiency_2$) - represents mostly the Bank overhead cost to Total Assets.

Efficiency Factor (*Efficiency*₃) - consists mostly the Bank Cost to Income Ratio, Bank Net Interest Margin, and Bank Noninterest Income to Total Income. Efficiency Factor (*Efficiency*₄) - consists mostly of the Bank Cost to Income Ratio, and Bank Return on Equity (before & after tax). Hence, the efficiency scores or indexes *Efficiency*₁, *Efficiency*₂, *Efficiency*₃, and *Efficiency*₄ are *Asset Efficiency*, *Cost Efficiency*, *Noninterest Income Efficiency*, and *Equity Efficiency* respectively. On the other hand, Stability Factor (*Stability*₁) - consists mostly the Bank Capital to Total Assets, and Bank Regulatory Capital to Risk-Weighted Assets. The Stability Factor (*Stability*₂) - captures mostly the Bank Credit to Bank Deposits, and Liquid Assets to Deposits & Short Term Funding. Stability Factor (*Stability*₃) - consists mostly the Bank nonperforming loans to gross loans (%), and Provisions to nonperforming loans (%). Stability Factor (*Stability*₄) - consists mostly of the Bank Z-Scores; titled *Capital Stability*, *Credit-Deposit Stability*, *Nonperforming Loan Stability*, and *Z-Score Stability* respectively.

Asset Efficiency (*Efficiency*₁) represents mostly the Bank Return on Assets (before & after tax) – the banks' returns to yearly averaged total assets. A high value of the Asset Efficiency is the anticipated outcome, which shows efficient returns. Hence, higher banks' returns imply higher Asset Efficiency. Conversely, lower the return on assets suggests lower Asset Efficiency. *Cost Efficiency* (*Efficiency*₂) represents mostly the Bank Cost to Asset Ratio – the banks' overhead costs to total assets – the banks' operating costs as a share of the value of all assets held. In line with our variables for cost efficiency, a high value of the cost efficiency is not a desirable thing. The higher the banks' costs to income or total assets imply higher banks' cost efficiency. In addition, the lower the income from either the interest bearing assets or the total assets, unlikely is the chances of covering the banks costs, thus increasing the banks' cost efficiency. However, when the banks' costs are relatively lower, this lowers the banks' cost efficiency. The higher the income from either the interest bearing assets or the total assets, the better chances of covering the banks costs, thus decreases the banks' cost efficiency. *Noninterest Income Efficiency* (*Efficiency*₃) consists mostly the Bank Net Interest Margin – the banks' net interest returns as a share of its average interest-bearing assets. Bank Noninterest Income to Total Income – the banks' income generated via non-interest related activities (percentage of total income). This is primarily from fees including deposit and transaction fees, insufficient funds fees, annual fees, monthly account service charges; inactivity fees, check and deposit slip fees, and so on. A high value of non-interest income efficiency is favourable. As a result, when there are more non-interest related activities, the higher the non-interest income to total income thus increasing the non-interest income efficiency. A lower efficiency on non-interest income arises when there are less non-interest related activities thus decreasing non-interest income efficiency. While *Equity Efficiency* (*Efficiency*₄) consists mostly the Bank Cost to Income Ratio – this is the banks' operating expenses as a share of the sum of net-interest revenue and other operating income, and the Bank Return on Equity (before & after tax) – the banks' income to yearly averaged equity. Costs and incomes are rooted on the existence of equity. Therefore, the higher the equity, the higher the return on it, and the more that equity is able to cover the banks' cost, thus increasing the equity efficiency. Contrariwise, the lower the equity, the lower the return on it, and the lesser the chances of that equity covering the banks' cost, thus a lower equity efficiency. Higher returns on equity suggests higher income, thus a lower cost to income ratio. Higher values of equity efficiency is dicey as it could imply jointly, greater returns on equity accompanied with less cost to income ratio or lesser return on equity accompanied with greater cost to income ratio.

Capital Stability (*Stability*₁) includes mostly the Bank Capital to Total Assets – the ratio of bank capital and reserves to total assets, and the Bank Regulatory Capital to Risk-Weighted Assets – compares total regulatory capital and assets held in ratios, weighted the assets riskiness. Thus, the more the bank has risky assets, the higher the requirement on the banks' regulation on capital. Then if the banks' capital is higher than total assets, it predicts liabilities are greater than assets (since capital is considered a liability) thus capital asset stability is high. However, Capital Stability becomes low when capital to total assets ratio is low (i.e. higher assets) given a relatively constant ratio of the regulatory capital to total risk-weighted assets (higher risky assets predicts higher regulatory capital) and vice versa. When the Capital Stability is high or low the banks are less or more stable respectively. *Credit-Deposit Stability* (*Stability*₂) captures mostly the Bank Credit to Bank Deposits – the financial means available to the private sector by domestic money banks as a share of total deposits. Liquid Assets to Deposits & Short Term Funding – the ratio of the value of liquid assets, which converts easily to cash to the short-term funding and total deposits. Consequently, more deposits imply more liabilities to the banks, thus decreasing the liquid assets to deposits ratio and the credit to deposits ratio. Therefore, more the banks' deposits the lower the Credit-Deposit Stability. The Credit-Deposit Stability is high when the financial means available to the private sector is higher than the total deposits and when there are more of the bank's assets easily converted to cash. *Nonperforming Loan Stability* (*Stability*₃) consists mostly the Bank nonperforming loans to gross loans (%) – the ratio of defaulting loans to total gross loans. In addition, the Provisions to nonperforming loans (%) – the amount set aside for loans in which the promised payments are overdue for more than a certain period. The lower the nonperforming

loans, the lower the defaulting loans and total gross loans ratio, lower provisions, thus increasing bank's stability. Contrarily, if nonperforming loan stability is low; the nonperforming loan, provisions, and the default loan to total loan ratio are high. *Z-Score Stability* ($Stability_4$) consists mostly the Bank Z-Scores – a measure of the solvency level of a Bank. Higher Z-Scores indicate the Bank is more sound thus implying lower probability of insolvency and lower Z-Scores indicate the Bank is less sound thus implying a higher probability of insolvency.

Table 2 shows the basic logistic model estimation results. It is important to state that the estimates of the logistic regression model are log odd-ratios while the exponential values of these log odd-ratios are the odd-ratios of efficiency given stability. The signs of these log odd-ratios do not really show the direction of the relationship between the stability and efficiency measures. Recall, the argument of the natural log function cannot be negative but it can return both negative and positive real numbers while the argument of the exponential function could be positive or negative real numbers but cannot report a negative real number. Therefore, a negative/positive log odd-ratio does not mean a negative/positive relationship between stability and efficiency. Rather all log odd-ratios, both positive and negative translate to a positive odd-ratio when exponential function is applied. Model adequacy test is conducted on each model's estimation result using the deviance techniques. The result is shown at the bottom of the corresponding model estimations in Table 2. The test shows that our proposed models are adequate. However, it is important to state that this study does not overlook possible omitted variable bias because we controlled for covariates that, correlates with stability and as well explain efficiency in the banking system such as competition, bank depth, etc. Our sample selection is random, as we do not select only economies with certain banking system features rather, we selected from all economies of the world. To an extent, measurement errors in variables are minimized given that our data set is from the World Bank. The heteroscedastic standard errors are reported to account for the variance-nature of our population (homoscedastic or heteroscedastic) therefore, our standard errors are robust and consistent to homoscedastic and heteroscedastic population. Finally, the possibilities of simultaneous or reverse causality bias (i.e. predicting efficiency using stability and predicting stability using efficiency) is solved using the factor model fitted values in our model estimations. This is tantamount to the instrumental variable 2SLS approach. Hence, we can conclude that our results are robust since $(Stability_i, Efficiency_i) \perp (Stability_j, Efficiency_j) \forall i \neq j$. Our focus here is to predict the likelihood of efficiency given stability. Therefore, we proceed to establishing the predictive power of the models using Sensitivity, Specificity, Receiver Operating Characteristics (ROC) curve, and Concordance Index.

The choice of cutoffs π_0 in table 3 are on the sample proportion of successes in the total sample. Given efficiency, the likelihood that the model predicts that there exists efficiency is Sensitivity (Sens.) while the likelihood that the prediction is inefficiency given that the true state is inefficiency is Specificity (Spec.). These are from the diagonal entries of each model's classification table and they are reasonably large. The Correct Prediction (CP) is the probability of making overall correct predictions about the true state of efficiency using the model. From the table, the diagonal entries of each classification table are larger than the off diagonal entries. Thus, resulting to a high sensitivity, specificity, and correct prediction for the models. The Concordance Index is the area under the ROC curve, which is also a measure of a likelihood model's predictive power. This index typically is the probability that the model predictions about success or failure of efficiency are concordant with the true state of efficiency. This predicts that success/failure outcomes have higher/lower predicted probabilities using the model and vice versa. The concordance Indexes for our models are 79%, 86%, 74%, 72% respectively, which suggests that generally our models are effectively doing a great job in predicting the states (success & failure) of efficiency. More so, the ROC curve plots the sensitivity against $1 - specificity$ of the model. Thus, connecting (0,0) and (1,1) coordinate points. It is more robust than the classification table because it summarizes the predictive power of the model for all possible cutoffs π_0 , shown in Figure 1. The ROC curve on the top-left part of the panel is that of model Efficiency₁, top-right is for model Efficiency₂, bottom-left is for model Efficiency₃, and bottom-right is for model Efficiency₄. True Positive rate is same as the sensitivity and the False Positive Rate is the $1 - specificity$ as shown in Figure 1. Just as deduced from the Concordance Index, the ROC curves have shown that the Predictive Power of our models are adequate for making valid predictions hence, we proceed to probability distribution predictions (see Figure 1).

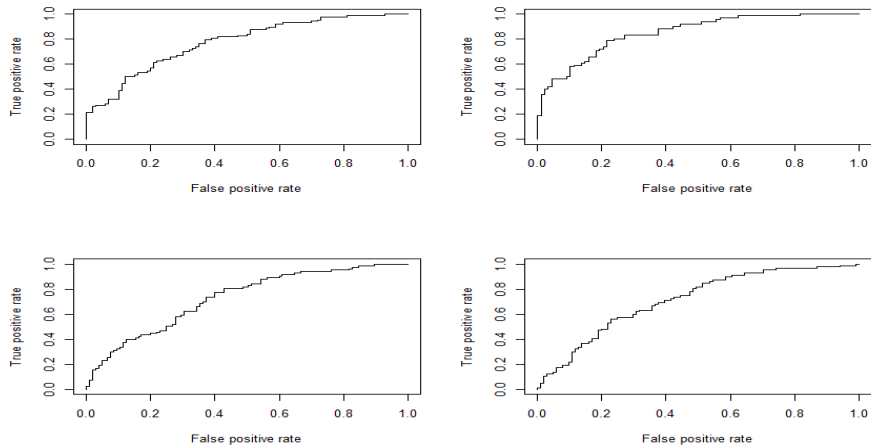


Fig-1: Receiver Operating Characteristics (ROC) curve

For comparison and mapping purposes, the cumulative distribution functions (Figure2 to Figure5) are normalized so that both negative and positive log-odd ratios will have a non-decreasing monotonic CDF plots. Hence, $CDF^* = 1 - CDF, \hat{\beta}_i < 0$ and $CDF^* = CDF, \hat{\beta}_i > 0$ where $i = 1, \dots, 4$. We predict the likelihood of efficiency given stability; using the normalized logistic cumulative distributions (CDF^*) and concluding on whether stability predicts efficiency in the banking system.

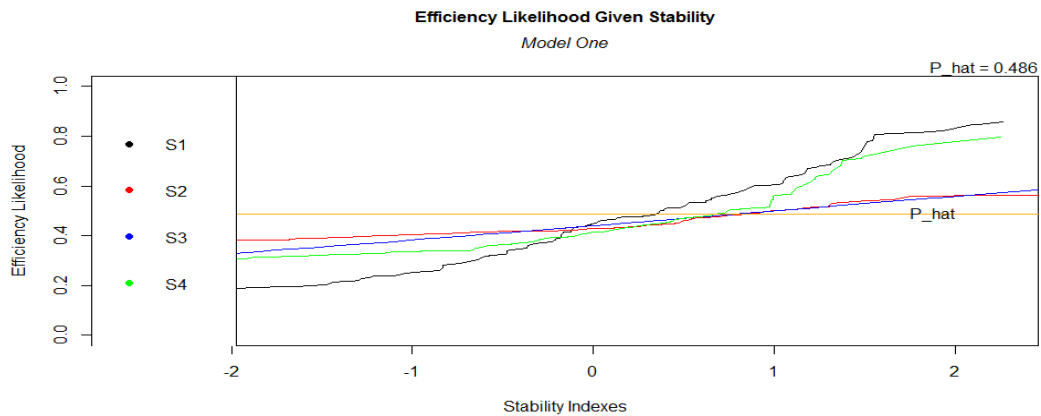


Fig-2: Asset Efficiency likelihood given Stability

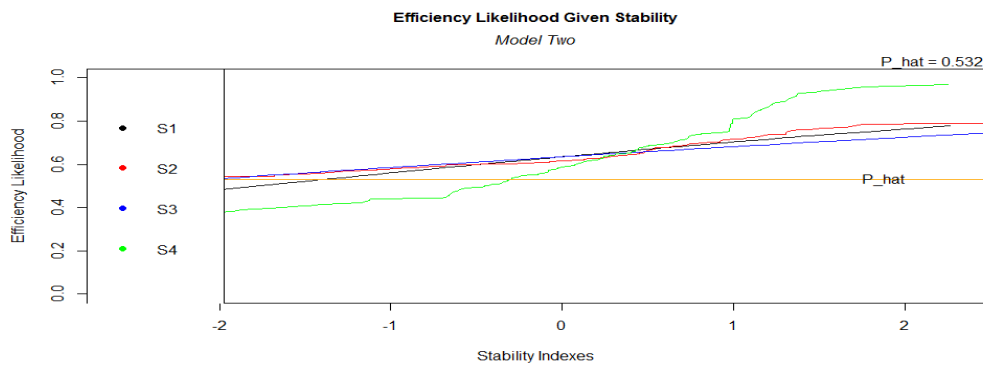


Fig-3: Cost Efficiency likelihood given Stability

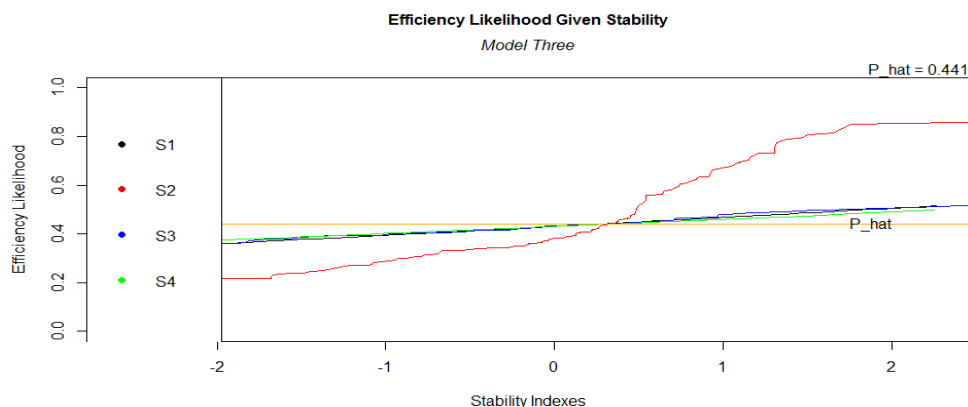


Fig-4: Noninterest Income Efficiency likelihood given Stability

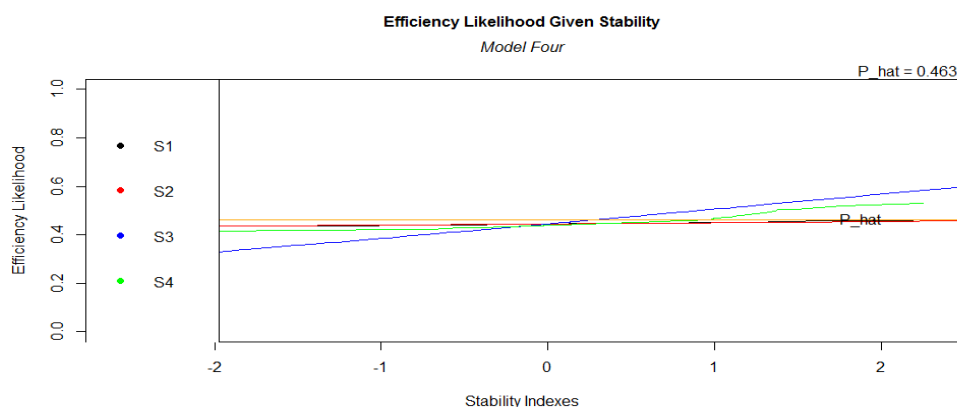


Fig-5: Equity Efficiency likelihood given Stability

Hypothesis 1: Capital Stability predicts Asset Efficiency in the banking system.

From Figure 2, the orange horizontal line shows the true sample proportion of Asset Efficiency. The chart shows the cumulative likelihood function (non-decreasing monotonic function) of stability index- i , $i = 1, \dots, 4$ while setting other variables at means. From the likelihood graph, as the level of stability increases, higher levels of Asset Efficiency ($Efficiency_1$) in the banking system is more likely; driven mostly by the Capital Stability ($Stability_1$). From definitions, we discovered that lower levels of assets relative capital increases the Capital Stability also, lower level of assets generates lower returns; decreasing the Asset Efficiency. When the true state is Asset Inefficiency (below the sample proportion; the orange line), the Capital Stability relatively makes the best prediction (i.e. have the least [closest to 0] probability values denoting failure of Asset Efficiency). When the true state is Asset Efficiency (above the sample proportion; the orange line), the Capital Stability relatively makes the best prediction (i.e. have the highest [closest to 1] probability values denoting success of Asset Efficiency). Since Capital Stability most likely predicts the true state of Asset Efficiency, we can conclude that Capital Stability is most predictive of Asset Efficiency and they are negatively related.

Hypothesis 2: Z-Score Stability predicts Cost Efficiency in the banking system.

In Figure 2, the orange horizontal line shows the true sample proportion of cost efficiency. The chart shows the cumulative likelihood function of cost efficiency given stability index- i , $i = 1, \dots, 4$ and other covariates are at mean. The likelihood graph shows that Z-score stability ($Stability_4$) most likely implies the cost efficiency ($Efficiency_2$). We have noted that higher Z-Scores indicate the Bank is sound thus implying lower probability of insolvency. When the bank is sound (lower insolvency), higher are the chances of covering the bank's costs thus more cost efficient the bank becomes. This conforms to the existing negative relationship between Z-Score Stability and cost efficiency.

Hypothesis 3: Credit-Deposit Stability predicts Noninterest Income Efficiency in the banking system.

Considering the third model for noninterest income efficiency shown in Figure 4, the orange horizontal line shows the true sample proportion of noninterest income efficiency. The chart shows the cumulative likelihood function of stability index- i , $i = 1, \dots, 4$ with other covariates at their mean values. From Figure 4, Credit-Deposit Stability ($Stability_2$) most likely predicts noninterest income efficiency ($Efficiency_3$). From earlier definitions, we discovered

that more deposits imply higher bank's liability thus decreasing the liquid assets to deposits ratio. The more the deposits also decrease the bank credit to bank deposits ratio therefore, more deposits leads to lower Credit-Deposit Stability. Since deposit charges are part of noninterest income, more deposits suggests higher noninterest income efficiency. This is in line with the data-driven relationship between noninterest income efficiency and the Credit-Deposit Stability.

Hypothesis 4: Nonperforming Loan Stability predicts Equity Efficiency in the banking system.

In Figure 5, the orange horizontal line shows the true sample proportion of equity efficiency. The chart shows the cumulative likelihood function of stability index- i , $i = 1, \dots, 4$ when other covariates are at mean. The likelihood graph shows that nonperforming loan stability ($Stability_3$) most likely implies equity efficiency ($Efficiency_4$) in the banking system. Lower nonperforming loans stability (favourable) suggests lower defaulting loans to total gross loans ratio. The lower nonperforming loans also leads to more equity, more return on equity, less cost to income ratio while more the nonperforming loans leads to less equity and return to equity and more cost to income ratio. However, it is vital to note that lower values of nonperforming loans and provisions directly translates to lower nonperforming loan stability which affects the major two components (return on equity & cost to income ratio) of equity efficiency differently. Lower nonperforming loan stability affects return on equity and cost to income ratio negatively and positively respectively. As to whether lower or higher levels of nonperforming loan stability predicts lower or higher levels of equity efficiency depends greatly on the magnitude of the impact on the two core components of equity efficiency. Moreover, given that the data driven additive model revealed a convex relationship existing between equity efficiency and nonperforming loan stability. This suggests that at lower levels of nonperforming loan stability, the overall impact on equity efficiency is negative which means the impact on returns on equity outweighs that of cost to income ratio (*left-side Asset Efficiency*). On the other hand, for higher values of nonperforming loan stability the overall impact is positive suggesting that the cost to income ratio impact exceeds that of equity return (*right-side Asset Efficiency*) and vice versa.

These findings categorize the various measures of stability to the various forms of efficiency, forming the unique one to one mapping that exists between efficiency and stability in the banking system. Our last objective is to establish the level of efficiency predicted by stability in the system. To evaluate this objective, we employ the groups-within-group definition of efficiency. This avails us the opportunity to develop an ordinal classification of efficiency in the banking system. We show the proportional multinomial logistic model estimation result for analysis in Table5.

One of the objectives of this work is to establish the nature of the relationship existing between the banking system stability and efficiency in the light of a data driven method, using the Spline estimation method (ridge penalty). To capture the dependency structure existing between these characteristics for adequate model fitting, we use the copula density estimation. Figure 6 shows joint density of efficiency and stability. From Figure 6, the joint distribution of efficiency and stability scores is asymptotically normal. Therefore, we fit the Additive Model using the Spline Estimation Method with Ridge Penalty and Gaussian family link function. The fitted model plots consists of the data points, fitted lines, and a 95% confidence interval line while plotting the efficiency variables (vertical axes) against stability (horizontal axes) variables.

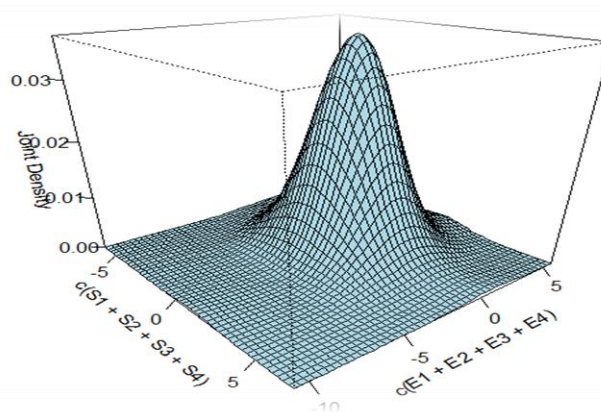


Fig-6: Joint density plot of Efficiency and Stability

From Figure 7, estimating the Additive Model for Asset Efficiency on the all stability factors; Capital Asset has an unrelated with Asset Efficiency with 0.00 effective degree of freedom which also is statistically insignificant. The relationship between Nonperforming Loan Stability and Asset Efficiency is that of a sine-cosine function with 4.3 effective degree of freedom. The relationship between Z-Score stability and Asset Efficiency capture 74% adjusted variations in the first factor of Efficiency. The estimation plot for the cost efficiency factor is shown in Figure 8. The

nature of the relationship existing between the Cost Efficiency factor and Capital Stability is increasing and statistically significant with an effective degree of freedom of 1.665. That of Cost Efficiency and Credit-Deposit Stability is convex and statistically significant with 1.438 effective degree of freedom. Cost Efficiency and Nonperforming Loan Stability are independent with 0.000 statistically insignificant effective degree of freedom. Lastly, the relationship between Cost Efficiency and Z-Score Stability is decreasing and statistically significant with 0.951 effective degree of freedom. We also proceed towards examining the form of the relationship between the noninterest income efficiency and the stability factors. For the noninterest income efficiency factor (see Figure 9), there exist an independent and statistically insignificant relationship between Cost Efficiency & Capital Stability and between Cost Efficiency and Nonperforming Loan Stability. While the relationship between Cost Efficiency & Credit-Deposit Stability and Cost Efficiency & Z-Score Stability is statistically significant with effective degree of freedom of 1.52 and 0.58 respectively. Finally, we examine the case of the equity efficiency factor and the Stability factors in Figure 10, there exist an independent and statistically insignificant relationship between Equity Efficiency & Capital Stability and Equity Efficiency & Z-Score Stability with 0.000 effective degrees of freedoms implying a constant efficiency relationship across those levels of Stability. The effective degree of freedom for Credit-Deposit and Nonperforming Loan Stability with Equity Efficiency are respectively 0.752 and 1.81, which are also statistically significant. For a better understanding, we summarize these forms of relationships in a Table 4 to make inference about the nature of the relationships between Efficiency and Stability in the banking System which is the first objective of this study. Table 4 summarizes the forms of relationships that exist between the banking system stability and efficiency (the mapped relationships of interest are circled in red). Generally, the relationship is truly complicated as Allen & Gale concluded and recommended that a balance should be sought. The red-circled relationship panels are those paired predictive mapping of efficiency and stability using the logistic cumulative distributions from the basic logit model. These data driven relationships are as explained in section 3.3 of this paper as informed by the plots in figure 2, figure3, figure4, and figure5. In nutshell, Capital Stability is mapped with Asset Efficiency and they are inversely related as well as the predictive mapping between Z-score stability & cost efficiency and between Credit-Deposit Stability & noninterest income efficiency. However, the mapping of nonperforming loan stability and equity efficiency showed that their relationship could be positive or negative depending on the magnitude of the impact on the principal components of equity efficiency. Given we have mapped these measures together and have examined the relationships between them; we can draw a road map on how best to achieve these measures of efficiency and stability in the banking system. More so, in as much as we can draw these road maps to achieve stability and efficiency in the banking system, we do not know exactly, the level of stability and the level of efficiency to desire/achieve. Knowing these desired levels would help policy makers to strike balances between stability and efficiency so that one do not ignore these tradeoffs and achieve levels of stability that would lead to inefficiency in the banking system. We move further to establish the tradeoffs between stability and efficiency rigorously

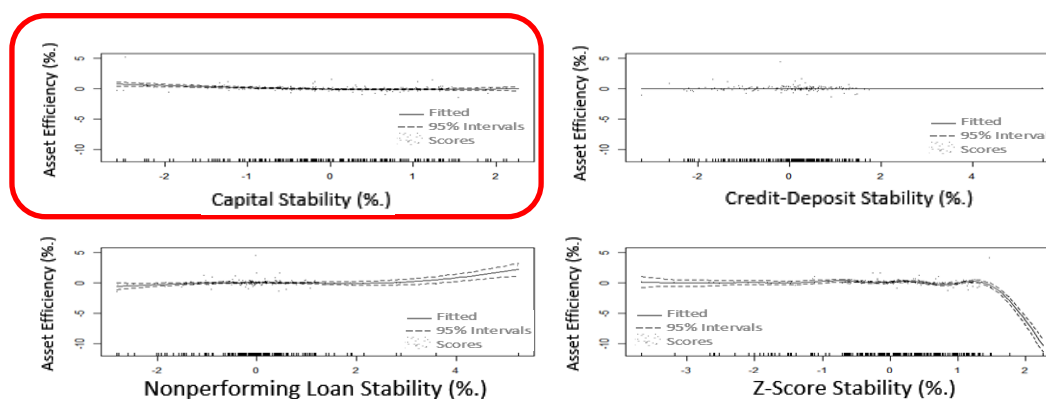


Fig-7: Asset Efficiency and Stability

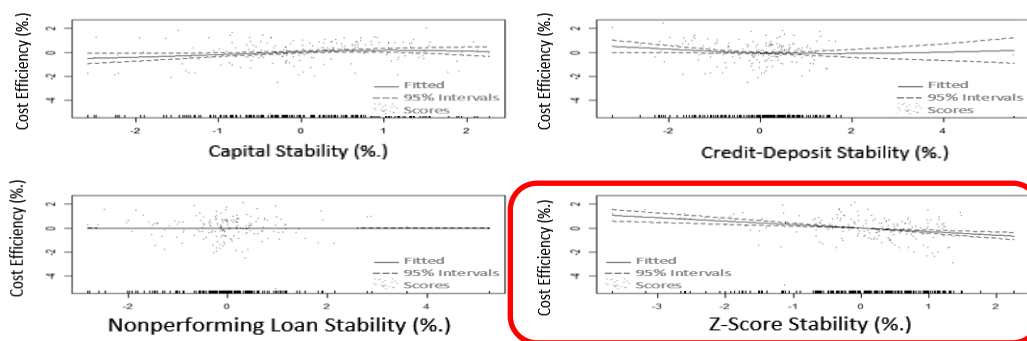


Fig-8: Cost Efficiency and Stability

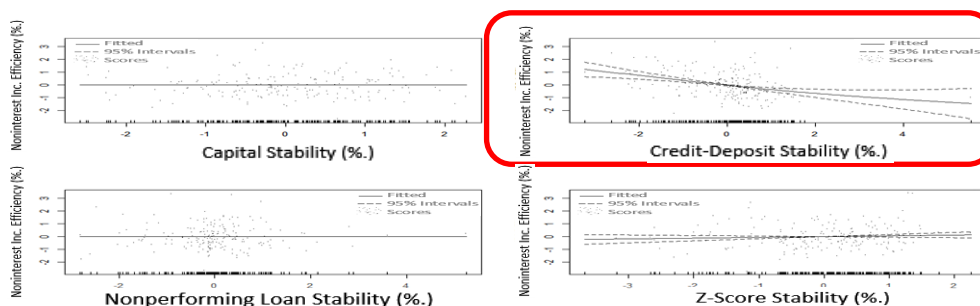


Fig-9: Noninterest Income Efficiency and Stability

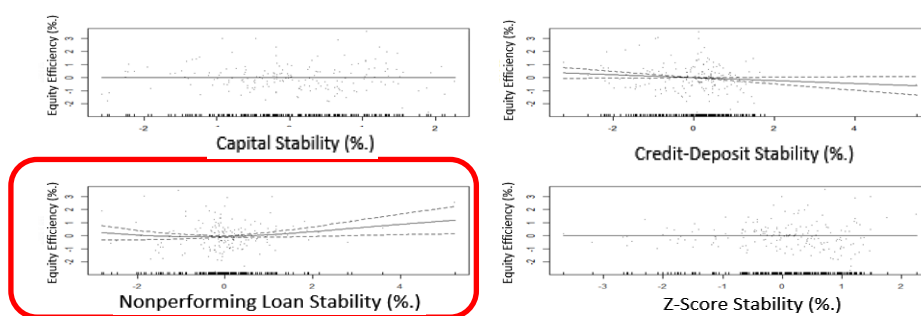


Fig-10: Equity Efficiency and Stability

Taking a new dimension through analyzing the efficiency levels using likelihood estimation. We set stability scores at quantile values and other covariates at mean while predicting the efficiency levels. The likelihood (marginal density functions) prediction is on the ordinal levels of efficiency, which will most likely prevail (most predictive) in the banking system given different stability levels. In doing so, we seek to answer the level of efficiency predicted by the stability measures in the system. In general, we plot the ordinal values of efficiency (vertical axes) against the quantile values of stability (horizontal axes). The quantiles are the 0%, 25%, 50%, 75%, and 100% values while the four efficiency levels are classified as strong (4), moderate (3), weak (2), and least (1).

From Figure 11, given that Asset Efficiency and Capital Stability are negatively related, the minimum level of Capital Stability predicts mostly the moderate level of Asset Efficiency while as Capital Stability increases; the weak level of Asset Efficiency is most likely predicted. Following the fact that z-score stability predicts mostly cost efficiency and the relationship is negative, the plot in Figure 12 validates that the minimum level of z-score stability predicts the strong level i.e. cost inefficiency in the banking system while the system become more cost efficient as z-score stability level increases. The third model's likelihood plot shows that Credit-Deposit Stability predicts the success of non-interest income efficiency and both are inversely related. The strong level of non-interest income efficiency is associated with the minimum level of Credit-Deposit Stability and the least level of non-interest efficiency with the maximum level of Credit-Deposit Stability and vice versa (see Figure 13). In Figure 14, weak equity efficiency level is maintained at values less than or equal to the 75% quantiles of non-performing loan stability. This weak level signifies the trade-off between the opposing components of equity efficiency while as non-performing stability increases further the equity cost to income ratio outweighs the return on equity thus leading to the strong level of equity efficiency due to the convex

relationship existing between these characteristics. It is therefore vital to make it clear that this predicted strong equity efficiency level is the *right-side* equity efficiency i.e. the case where cost to income ratio outweighs the return on equity. This is highly intuitive as higher levels of nonperforming loans invariably leaves the system with more cost than income and less equity therefore, the costs increases relative to income and this increases the cost to income ratio and decreases return on equity. Hence, banks should dread any level of nonperforming loan stability above the 75% quantile because the *right-side* Asset Efficiency is predicted.

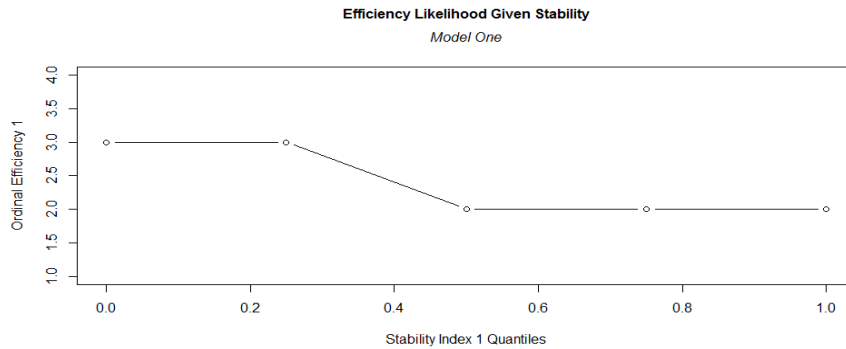


Fig-11: Asset Efficiency levels given Capital Stability levels

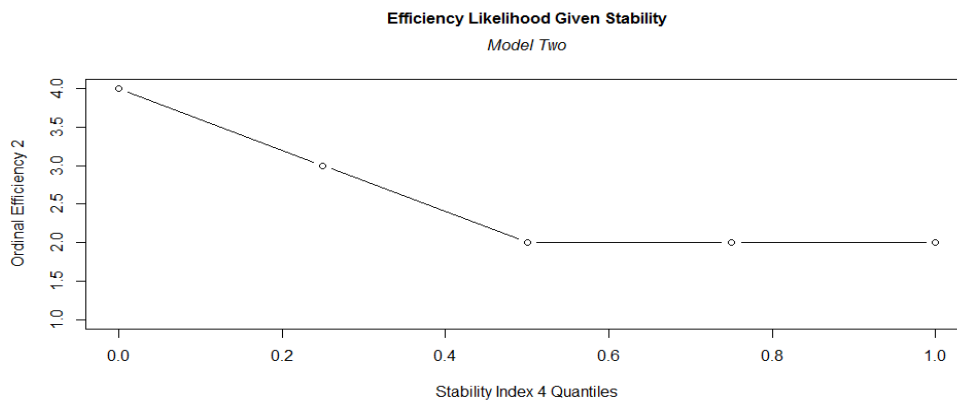


Fig-12: Cost Efficiency levels given Z-Score Stability levels

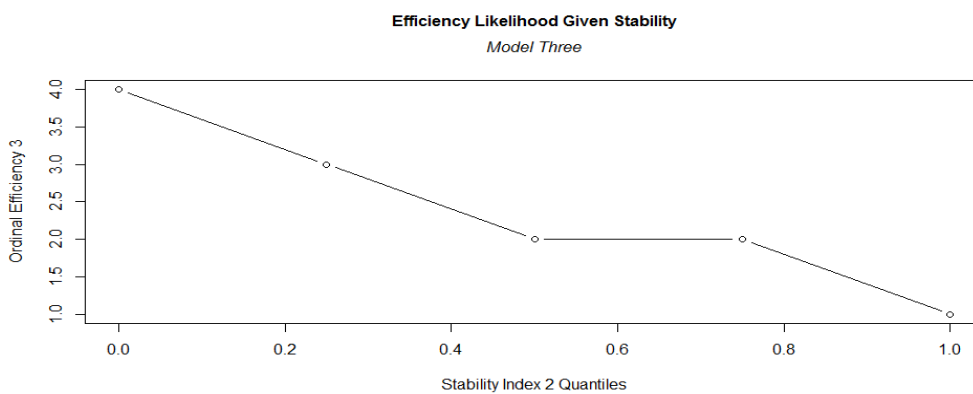


Fig-13: Noninterest Income Efficiency levels given Credit-Deposit Stability levels

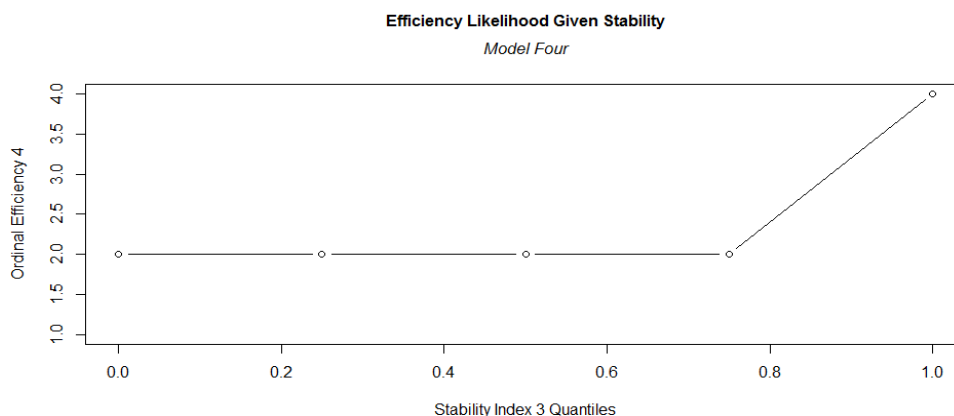


Fig-14: Equity Efficiency levels given Nonperforming loan Stability levels

We have shown that the relationship between efficiency and stability in the banking system is complicated using the nonparametric additive model while there exists a one to one mapping between the efficiency and stability scores in the system. We went further to determine the various levels of efficiency predicted at various quantile levels of stability in the system. The overall relationship is dynamic and requires careful considerations with the trade-offs in mind in deciding the forms and choices of efficiency and stability in the banking system. These findings are in agreement with already existing literature. It shows inverse relationships as stated by Franklin & Douglas (2003), Allen and Gale [2], Perotti & Suarez (2003), and De Nicolo [22] and a positive relationship stated by Beck, *et al* [4] and more importantly establish the road maps towards balancing stability and efficiency in the banking system as initiated by Freixas & Parigi, [5] and Allen & Gale, [1].

The issue of correlation and causality (causal effect) in economics and finance is crucial and needs to be explicitly expatiated in regression analysis. This boils down to whether changes in a variable lead to changes in another (causal effects) or whether changes in both variables are associated together (correlations). To establish directional causality, the four basic regression assumptions must be satisfied. An ideal randomized control experiment guarantees that these assumptions are met. First, we require the conditional mean of the error term condition on the regressors to be zero. This is rather a severe assumption that is met with an ideal randomized control experiment. However, conditional mean independence assumption is satisfied in our model on which we postulate that the zero conditional mean of the error term on the regressors depends on the banking system competition, depth, and access (control variables). In addition, the resulting factors are latent (unobserved) variables and most likely does not correlate with the residual. Next, factor analysis gives latent and independent values hence, the efficiency and stability measures of $economy_i$ is independent of that of $economy_j$, for $i \neq j$. Our original measures of efficiency and stability are in percentages (0% – 100%) therefore, chances of outliers are rear. In addition, the copula density estimator shows that the joint density of the efficiency and stability measures follows multivariate Gaussian distribution and thus they have finite fourth moments. Finally, there exists no perfect multicollinearity among the regressors because the inverse of the covariate matrix exists. Threats to internal validity of our estimates have been discussed (see 1.0 Introduction). However, we need to address the issue of reverse causality (directional causality). One of the solutions to reverse causality is the use of instrumental variable(s) that must be relevant and exogenous. The first stage measures the instrumental relevance and at this stage, we seek to predict the fitted values of the endogenous variable in our model and use it as the regressor in the second stage. This first stage is same as the factor analysis where we use the predicted latent stability scores (instruments) using the least squares estimation methods and used this predicted values in our logistic regression models that is, the second stage. Therefore, it is plausible to say that using the stability instruments from the factor analysis instead of the original stability measures and using these instruments in our logistic regression is the basic instrumental variable two stage least squares. Hence, we control for simultaneous causality bias. Given that our model satisfies the four basic regression assumption and no threat to internal validity, we can interpret the effect of stability on efficiency as causal effects and not correlation therefore; we make policies on the bases of causal effects.

CONCLUSIONS

Banking cum Financial system instability has the potentials to drive an economy into recession and depression. Allen & Gale (2000) were able to show that there exists a contagion effect in the financial system hence financial crisis from an economy can spread to the rest of world economies, thereby causing global financial crisis as experienced in the past. This then leads to global financial crisis, recessions, and depressions. This has attracted to itself the interest of

researchers towards studying the stability and efficiency of the financial system to be able to avoid instability and inefficiency, which are most likely to result in a global financial crisis.

Some researchers claimed that the relationship existing between financial system efficiency and stability is negative as striving to achieve one entails giving up the other. This includes the likes of Franklin & Douglas (2003), Allen and Gale [2], Perotti & Suarez (2003), and De Nicolo [22]. Since there exists an inverse relationship between these two important characteristics, Freixas & Parigi [5] then established a tradeoff between them. Beck et al. (2003) carried out a similar study about the same nature of the relationship and they discovered instead a positive relationship. These compose the divergent views on the nature of the relationship that exists between banking (financial) system stability and efficiency in literature.

This work sets out to establish the nature of relationships between these efficiency and stability in the banking system, validate whether stability predicts efficiency in the system, and which level of efficiency implied given stability. In other words, we seek to show whether achieving stability is tantamount to achieving efficiency in the banking system. Data driven method established the nature of the relationships between the characteristics after using PCA loadings to produce some adequate latent scores that measures banking efficiency and stability. The results show the true complication in their relationship. The likelihood of efficiency and its levels given stability using the basic and proportional odd cumulative logistic model is also included in the results. The models show that stability predicts efficiency on a one-to-one predictive mapping relationship. In conclusion, after carrying out this study, we discovered variant forms of relationships between efficiency and stability. In addition, stability predicts efficiency in the banking system.

Directly from the findings of this paper, we recommend *contingent planning* in the banking systems. This predicts, making decisions based on the present priorities, objectives, and consequences of actions taken in the system. Every economy should first establish what level and form of efficiency required then, choose to pursue the appropriate form(s) of stability while bearing in mind the resulting efficiency and levels. This makes stability the policy instrument of efficiency; the choice instrument. By so doing, economies of the world will be able to achieve and maintain different levels of efficiency and stability depending on current economic conditions in the economies and thereby maintaining a stable and efficient banking and financial system contemporaneously. Contingency planning is therefore the stone with which economies could kill (achieve) the two birds (efficiency and stability).

Explicitly, our findings showed that stability comes at a cost. In as much as a stable system drives confidence and ultimately increasing efficiency in the system, the balance showed is borne in mind. Recommendations on contingency planning follows that the banks make and have:

- *Monetary policies* geared towards:
 - Targeting a positive capital to asset ratio of below twenty-five percent (25%). At this level, the highest level of Asset Efficiency is attained and
 - Pursue and maintain liquidity levels between fifty percent (50%) and seventy-five percent (75%). This maintains a relatively stable non-interest income efficiency level without compromising the balance between the banks' lending and borrowings.
- *Credit -risk policies* in line with:
 - Not holding more than seventy-five percent (75%) of non-performing loans as this is very risky and leads to right-side equity efficiency. The risk and compliance bank team should clearly assess the borrower's ability, capacity, integrity, and wisely structure a credit facility that is appropriate to the needs of both the bank and the borrower.
- *Solvency policies* to maintain:
 - A Z-score value greater than fifty percent (50%). This guarantees lower cost inefficiency (high cost efficiency) and makes insolvency unlikely.

REFERENCES

1. Allen, F., & Gale, D. (2004). Competition and financial stability. *Journal of Money, Credit, and banking*, 36(3), 453-480.
2. Allen, F., & Gale, D. (2000). Financial Contagion. *The Journal of Political Economy*, 108(1), 1-33.
3. Nicolo, G. D., & Lucchetta, M. (2010). *Systemic Risk and the Macroeconomy*, Washington DC: Working Paper of the International Monetary Fund .
4. Beck, T., Demirguc-Kunt, A., & Levine, R. (2004). *Bank Concentration, Competition and Crisis*, Bretton Wood: Working Paper, World Bank.

5. Freixas, X., & Parigi, B. (1998). Contagion and Efficiency in Gross and Net Interbank Payment Systems. *Journal of Financial Intermediation*, 3-31.
6. Wen, S. Y., & Yu, J. (2013). Banking Stability, Market Structure and Financial System in Emerging Countries. *Journal of Applied Finance and Banking*, 3(3), 1-13.
7. Isik, I., & Hassan, M. (2003). Financial Deregulation and the Total Factor Productivity Change: An empirical Study of Turkish Commercial Banks. *Journal of Banking and Finance*, 27(1), 1455-1485.
8. Staub, R., De Souza, G., & Tabak, B. (2010). Evolution of Bank Efficiency in Brazil; A DEA approach. *European Journal of Operational Research*, 202(1), 204-213.
9. Berger, A. N., & Humphrey, D. B. (1997). Efficiency of Financial Institutions: International survey and directions for future research. *European Journal of Operation Research*, 175-212.
10. Sharma, D. (2012). *Predicting the Probabilities of most and least efficient banks: Data Envelopment Analysis and Logit Regression approach*, s.l.: Research Gate.
11. Murillo-Zamorano, L. R. (2004). Economic Efficiency and Frontier Techniques. *Journal of Economic Survey*, 18(1), pp. 33-45.
12. Farrell, J. M. (1957). The Measurement of Productive Efficiency. *Journal of the Royal Statistical Society*, 120, 253-281.
13. Koopmans, T. (1951). *An Analysis of Production as Efficient Combination of Activities*, New York: Cowles Commission for Research in Economics, Monograph no. 13.
14. Shanmugam, K., & Das, A. (2004). Efficiency of Indian Commercial Banks During Reform Period. *Applied Financial Economics*, 14(1), 681-686.
15. Bonin, J. I. H. (2005). Bank Performance, Efficiency and Ownership in Transition Countries. *Journal of Banking and Finance*, 29(1), 31-53.
16. Sensarma, R. (2006). Are Foreign Banks always the best? Comparison of State-owned, Private-owned and Foreign Banks in India. *Economic Modelling*, 23(1), 717-735.
17. Barros, C. C. F. (2007). Analysis of the Determinants of Performance of Best and Worst European Banks: A mixed Logit approach. *Journal of Banking and Finance*, 31(1), 2189-2203.
18. Berger, A. N., Hasan, I., & Zhou, M. (2009). Bank ownership and efficiency in China: What will happen in the world's largest nation?. *Journal of Banking & Finance*, 33(1), 113-130.
19. Behn, M., & Carsten Detken, T. P. W. S. (2016). *Predicting Vulnerabilities in the EU Banking sector: the role of Global and Domestic Factors*, s.l.: Working Paper Series no. 29, European Systemic Risk Board.
20. Arabi, K. A. M. (2013). Predicting Banks' Failure: The Case of Banking Sector in Sudan for the Period (2002-2009). *Journal of Business Studies Quarterly*, 4(3), 160.
21. Miller, S. M., & Noulas, A. G. (1996). The technical efficiency of large bank production. *Journal of Banking & Finance*, 20(3), 495-509.
22. Mukherjee, K., Ray, S. C., & Miller, S. M. (2001). Productivity growth in large US commercial banks: The initial post-deregulation experience. *Journal of Banking & Finance*, 25(5), 913-939.
23. Casu, B., & Girardone, C. (2010). Integration and efficiency convergence in EU banking markets. *Omega*, 38(5), 260-267.
24. Halkos, G. E., & Salamouris, D. S. (2004). Efficiency measurement of the Greek commercial banks with the use of financial ratios: a data envelopment analysis approach. *Management accounting research*, 15(2), 201-224.
25. Isik, I., & Darrat, A. F. (2009, May). The effect of macroeconomic environment on productive performance in Turkish banking. In *Economic Research Forum Working Papers* (No. 487).
26. Allen, F. (2004). *The Efficiency and Stability of Banks and Markets*. Belgium, National Bank of Belgium.
27. Allen, F., & Gale, D. (1998). Optimal financial crises. *The journal of finance*, 53(4), 1245-1284.
28. De Nicolo, G., & Kwast, M. L. (2002). Systemic risk and financial consolidation: Are they related?. *Journal of Banking & Finance*, 26(5), 861-880.
29. Karlan, D., & Zinman, J. (2009). Observing unobservables: Identifying information asymmetries with a consumer credit field experiment. *Econometrica*, 77(6), 1993-2008.
30. Arabi, K. A. M. (2013). Predicting Banks' Failure: The Case of Banking Sector in Sudan for the Period (2002-2009). *Journal of Business Studies Quarterly*, 4(3), 160.
31. Sklar, M. (1959). Fonctions de repartition an dimensions et leurs marges. *Publ. inst. statist. univ. Paris*, 8, 229-231.
32. Spearman, C. (1907). *Demonstration of formulae for true measurement of correlation*. University of Illinois Press.

APPENDICES

Table 1a: Efficiency and Stability Summary Statistics

Measures	Statistic	N	Mean	St. Dev.	Min	Max
Efficiency	CIR	188	59.416	15.502	22.818	116.712
Efficiency	NIM	188	4.702	2.487	0.743	11.475
Efficiency	NITI	188	1.112	2.413	0.023	9.736
Efficiency	OCTA	188	38.578	14.060	10.279	80.229
Efficiency	ROAa	188	3.883	3.052	0.038	25.556
Efficiency	ROAb	188	1.263	2.610	-28.08	12.748
Efficiency	ROEa	188	1.701	2.810	-27.97	12.975
Efficiency	ROEb	188	12.428	11.278	-41.77	91.398
Stability	CTA	188	8.828	4.287	1.420	23.900
Stability	CBD	188	89.634	64.227	20.147	800.172
Stability	NLGL	188	5.907	4.956	0.012	25.500
Stability	RCRWA	188	16.737	7.253	1.420	53.320
Stability	ZS	188	15.846	10.677	-3.725	57.904
Stability	LADF	188	34.566	17.545	3.394	83.024
Stability	PNPL	188	62.534	38.431	1.315	352.700

Table 1b: Variable Correlation Matrices

	<i>Efficiency Variables</i>									<i>Stability Variables</i>						
	<i>CIR</i>	<i>NIM</i>	<i>OCTA</i>	<i>NITI</i>	<i>ROAa</i>	<i>ROAb</i>	<i>ROEa</i>	<i>ROEb</i>		<i>CTA</i>	<i>CBD</i>	<i>NLGL</i>	<i>RCRWA</i>	<i>ZS</i>	<i>LADF</i>	<i>PNPL</i>
<i>CIR</i>	1.00								<i>CTA</i>	1.00						
<i>NIM</i>	.13	1.00							<i>CBD</i>	.13	1.00					
<i>OCTA</i>	.14	-.02	1.00						<i>NLGL</i>	.17	.01	1.00				
<i>NITI</i>	.50	.67	.38	1.00					<i>RCRWA</i>	.34	-.10	.03	1.00			
<i>ROAa</i>	-.42	.28	.08	.07	1.00				<i>ZS</i>	-.09	.02	-.02	.04	1.00		
<i>ROAb</i>	-.44	.34	.10	.11	.99	1.00			<i>LADF</i>	-.10	-.19	-.12	.25	-.10	1.00	
<i>ROEa</i>	-.42	.30	.07	.05	.49	.52	1.00		<i>PNPL</i>	.22	.05	-.09	-.03	-.05	-.02	1.00
<i>ROEb</i>	-.48	.43	.11	.11	.47	.57	.74	1.00								

Table 3: Multiway Classification Table

	<i>Efficiency₁</i>		<i>Efficiency₂</i>		<i>Efficiency₃</i>		<i>Efficiency₄</i>	
	$\pi_0 = 0.468$		$\pi_0 = 0.532$		$\pi_0 = 0.441$		$\pi_0 = 0.463$	
	$\widehat{E}_1 = 1$	$\widehat{E}_1 = 0$	$\widehat{E}_2 = 1$	$\widehat{E}_2 = 0$	$\widehat{E}_3 = 1$	$\widehat{E}_3 = 0$	$\widehat{E}_4 = 1$	$\widehat{E}_4 = 0$
E = 1	65	23	75	25	63	20	66	21
E = 0	32	68	16	72	36	69	31	70
	<i>Sens.</i>	<i>Spec.</i>	<i>Sens.</i>	<i>Spec.</i>	<i>Sens.</i>	<i>Spec.</i>	<i>Sens.</i>	<i>Spec.</i>
	74%	68%	75%	82%	76%	66%	76%	69%
CP	71%		78%		70%		72%	

Table 4: Functional Relationships between Stability and Efficiency

	Credit-Asset Stab.	Credit-Liquidity Stab.	Nonint. Inc. Stab.	Z-Score Stab.
Asset Efficiency	<i>Decreasing</i>	<i>Independent</i>	<i>Sine-Cosine</i>	<i>Sine-Cosine</i>
Cost Efficiency	<i>Increasing</i>	<i>Convex</i>	<i>Independent</i>	<i>Decreasing</i>
Nonint. Inc. Efficiency	<i>Independent</i>	<i>Decreasing</i>	<i>Independent</i>	<i>Increasing</i>
Equity Efficiency	<i>Independent</i>	<i>Decreasing</i>	<i>Convex</i>	<i>Independent</i>

Table 2: Basic Logistic Estimation Results

	The Dependent Variable is the individual log odd-ratio of the four Efficiency Indexes (Measures)											
	Asset.E	Cost.E	Nonint.E	Equity.E	Asset.E	Cost.E	Nonint.E	Equity.E	Asset.E	Cost.E	Nonint.E	Equity.E
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Capital Stability	-0.779***	0.301***	0.126	-0.27	-0.787***	0.319***	0.111	-0.030	-0.784***	0.310**	0.118	-0.024
	(0.174)	(0.106)	(0.161)	(0.299)	(0.182)	(0.112)	(0.171)	(0.080)	(0.203)	(0.148)	(0.181)	(0.038)
Credit-Deposit Stability	-0.178	-0.285**	-0.773***	-0.105**	-0.199	-0.291**	-0.760***	0.110**	-0.181	-0.287**	-0.765***	0.109**
	(0.158)	(0.132)	(0.194)	(0.046)	(0.181)	(0.138)	(0.199)	(0.047)	(0.201)	(0.142)	(0.211)	(0.048)
Nonperforming Loan Stability	0.224**	0.210	-0.155	0.243*	0.249**	0.215	-0.146	0.259*	0.238**	0.209	-0.153	0.245*
	(0.113)	(0.195)	(0.171)	(0.140)	(0.125)	(0.198)	(0.179)	(0.156)	(0.121)	(0.194)	(0.183)	(0.144)

Z-Score Stability	- 0.442*** (0.161)	- 0.803*** (0.181)	0.148* (0.081)	0.098 (0.148)	-0.437** (0.181)	- 0.795*** (0.233)	0.151* (0.088)	-0.091 (0.161)	-0.437** (0.195)	- 0.799*** (0.246)	0.150* (0.09)	-0.093 (0.174)
Constant	-0.149 (0.157)	0.153 (0.156)	-0.267* (0.158)	-0.151 (0.147)	-0.783 (1.111)	- 2.699*** (0.888)	-1.107** (0.514)	0.159 (0.750)	-0.945 (1.356)	-2.363 (1.514)	0.081 (1.251)	-0.620 (1.221)
Control (Competition)	NO	NO	NO	NO	YES	YES	YES	YES	YES	YES	YES	YES
Control (Depth and Access)	NO	NO	NO	NO	NO	NO	NO	NO	YES	YES	YES	YES
Observations	188	188	188	188	188	188	188	188	188	188	188	188
Log Likelihood	- 117.332	- 118.594	-116.511	- 128.589	- 105.896	-88.746	-113.392	- 117.380	- 102.429	-86.142	-111.268	- 114.805
Akaike Inf. Crit.	244.664	247.187	243.022	267.179	229.792	197.493	244.785	252.759	234.858	202.283	252.536	259.609
Null Deviance	259.9	259.9	258.0	259.4	259.9	259.9	258.0	259.6	259.9	259.9	258.0	259.6
Residual Deviance	234.7	237.2	233.0	237.2	211.8	177.5	226.8	234.8	204.9	172.3	222.5	229.6
d.f.	4	4	4	4	8	9	8	8	14	14	14	14
P-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.001	0.008
Model Adequacy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
$H_0 = \beta_1 = \beta_2 = \beta_3 = \beta_4 = 0$	0.000	0.001	0.000	0.003	0.000	0.002	0.004	0.005	0.000	0.005	0.009	0.007

Note: *p<0.1; **p<0.05; ***p<0.01

Asset. E, Cost. E, Nonint. E, and Equity. E are the models for the four Efficiency Scores/Measure with binary response variable (using the central tendency definition) and only the four Stability Scores as the explanatory Variables (column 1 to column 4). We control for competition, access, and depth covariates in the subsequent column. This robustness test guarantees to an extent that we have robust estimates. The p-values of the linear hypothesis tests are reported in the last row

Table 5: Cumulative Logistic Estimation Results

	The Dependent Variable is the individual log odd-ratio of the four Efficiency Indexes (Measures)											
	Asset.E	Cost.E	Nonint.E	Equity.E	Asset.E	Cost.E	Nonint.E	Equity.E	Asset.E	Cost.E	Nonint.E	Equity.E
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Capital Stability	0.541*** (0.148)	0.246*** (0.058)	-0.011 (0.028)	0.016 (0.021)	0.523*** (0.099)	-0.271** (0.135)	0.017 (0.023)	0.025 (0.038)	0.534** (0.240)	-0.260** (0.129)	0.017 (0.019)	-0.017 (0.023)
Credit-Deposit Stability	0.089 (0.139)	0.264** (0.124)	0.847*** (0.159)	0.010** (0.005)	0.083 (0.152)	0.282** (0.119)	0.813*** (0.164)	0.009*** (0.001)	0.083 (0.162)	0.279** (-0.118)	0.831*** (-0.174)	-0.012*** (0.004)

Nonperforming Loan Stability	-0.219** (0.101)	0.053 (0.060)	0.097 (-0.121)	-0.351* (0.188)	-0.243** (0.122)	0.045 (0.052)	0.064 (-0.140)	-0.330* (0.196)	-0.231** (0.100)	0.047 (0.251)	0.087 (0.143)	-0.327** (0.160)
Z-Score Stability	0.399*** (0.142)	0.850*** (0.153)	-0.282** (0.136)	0.207 (0.19)	0.418*** (0.146)	0.837*** (0.171)	-0.352** (0.142)	0.181 (0.175)	0.406** (0.165)	0.846*** (-0.174)	-0.294* (0.155)	0.196 (-0.155)
(Intercept):1	-3.11*** (0.337)	-1.78*** (0.207)	-1.25*** (0.179)	-1.25*** (0.176)	2.880*** (0.976)	0.404 (0.729)	-0.854** (0.430)	-1.353** (0.635)	-2.398** (1.149)	0.614 (1.091)	2.084** (1.043)	-1.242 (1.030)
(Intercept):2	0.173 (0.154)	-0.169 (0.156)	0.264* (0.156)	0.173 (0.148)	0.621 (0.938)	2.385*** (0.743)	0.690 (0.428)	0.202 (0.626)	1.217 (1.115)	2.619** (1.105)	-0.514 (1.034)	0.391 (1.024)
(Intercept):3	2.140*** (0.234)	1.225** (0.182)	1.632*** (0.201)	1.662*** (0.199)	2.691*** (0.958)	4.103*** (0.784)	2.086*** (0.455)	1.784** (0.643)	3.395*** (1.143)	4.422*** (1.140)	0.918 (1.038)	2.020* (1.036)
Controls (Competition)	NO	NO	NO	NO	YES	YES	YES	YES	YES	YES	YES	YES
Controls (Depth & Access)	NO	NO	NO	NO	NO	NO	NO	NO	YES	YES	YES	YES
Observations	188	188	188	188	188	188	188	188	188	188	188	188
Log Likelihood	-201.80	-237.29	-240.97	-252.68	-193.53	-207.79	-237.78	-243.08	-186.98	-203.25	-234.74	-237.77
Akaike Inf. Crit.	411.593	482.582	489.938	513.359	403.06	433.576	491.566	502.157	401.97	434.503	497.474	503.537
Null Deviance	533.934	533.934	533.934	533.934	533.934	533.934	533.934	533.934	533.934	533.934	533.934	533.934
Residual Deviance	403.593	474.583	481.938	505.353	387.056	415.576	475.566	486.158	373.97	406.501	469.474	475.537
d.f.	4	4	4	4	8	9	8	8	14	14	14	14
P-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.000	0.000
Model Adequacy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
$H_0 = \beta_1 = \beta_2 = \beta_3 = \beta_4 = 0$	0.000	0.001	0.000	0.001	0.000	0.002	0.000	0.001	0.000	0.000	0.000	0.000

Note: *p<0.1; **p<0.05; ***p<0.01

Asset. E, Cost. E, Nonint. E, and Equity. E are the models for the four Efficiency Scores/Measure with binary response variable (using the central tendency definition) and only the four Stability Scores as the explanatory Variables (column 1 to column 4). We control for competition, access, and depth covariates in the subsequent columns. This robustness test guarantees to an extent that we have robust estimates. The p-values of the linear hypothesis tests are reported in the last row