The Effect of Quantitative Complexity Analysis on the Resilience of Nigerian Banks. Case Study: The Four Listed Nigerian Banks on the Premium Board of the Nigerian Exchange Group (NGX) for the Year 2019 -2022

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ABSTRACT

The main aim of this study is to investigate the effect of quantitative complexity analysis on the resilience of Nigerian banks. The descriptive research strategy was carefully selected for this examination because it has the intrinsic potential to capture and depict the investigated phenomena in their natural surroundings. All of the Nigerian banks listed on the premium board of the Nigerian Exchange Group (NGX) from 2019 to 2022 make up the population of the study. During this time, there were four banks that were listed. Zenith Bank, First Bank of Nigeria, Access Bank, and United Bank for Africa are among the banks. The sample size for the investigation was chosen using a purposive sampling technique. The four listed banks on the premium board of the NGX were chosen because they are the most capitalized stocks of banks in the Nigerian banking industry that meet trading global standards and stringent corporate governance set by the Nigerian Exchange, hence the purposive sampling technique was adopted. The annual reports and financial statements of the chosen banks for the years 2019 to 2022 served as the source of the data for this study. Descriptive statistics and inferential statistics were both used to analyze the obtained data. The traits of the banks that were chosen are treated using descriptive statistics and the inferential statistics is used to analyze the quantitative complexity and resilience of the chosen banks for the Network analysis, Principal component analysis, Hierarchical clustering analysis, Capital adequacy ratio (CAR), Non-performing loans (NPL) ratio, Liquidity ratio and Efficiency ratio. IBM SPSS was used to analyze the financial data of all the banks for insights on PCA and HCA and then Ontonix QCM Software was used to explore and analyze the financial data of all the banks for insight on Network Analysis. And Excel Spreadsheet was used to analyze the financial data of the 4 banks for insight to CAR, NPL, Liquidity Ratio and Efficiency Ratio. The study discovered that better resilience is positively associated with higher levels of quantitative complexity analysis in a financial structure of the bank and operations. This shows that banks are better able to resist negative occurrences or shocks than those who will not regularly participate in quantitative complexity analysis of their financial structure and operations. Banks must make an effort to preserve requisite complexity in the BANI (brittle, ambiguous, nonlinear, and incomprehensible) business environment of today. The study recommends among others that for companies and banks, BANI circumstances make it challenging to develop successful plans for the future. Companies and banks must be prepared to swiftly adapt and thrive in order to remain competitive in a world where change occurs fast and unexpectedly. In order for businesses and banks to develop resilience, they must understand the idea of requisite complexity, which is the appropriate level of complexity needed to address and navigate any issue or situation.

Keywords: Quantitative Complexity, Bank Resilience, Requisite Complexity, Nigerian Exchange Group (NGX), Leverage Points, Model-Free, Financial Structures and Operations.

JEL: G21, C58, G28

INTRODUCTION

The banking industry in Nigeria has played a significant role in the economic expansion of the nation by offering both corporations and private citizens important financial services (Babajide, Adegboye, & Omankhanlen,

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2015). The industry has been growing steadily over the years, with over 95,000 bank employees in the country as of Q4 2020. As of 2021, there were around 133.5 million active bank accounts in Nigeria, while savings accounts added up to approximately 120 million. The Nigerian banking sector is diversified, with the largest banks following the universal banking model and a range of specialized actors tapping specific niches. The sector has also seen growth in fintech investments, which have grown by 197% over the past three years (Sasu, 2023).

In the banking sector, the system and economic landscape defies simplicity and stability. It is a constantly shifting system, influenced by the intricate and often unpredictable behaviors of billions of humans. It is hard to fathom how some prominent regulators and industry analysts have portrayed it as straightforward and static. Surprisingly, many of the methods we use to evaluate banks are rooted in these assumptions that the dynamics of the financial structures and operations of banks are simple, silo, straightforward, static and stable, even though the real world they navigate is far more complex and everchanging. Gharajedaghi (2011) explained that complex systems, whether they are in business, technology, or other areas, often exhibit non-linear, unpredictable behaviors.

As noted by De Toni & De Zan (2016), the contemporary turbulent markets necessitate managers to confront the escalating challenges posed by external complexity. This situation places organizations at a pivotal juncture, commonly referred to as the 'complexity dilemma': the choice between embracing and nurturing complexity or opting to circumvent and diminish it. This dichotomy finds its theoretical roots in Ashby's Law of Requisite Variety and Luhmann's Complexity Reduction. It is worth noting that both Ashby and Luhmann's theories hold validity, owing to the observed inverted U-shaped relationship between complexity and a firm's performance, referred to as the 'complexity curve'. As the level of external complexity is held constant, performance tends to improve with the augmentation of internal complexity, up to a certain critical threshold; beyond which, an excess of complexity can have detrimental effects on performance. Addressing the Ashby-Luhmann complexity trade-off and maneuvering along the complexity curve, the authors propose that complex organizational structures may be facilitated by a simple design characterized by (i) modularity, (ii) simple rules, and (iii) organizational capabilities.

Quantitative complexity analysis has emerged as a useful tool for assessing the level of complexity within organizations, including banks (Marczyk, 2013). Complexity refers to the number of interdependent elements in a system, and how they interact with each other (Sargut & McGrath 2011). This complexity can have both positive (Reeves, Levin, Fink & Levina, 2020) and negative effects (Malik, 2022) on the ability of an organization to adapt and respond to changing environments. In fact, complexity can be harmful to companies' performance if it is not managed properly (Birkinshaw & Heywood, 2010). On the other hand, bank resilience refers to the ability of a bank to withstand and recover from shocks and disruptions, while still maintaining its core functions and operations (Markman & Venzin, 2014). It can be recorded that bank resilience is influenced by various factors, and these factors are often assessed through financial ratios such as the capital adequacy ratio, non-performing loans ratio, liquidity ratio, and efficiency ratio (Kutum, & Al-Jaberi, 2015). Nevertheless, the industry has encountered a number of difficulties throughout time, including high levels of non-performing loans, shoddy corporate governance systems, and insufficient risk management frameworks (Nwosu and Anih, 2020).

The banking sector in Nigeria had faced difficulties before the epidemic, including significant non-performing loan levels, a low capital adequacy ratio, and liquidity issues (Duan, El Ghoul, Guedhami, Li, & Li, 2021). These problems were made worse by the pandemic, which also caused a drop in the income and profitability of banks in the country at 5% level of significance (Amnim, Aipma, & Obiora, 2021). According to a PwC. (2020), analysis, the pandemic has significantly impacted banking activities in the nation, increasing the credit risk for banks and decreasing profitability. A prominent one of these difficulties was the 2009 crisis that prompted the Central Bank of Nigeria (CBN) to save a number of banks from failure (Kama, 2010). The CBN had implemented a number of regulatory measures to address these issues and improve the stability and toughness of the banking industry (Sanusi, 2010). The implementation of the International Financial Reporting Standards (IFRS), the adoption of risk-based supervision (Nurunnabi, 2021), the creation of a credit registry, the introduction of the bank verification number (Onaolapo, 2015) has improved financial reporting standards, increased openness, and decreased the likelihood of fraud in the industry (Ball, 2001).

Credit risk, market risk, and operational risk are only a few of the dangers and uncertainties that the Nigerian banking system is still exposed to despite these reforms (Obafemi & Sunday, 2023). The complexity of the sector, which results from a variety of factors such as the variety of financial products, the heterogeneity of consumer wants, and the complexity of the regulatory framework, magnifies these risks (Lee & Vu, 2020). Moreso, the difficulties associated with data management, analytics, and information sharing further increase the complexity of the Nigerian banking sector and hinder banks' capacity to adapt to new threats and make data-driven choices (Oguejiofor, Omotosho, Abioye, Alabi, Oguntoyinbo, Daraojimba & Daraojimba, 2023).

A rising need exists to assess the complexity and resilience of Nigerian banks in light of these difficulties in order to comprehend how well they are able to absorb shocks and preserve financial stability. In order to analyze the degree of complexity of a system, quantitative complexity analysis offers a framework. This framework may help detect possible weak points and boost resilience. Notably, the complexity of a financial system may significantly affect its resilience. It goes to say that rising interdependence and the possibility of cascade failures are two effects of complexity (Acemoglu, Ozdaglar, and Tahbaz-Salehi, 2015). According to Bhattacharyya, Dietz, Edlich, Mehta, Weintraub & Windhagen, (2021), banks with a lower degree of complexity may be better equipped to adjust to changing conditions and continue to be robust in the face of economic shocks.

Numerous research in developed and developing economies have shown the value of quantitative complexity analysis in boosting banks' resilience (Aduda & Kalunda, 2012).

The safety and stability of Nigeria's financial system are at risk due to various issues. The complexity of the system stems from factors such as the multitude of financial products, diverse consumer needs, and intricate regulations, which further worsen the problems. It can be rational to believe that banks can implement cutting-edge risk management strategies, such as quantitative complexity analysis, which can assist them in spotting potential operational flaws and aid them in making data-driven decisions to increase their performance and resilience (Adekunle, Alalade, Agbatogun & Abimbola, 2015).

The study will concentrate on Zenith Bank, First Bank of Nigeria, Access Bank, and United Bank for Africa, as they are the four listed Nigerian banks on the premium board of the Nigerian Exchange Group (NGX) during the years 2019-2022.

Statement of the Problem

The consolidation of the industry and the embrace of risk-based supervision and regulation of the Central Bank of Nigeria (CBN) have both contributed to the considerable transformation of the Nigerian banking sector during the past ten years. But the industry still has a lot of problems, like insufficient corporate governance, subpar risk management procedures, sensitivity to macroeconomic shocks, and changes in regulatory requirements (Oyewo, 2022). The COVID-19 epidemic has also had an effect on the sector, raising credit risk and degrading asset quality.

Enhancing Nigerian banks' resilience to shocks and disturbances is one of their biggest challenges. Dowell-Jones & Buckley (2016), inferred that resilience is the capacity of banks to withstand shocks and retain their financial stability and viability. For the purpose of preserving financial stability and averting systemic risks, banks' resilience is essential. However, improving bank resilience is an intricate and diverse task that calls for a comprehensive strategy that incorporates strong corporate governance, efficient risk assessment and management, and stable financial structures and operations.

By revealing the complexity of banks' financial structures and operations, quantitative complexity analysis has become a promising strategy for improving banks' resilience. In order to assess the complexity of financial systems and pinpoint potential sources of systemic risk, complexity analysis employs mathematical and statistical models (Liao, Zhou, Xu & Shu, 2020). However, traditional methods of assessing systemic risk in financial systems rely on mathematical models that may not capture the full complexity of the system. Model-free methods, on the other hand, do not rely on any specific model and can be used to analyze complex financial systems without making any assumptions about their underlying structure (Davis, 2016). Quantitative complexity analysis is still rarely used in developing nations like Nigeria, and its effects on bank resilience are poorly understood.

The inadequate understanding of how quantitative complexity analysis affects the resilience of Nigerian banks is the issue that this study tries to solve.

Objectives of the Study

The main aim of this study is to investigate the effect of quantitative complexity analysis on the resilience of Nigerian banks.

Specific Objectives:

i. To find out if there is a significant effect of the level of complexity of the financial structures and operations of the four listed Nigerian banks on the premium board of the Nigerian Exchange Group (NGX) for the years 2019-2022 on their resilience.
ii. To find out whether the use of quantitative complexity analysis positively influence the resilience of the four listed Nigerian banks.
iii. To find out if the risk management practices of the four listed Nigerian banks have a significant impact on their resilience.

Research Questions

i. Is there a significant effect of the level of complexity of the financial structures and operations of the four listed Nigerian banks on the premium board of the Nigerian Exchange Group (NGX) for the years 2019-2022 on their resilience?

ii. Does the use of quantitative complexity analysis positively influence the resilience of the four listed Nigerian banks?

iii. Do the risk management practices of the four listed Nigerian banks have a significant impact on their resilience?

Research Hypotheses

H1: The level of complexity in the financial structures and operations of the four listed Nigerian banks on the premium board of the Nigerian Exchange Group (NGX) for the years 2019-2022 has a significant effect on their resilience.

H0: The level of complexity in the financial structures and operations of the four listed Nigerian banks on the premium board of the Nigerian Exchange Group (NGX) for the years 2019-2022 has no significant effect on their resilience.

H1: The use of quantitative complexity analysis positively influences the resilience of the four listed Nigerian banks.

H0: The use of quantitative complexity analysis does not significantly influence the resilience of the four listed Nigerian banks.

H1: The risk management practices of the four listed Nigerian banks have a significant impact on their resilience.

H0: The risk management practices of the four listed Nigerian banks do not significantly impact their resilience.

Scope of the Study

The focus of the study is only on how quantitative complexity analysis affects the resilience of Nigerian banks.

The analysis focuses specifically on the four listed Nigerian banks for the years 2019-2022, which are listed on the premium board of the Nigerian Exchange Group (NGX).

In order to gather pertinent data for the study, a quantitative research approach will be used, and secondary data sources including annual reports and financial statements will be used. To test the research hypotheses, the study will also employ statistical analytic techniques including regression analysis.

It is vital to note that this study does not compare Nigerian banks or evaluate regulatory framework of Nigeria for the financial sector. The four listed Nigerian banks on the premium board of the Nigerian Exchange Group (NGX) for the years 2019-2022, however, are the subject of the study, along with their resiliency. The conclusions of the study might not apply to other Nigerian banks or the whole banking sector of the country.

Limitations of the study

Like any research studies, this one includes some restrictions that might influence how the findings should be interpreted. The following are some of the limitations of the study:

1. Limited data availability: This study depends on secondary data sources, which may not cover all aspects of the financial operations and architecture of Nigerian banks. It is possible that certain crucial data or indications are either unavailable or absent, which could have an impact on the conclusions of the study.

2. Time limitations: For the years 2019-2022, this analysis focuses on the four listed Nigerian banks on the premium board of the Nigerian Exchange Group (NGX). So, the study only covers data from 2019 to 2022, which may not be sufficient to capture long-term trends.

3. Generalizability: This analysis is restricted to the four listed Nigerian banks on the premium board of the Nigerian Exchange Group (NGX) for the 2019-2022 period. As a result, it is possible that the conclusions cannot be applied to other Nigerian banks or the whole financial sector of the country.

4. Methodology: This study conducted a quantitative complexity assessment with a proprietary, model-free tool based on quantitative complexity theory for the four banks to measure complexity and robustness during the review period. The approach does not consider the financial performance of the institutions. Additionally, it is possible that additional elements that can affect the banks' resilience were not taken into consideration when the study used the analysis of financial ratios to assess its research hypotheses.

5. Absence of primary data: The study uses secondary data, which might not offer the level of specificity required to fully comprehend the influence of quantitative complexity analysis on bank resilience. In-depth information about the operations and risk management procedures of the banks may be obtained through primary data gathering techniques like interviews or surveys.

The findings and conclusions of the study should be interpreted with these limitations in mind overall.

LITERATURE REVIEW

Conceptual Framework

Definition and concepts of complexity and resilience

Two key ideas, complexity and resilience, are extensively researched in many domains, including finance and banking. According to Mathieu, Gallagher, Domingo & Klock, (2019) in the context of banking, complexity refers to the degree of complexity, diversity, and interaction among the numerous parts and activities that make up the operations of a bank. According to (Poutanen, Soliman and Ståhle, 2016), the complexity of a bank can be related to various elements, including the variety of its products and services, the number of its business divisions, the complexity of its organizational structure, and the sophistication of its technological systems. The ability of a bank to endure and recover from unfavorable events, shocks, and disruptions to its operations and financial performance is referred to as resilience (Khiaonarong, Leinonen and Rizaldy, 2021).

The terms complexity and resilience are closely related since the level of complexity of a bank can influence how resilient it is to different risks and difficulties. With more integrated and interdependent systems and processes that could have cascade impacts in the event of a disruption, banks with higher levels of complexity may have a harder time managing risks and sustaining financial stability (Adrian, 2023). However, banks with higher levels of resilience might be better able to handle complexity and lessen the negative effects it has on their business processes and financial performance (Buch, C. M., & Goldberg, 2021). The study of the relationship between complexity and resilience in banking as well as the application of quantitative complexity analysis to quantify and manage complexity and resilience in banks have both received very little interest in the past years (MacDonald & van Oordt, 2017).

Quantitative complexity theory (QCT) is a relatively new approach to the study of complex systems that has gained significant attention in recent years. This method involves the use of statistical techniques to analyze the structure and dynamics of complex systems, such as networks, biological systems, and financial markets. Compared to other financial theories, QCT is unique in its holistic approach to analyzing the complexity of financial markets. QCT considers the complexity of the system as a whole, rather than focusing on individual components or agents (Brunnermeier, Oehmke & Jel, 2009). This approach allows for a more comprehensive understanding of the system's behavior and dynamics.

Quantitative Complexity Analysis has been used to analyze the complexity of various systems, including financial markets, where it has been applied to study the structure and behavior of financial networks and to identify patterns of financial contagion and systemic risk. In the work of Santos & Zhao (2017), one of the key features of Quantitative Complexity Analysis that could be inferred is the ability to identify emergent properties of complex systems that cannot be easily inferred from the properties of their individual components (Gai, Haldane & Kapadia, 2011). Complexity Theory can be used to study the resilience of complex systems, including banks, by analyzing their internal structure and dynamics (Linkov, Trump & Hynes, 2019). This involves examining the interconnectedness of the various components of the system, and how they respond to different types of shocks and disturbances.

Siegenfeld and Bar-Yam (2020), discussed the concept of complexity and its applications in different fields such as biology, physics, and social sciences was discussed. While the work does not specifically address quantitative complexity analysis, it lays the foundation for understanding complexity as a fundamental property of many natural and social systems. In Barin Cruz, Ávila Pedrozo & de Fátima Barros Estivalete, 2006), Edgar Morin emphasizes the need for a multidisciplinary approach to understand complex systems, which involves taking into account the interdependencies and feedback loops among their components. The work is more focused on providing a philosophical and theoretical framework for complexity rather than presenting specific quantitative methods for its analysis.

The researchers Bastan, Tavakkoli-Moghaddam & Bozorgi-Amiri (2023) developed a comprehensive model that examines the banking business's causal structure. This model evaluates the effectiveness of risk and crisis management policies. The authors used a system dynamics methodology to create a simulation model that assesses how certain crises affect the bank's performance. The study's findings suggest that current business continuity management policies are not adequately resilient in dealing with various crises.

However, Marczy (2009) started by discussing the importance of understanding systemic risks and their potential impact on the financial system as a whole. He then introduces the concept of complexity and its relation to systemic risks, noting that complex systems are often more vulnerable to disruptions and failures. The article goes on to provide a detailed overview of various quantitative complexity metrics that have been proposed in the literature, including measures and visualization of diversity, nonlinearity, interdependencies, interconnectivity, entropy and feedback loops. The study argues that these metrics can be useful for assessing the resilience, stability, and complexity of banks and other financial institutions. The article concludes by highlighting the potential benefits of model-free quantitative complexity analysis for policymakers and regulators, who can use these tools as early-warning identification of systemic risks, volatility and take appropriate measures to mitigate them.

Overall, Complexity can be defined as a fundamental property of every dynamical system which can be appropriately measured by model-free statistical methods (Marczyk, 2015). While, Resilience refers to the capacity of a bank to resist and bounce back from negative situations or shocks like financial crises, economic downturns, or operational disruptions (Khiaonarong, Leinonen & Rizaldy, 2021). Quantitative Complexity Analysis provides a powerful tool for studying complex systems and their resilience. Its ability to identify emergent properties and analyze the structure and dynamics of complex systems makes it a valuable tool for understanding the behavior of banks and other complex systems, and for developing strategies for improving their resilience in the face of external shocks and disturbances.

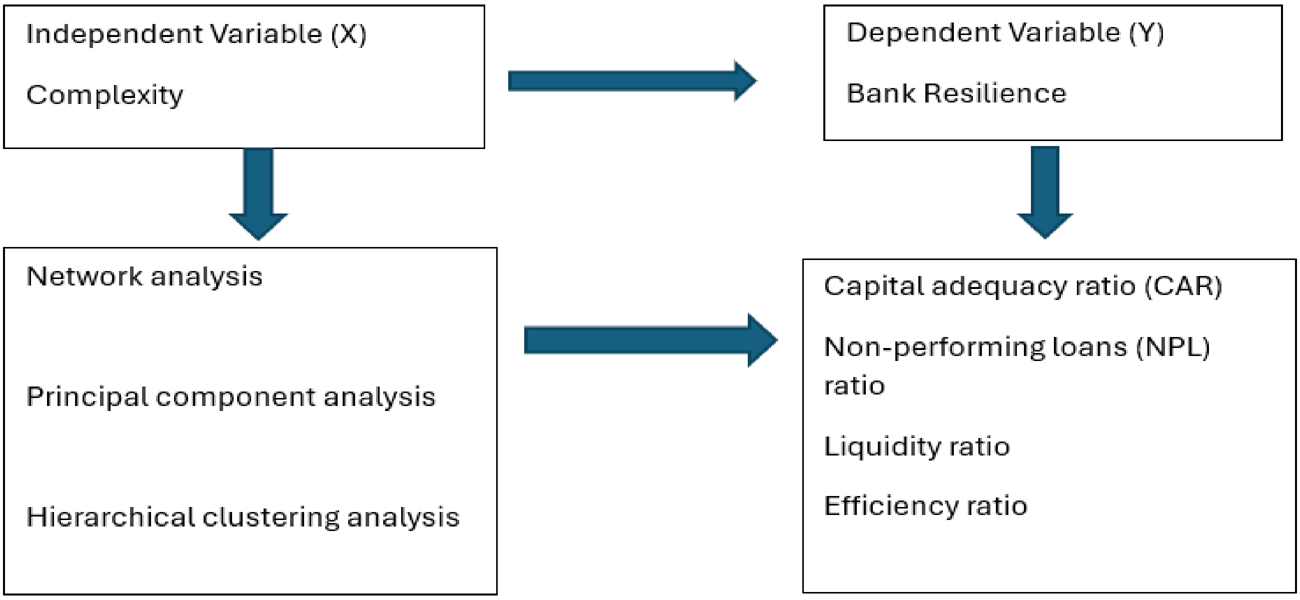

Figure 1: Conceptual Model

Quantitative complexity analysis

Quantitative complexity analysis is the process of measuring and assessing the degree of complexity in dynamic systems using statistical methods that are often model-free. Complexity analysis in banking focuses on identifying and quantifying the different interrelated elements that add to the overall complexity of operations and organizational structure of a bank (Liao, Zhou, Xu & Shu, 2020). Network topology, degree distribution, clustering coefficient, and centrality measurements are some of the metrics and indicators used in complexity analysis to evaluate the complexity of a banking system.

Quantitative complexity analysis is nevertheless a useful tool for determining and controlling complexity in the banking industry, despite these drawbacks. Banks may simplify their operations, lower their risk exposure, and eventually improve their overall resilience by offering a more thorough understanding of the elements that contribute to complexity. Quantitative complexity analysis, which makes use of statistical methods to examine vast and intricate data sets, is used to gauge the complexity of a banking system. The capability to gauge how interrelated various components of the financial system are is one of the main advantages of quantitative complexity analysis. Several metrics, including network density, centrality measures, and clustering coefficients, can be used to quantify this interconnection (Krzesiński et al., 2021).

Overview of resilience in banking

The concept of resilience in banking is often characterized by the capacity of the banking system to withstand and rebound from adverse events such as economic shocks, financial crises, or natural disasters, as articulated by (Xu & Kajikawa, 2018). Qualitative measurements are derived from the discerning perspectives of experts and subjective analyses, while quantitative metrics are derived from precise numerical data and rigorous statistical models (Hanea, Hemming & Nane, 2022). The ability of banks to resist shocks and pressures and recover after them makes resilience a crucial component of the banking system. In order to maintain stability and avoid financial catastrophes, banks must be resilient. The ability of a bank to endure and recover from negative events such financial market disruptions, natural catastrophes, cyber-attacks, and other unforeseen events can be referred to as resilience in banking (Salignac, Marjolin, Reeve & Muir, 2019).

Advantages and Limitations of Resilience Metrics

The ability of a bank to survive negative events and interruptions can be evaluated using resilience measurements, which are crucial tools. These indicators do, however, have benefits and drawbacks, just like any other measurement methods. We'll talk about the benefits and drawbacks of resilience indicators used frequently in banking in this section.

Resilience metrics' benefits

1. Improved risk management: Banks may detect and evaluate potential risks to their operations and financial stability with the aid of resilience indicators. Banks can create efficient risk management plans to reduce these risks by recognizing and measuring them. By doing this, the bank is better able to withstand unfavorable circumstances and preserve financial stability.

2. Increased regulatory compliance: Regulators evaluate the resistance of banks to unfavorable occurrences using resilience criteria. Banks can demonstrate their ability to meet regulatory standards for financial stability by adhering to the regulatory requirements for resilience measures. This could improve the reputation of the bank and assist in establishing confidence with regulators.

3. Better decision-making: Resilience metrics give banks vital data that can help them make better decisions. Banks may make wise judgments about their operations, financial planning, and risk management strategies by measuring and evaluating resilience measures. By doing this, the bank is better able to withstand unfavorable situations and maintain uninterrupted customer service.

4. Greater investor assurance: Investors use resilience indices to evaluate the financial stability and resilience of institutions. Banks can increase investor trust and draw in additional capital by exhibiting great performance on resilience metrics. This contributes to the bank's increased financial stability and supports its continued expansion.

Resilience measurements have some limitations.

1. Overreliance on measurements: There is a danger of over-relying on metrics for resilience, which could result in complacency and a delusion of security. Banks can put too much emphasis on hitting the benchmarks rather than creating efficient risk management plans. As a result, the bank's ability to recognize and manage new risks may be compromised.

2. Inadequate coverage: Not all potential hazards to a bank's operations and financial stability may be taken into account by resilience measurements. To capture growing risks including those related to climate change, cyberthreats, and geopolitical concerns, banks may need to establish new metrics. The inability to identify these risks might make it difficult to create efficient risk management plans and weaken the resilience of the bank.

3. Limited comparability: The usefulness of resilience indicators for benchmarking and regulatory compliance may be constrained because they may not be comparable across banks or jurisdictions. The risk profiles and business models of various banks may differ, necessitating the use of various resilience indicators. Comparing the resilience of several banks or evaluating regulatory compliance may be difficult as a result.

4. Resilience indicators may have low predictive value when it comes to identifying new risks or forecasting the effects of unfavorable events. To increase their predictive potential, banks may need to combine the data with additional techniques like stress tests, scenario analysis, and risk assessments. If this isn't done, developing risks may not be recognized and mitigated, which could compromise the resilience of the bank.

Resilience measures are essential tools for evaluating a capacity of the bank to endure unfavorable events and interruptions. They give financial institutions, government agencies, and investors the vital data they need to manage risks, prepare for the future, and comply with regulations. Resilience measurements do, however, have limits that must be acknowledged and addressed in order to increase their value and efficacy. To protect their resilience to unfavorable events and sustain financial stability, banks must strike a balance between satisfying the resilience criteria and creating efficient risk management techniques.

Complexity and Risk

Complexity can manifest in various ways, stemming from factors such as the abundance of elements involved, the intricate connections between them, or the inherent uncertainty and unpredictability associated with their actions. Managing complexity is of utmost importance, particularly in the financial sector. To gain a deep understanding of the system's dynamics, it is necessary to model its behavior and identify the key drivers. By utilizing this knowledge, banks can create effective strategies to navigate or take advantage of complexity in order to achieve desirable outcomes. Complexity is not necessarily a negative attribute; in fact, it can foster innovation and enhance competitiveness when effectively managed (Emblemsvåg, 2020) .

Risk is a fundamental concept that is closely linked to complexity and can be found in various fields like finance, insurance, and project management. It is the possibility of experiencing unfavorable or unforeseen outcomes or events that could have a detrimental effect on goals or outcomes. There are various sources from which risks in finance can arise, including market volatility, credit default by borrowers, operational errors, regulatory changes, and external economic shock. Risk mitigation strategies may include diversifying assets, hedging against adverse movements, obtaining insurance, or using risk-adjusted return metrics. It is crucial to effectively manage risk in order to protect investments, maintain financial stability, and accomplish long-term goals (Hanley & Hoberg, 2019).

Network Analysis

The field of network analysis encompasses the study and examination of complex systems composed of interconnected elements. By employing mathematical models and algorithms, the utilization of network analysis serves as a formidable methodological strategy to thoroughly scrutinize and visually depict the intricate interplay of relationships and connections among diverse banks or other organizations. In this study, it entails a comprehensive exploration of the complex interdependencies among diverse components within the Nigerian banking framework, encompassing entities such as commercial banks, financial institutions, regulatory authorities, and a multitude of interested parties (Hassanein & Mostafa, 2022). Within the domain of financial analysis, Network Analysis assumes a paramount significance as it endeavors to unravel the complex and intricate fabric of the Nigerian banking system. The primary objective of Network Analysis lies in the discernment of pivotal actors within the intricate web of the Nigerian banking network.

Furthermore, it is imperative to acknowledge that Network Analysis plays a pivotal role in the evaluation of vulnerabilities. It facilitates the discernment of prospective vulnerabilities or areas of susceptibility within the banking infrastructure (Alnajem, M., Mostafa, M. M., & ElMelegy, A. R. 2020). The act of acknowledging these vulnerabilities serves as a pivotal measure in formulating tactics to alleviate risks and handling complexity. One of the pivotal facets of Network Analysis lies in its inherent capacity to deconstruct the intricate dynamics governing the dissemination and circulation of information within a given system. In the dynamic areas of banking, the expeditious acquisition and precise dissemination of information hold utmost significance (Learning, 2022). Gaining insight into the mechanisms by which information propagates throughout a network can augment transparency, bolster the quality of decision-making processes, and ultimately handle the complexity of the sector.

Robustness in network analysis refers to the ability of a network to maintain its structural integrity and functionality after being subjected to attacks or failures. It is a crucial aspect of network analysis that has been studied extensively in recent years. One of the most common ways to evaluate network robustness is by using maximum flow-based methods (Cai, Liu, & Cui, 2021). In essence, Network Analysis plays a pivotal role in facilitating a thorough assessment of the complexity exhibited by Nigerian banks. It affords a comprehensive perspective on the intricacies, merits, and susceptibilities of the system. It elucidates the ramifications of quantitative complexity analysis on the capability of Nigerian financial institutions, thereby imparting invaluable

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discernment for both the sector and governing bodies (Anande-Kur, Faajir, & Agbo, 2020).

Principal Component Analysis (PCA)

Principal Component Analysis (PCA) is defined as a powerful statistical method for simplifying data by recognizing patterns and reducing the number of independent variables in a study. This study relies heavily on PCA as a foundational methodology for deconstructing large datasets with several metrics and indicators that are important for gauging the strength of Nigerian banks (D'Souza, Ahmed, Khashru, Ahmed, Ratten, & Jayaratne, 2022). PCA is a powerful tool for dealing with high-dimensional datasets. When it comes to the complexity of Nigerian banking, PCA simplifies the information by keeping just the most relevant variables. The reduced number of dimensions makes analysis simpler and the findings easier to understand. In addition to its use in reducing the number of dimensions, PCA is very effective in isolating the key characteristics or factors that have a major impact on the stability of Nigerian banks (Jolliffe & Cadima, 2016). It deduces the structure behind the data, drawing out significant features. Financial ratios, performance measures, and risk indicators are all examples of the kinds of information that may be retrieved and used to assess a complexity of the bank. (Tsoulfidis & Athanasiadis, 2022).

Complex patterns and correlations in the data may be unearthed with the help of principal component analysis (PCA). It reveals how various metrics and indicators have a similar or dissimilar effect on the complexity of Nigerian banks (Farnè & Vouldis, 2021). It elucidates whether aspects of a performance of a bank, risk profile, or operational strategy substantially impact its resilience, adaptability, and stability. In a nutshell, Principal Component Analysis is a powerful analytical tool that can aid this study. It helps to reduce complexity data to their elementary parts, providing a more straightforward and interpretable understanding of the connection between quantitative complexity analysis and the robustness of Nigerian banks (Li, 2019).

Hierarchical Clustering Analysis

Hierarchical cluster analysis is a robust technique in data analysis and statistics for organizing sets of data into logically meaningful clusters (Hayashi, Friedel, Foreman & Wirth, 2023). Cluster analysis groups the (multivariate) observations into clusters to look for patterns in a data set. The objective is to identify the best possible clustering where observations or objects are comparable within each cluster but not to other clusters. The goal is to identify the logical, naturally occurring categories in the data. The dendrogram is a graphic that resembles a tree that is created by the hierarchical clustering approach using the distance matrix (Babasola & Onoja, 2017).

As noted, Hierarchical clustering is a method of clustering that involves creating a hierarchy of clusters. It is a popular method in data analysis and has been used in various fields such as biology, computer science, and social sciences (Campello, Moulavi & Sander, 2013). Density-based clustering, on the other hand, is a clustering method that groups together points that are close to each other in terms of density (Gandhi, Goyal, Guha, Pithawala & Joshi, 2021).

It is an important method for this study because it allows for grouping together comparable pieces of information on the resilience of Nigerian banks and then that information can be used to find out which banks have good capacity to manage complexity. When it comes to recognizing patterns in large datasets, Hierarchical Clustering Analysis stands out as a top performer (Backhaus, Erichson, Gensler, Weiber & Weiber, 2023).

To create complexity typologies, Hierarchical Clustering Analysis is a useful tool. This implies that the Nigerian banks can be divided into separate complexity accommodating types according to the clustering findings. The capacity to classify banks according to their relative complexity management helps shed light on the various approaches used by financial institutions to ensure their long-term viability. Dendrograms or tree-like structures that graphically show the connections between data points are common outcomes of hierarchical clustering analyses, which are used for visualization purposes (Hulme, 2021). These dendrograms provide a visually appealing illustration of the hierarchical structure of clusters and the interconnectedness of banks in terms of their complexity management. Banks may be clustered according to the characteristics that contribute to their

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complexity management, and then comparison analysis can be run to identify the characteristics and behaviors that set each cluster apart. By comparing other banks' tactics and results for ensuring their survival in the face of adversity, we may learn more about what makes certain institutions stand out from the rest (Žarko & Žarko, 2022).

Capital Adequacy Ratio (CAR)

The Capital Adequacy Ratio (CAR) is a key financial indicator used by the banking sector to evaluate a bank's health and its capacity to withstand and recover from financial setbacks (Md Shah Naoaj, 2023). Capital adequacy is the ratio of a bank's risk-weighted assets (loans, investments, and other exposures) to the bank's equity and reserves. CAR is a measurement of a bank's ability to weather financial and operational difficulties (Ikue, Denwi, Sodipo & Enegesi, 2022). In assessing the soundness of Nigerian banks, the capital adequacy ratio (CAR)is a Key Indicator. It provides information on a resilience of the bank in the face of economic downturns or unexpected losses. Banks' skills to handle their assets and liabilities safely and responsibly are reflected in their CAR scores. With a greater CAR, the bank is showing its dedication to reducing risk by providing a larger buffer against losses. Also, regulatory bodies, like Nigeria's Central Bank, set minimum CAR standards that banks must meet. To protect depositors and keep the financial system stable, CAR is used as a compliance method to ensure that banks have sufficient capital (Suroso, 2022).

A properly analyzed CAR increases investor confidence in a bank. It sends a message to potential investors that the bank has a strong financial footing and is less likely to experience insolvency or significant financial difficulties. It is also noteworthy that CAR has an indirect effect on a bank's ability to lend. When banks have a high CAR, they are more likely to lend money to consumers and businesses, which is good for the economy as a whole. To evaluate the robustness of Nigerian banks for the sake of this study, CAR is a key indicator. A greater CAR indicates a larger capital cushion. CAR is mostly represented as a percentage. To ensure that banks are solvent and able to meet their debt obligations to depositors and creditors, regulators set minimum CAR criteria (Ikue, Denwi, Sodipo & Enegesi, 2022).

Non-Performing Loans (NPL) Ratio

The Non-Performing Loans (NPL) Ratio is a vital financial metric used in the banking industry to evaluate the strength of a bank's loan portfolio and the quality of its total asset base. It calculates the percentage of loans that are no longer being repaid by the borrowers, which usually happens as a result of default or late payments. The entire number of non-performing loans is divided by the total amount of the bank's outstanding loans to arrive at the NPL ratio, which is commonly stated as a percentage (Widyarti, Widyakto & Suhardjo, 2022).

The NPL Ratio gives a clear picture of a bank's asset quality. A higher NPL Ratio shows that a larger percentage of loans are at danger of default, which may suggest underlying problems with the bank's lending policies or the economic environment it works in. An important part of a risk management of a bank strategy is monitoring the NPL Ratio. It enables banks to quickly detect and deal with depreciating loan assets, putting steps in place to reduce future losses and manage credit risk (Nasution, Sinaga, Panjaitan & Naibaho, 2023). As part of prudential rules, regulatory bodies often impose upper bounds on the NPL Ratio that banks must abide by. To preserve financial stability and safeguard depositors' interests as well as those of the larger financial system, compliance with these regulatory requirements is essential (Stephen, Macha, & Gwahula, 2018). A lower NPL Ratio shows responsible lending practices and a decreased chance of running into financial trouble, which might attract investments and cut the bank's borrowing costs. The NPL Ratio is a crucial indicator for assessing the resilience of Nigerian banks within the context of your study. It evaluates the efficiency with which banks handle credit risk, a factor that is especially important when considering the influence of quantitative complexity analysis on a capacity of the bank to resist bad situations. The NPL Ratio may also be used as a measure of the general economic health of the areas where a bank does business. A growing NPL Ratio may be a sign of economic difficulties that limit borrowers' capacity to pay back debts. It is a vital indicator of the asset quality, risk management procedures, and general financial health of a bank. It is crucial to understanding the resilience of Nigerian banks in the context of this study since it reveals how well they are able to control credit risk and deal with difficult situations.

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Liquidity Ratio

Liquidity ratio is used as a crucial financial statistic to evaluate a capacity of the bank to satisfy its short-term financial commitments and manage its cash flow. It is a more comprehensive measure of a bank's short-term liquidity and is arrived at by dividing Current Assets by Current Liabilities (Li, 2023). It is a stricter measure of liquidity since it does not include inventories in current assets but rather looks at just the most liquid assets. Banks must always have enough cash on hand to avoid a liquidity crisis, which is why managing this risk is so important. Banks need sufficient liquidity to immediately pay out withdrawal requests from customers, cover operating expenditures, and repay obligations when they come (Li, 2023). High liquidity ratios reassure investors that a bank has a strong liquidity position, lowering their risk when making investments or deposits. Keeping the bank running smoothly every day requires a steady supply of liquid assets. As a result, they won't have to worry about any interruptions in service due to a lack of cash on hand. It can be stated that liquidity ratios are important indicators of the stability of Nigerian banks in the context of this study. Particularly pertinent in the context of quantitative complexity analysis and its influence on a capacity of the bank to navigate complexity financial conditions, they measure how well banks handle their short-term liquidity requirements. According to Li (2023), is safe to say that liquidity ratios are crucial indicators of a bank's short-term financial stability and its capacity to handle cash flow efficiently.

Efficiency Ratio:

Efficiency ratio, commonly referred to as the cost-to-income ratio, is a critical financial indicator used in the banking industry to assess a bank's operational effectiveness and its capacity to successfully control costs. This ratio offers a numerical assessment of how effectively a bank uses its resources to create money while keeping operational costs under control. It is crucial in determining if the bank can manage its resources effectively to sustain profitability and financial stability (Kenton, 2021). A lower efficiency ratio indicates that a bank is more efficient because it is spending a smaller percentage of its revenue on operating expenses. To get the efficiency ratio, a bank's entire operating costs is divided by its total income, the result multiplied by 100, and then converted to a percentage. All expenditures incurred by the bank in carrying out its daily business, such as personnel costs, rent, utilities, and administrative charges, are referred to as operating expenses. The bank's total revenue includes all sources of income, including interest income from loans, fee income from services, and any other money produced by its banking operations (Jacewitz & Kupiec, 2012).

Quantitative Complexity Theory

Quantitative Complexity Theory (QCT) provides quantitative and holistic information on the state of multi-functional dynamic systems. QCT offers a comprehensive and quantitative framework for assessing the intricate dynamics of multifunctional systems, (Krzesiński, Marczyk, Wolszczak, Gielerak & Accardi, 2023). QCT is an interdisciplinary analytical framework used to examine complex systems in a variety of fields such as economics, finance, biology, sociology, and others. QCT's core goal is to comprehend, measure, and analyze the complexity dynamics, interdependencies, and emergent features of these complex systems. The idea of complex systems, which is central to QCT, is characterized by a plethora of interrelated components or agents. These systems produce non-linear and often unexpected behaviors, posing a challenge to classic reductionist techniques. Financial markets and ecosystems, as well as social networks and organizational structures, are examples of complex systems at action (Curry, Nembhard & Bradley, 2017). One of the cornerstones of QCT is the acknowledgment of the critical role that interactions and connections play within complex systems. Cooperation, competitiveness, feedback loops, and interdependence are all examples of interactions. Understanding how these interactions influence system behavior is a critical part of QCT. QCT relies heavily on network analysis. It entails mapping and analyzing the interactions and connections between the many components of a complex system. These interactions are often depicted as networks or graphs, allowing essential nodes and patterns of linkage to be identified. Network analysis methods are critical for uncovering complex systems' structural and relational characteristics. Metrics and quantification are critical components of QCT. Quantitative measurements and metrics are used to quantify different characteristics of system complexity. These measures take into account network features including centrality, node degree, and betweenness. Quantification facilitates empirical investigations by allowing for the comparison and study of complexity systems (Thompson, Fazio, Kustra, Patrick & Stanley, 2016).

Complex systems commonly display emergent properties, which are features or behaviors that emerge through interactions between components but cannot be described by looking at individual components separately. QCT tries to detect, quantify, and comprehend these emergent features, offering information on the overall behavior of the system. Another key part of QCT is the evaluation of a resilience of the system and robustness. The ability of a system to tolerate and recover from disturbances or shocks is referred to as resilience, while robustness refers to its ability to sustain stability even when exposed to perturbations. Evaluating resilience and robustness in complex systems is important in a variety of domains, including finance and ecology (Molon, Marczyk, Virzi, Accardi, Costa & Barbieri, 2013).

Complex systems may have both hierarchical and non-hierarchical structures, and QCT can analyze both. Nested components are used in hierarchical systems, while scattered and linked components are used in non-hierarchical structures. Researchers may use QCT to investigate and comprehend the underlying dynamics and relationships in these systems. In practice, QCT uses data analysis methods and computer simulations to model and understand the behavior of complex systems (Curry, Nembhard & Bradley, 2017). These simulations allow users to experiment with various situations, test assumptions, and gain insight into the dynamics of complex systems. Importantly, QCT takes an interdisciplinary approach, including concepts and approaches from mathematics, physics, computer science, economics, and other disciplines. Because of its multidisciplinary character, QCT provides a flexible framework for researching complex systems across several fields.

Model-Free Quantitative Complexity Theory

The inception of Model-free Quantitative Complexity Theory (QCT) occurred between year 2000 and 2005, where it introduced the area of Quantitative Complexity Management (Marczyk, 2008). Jacek Marczyk developed the first comprehensive measure of complexity that combines structure and entropy, which establishes a link between physics and information theory (Marczyk, 2013). In this theoretical framework, the concept of complexity has undergone a paradigm shift, where it is now regarded not merely as a dynamic phenomenon, but rather as an emergent attribute of systems that can be objectively measured and quantified (Molon, Marczyk, Virzi, Accardi, Costa & Barbieri, 2013). Complexity, henceforth, akin to energy, is an inherent characteristic and property of any system and can be ascertained by evaluating the discernible inputs and/or outputs of said system. Quantitative Complexity Analysis is an effective method for understanding the behavior of complex systems which can be informally defined as networks (Sayama, 2015). It provides a systematic framework for investigating the deep linkages and dynamics inside these systems, giving useful insights for academics and decision-makers confronted with the problems of complexity. In contrast to traditional methods that associate complexity with either entropy or structure, the QCT integrates both entropy and structure by considering the information flow topology among agents within a specific system. The complexity function in the model-free QCT is limited. Within the vicinity of the minimum threshold, the behavior of system dynamics is primarily influenced by its arrangement (for instance, the motion of a timepiece) and tends to exhibit predictability. At the vicinity of the maximum limit, referred to as critical complexity, the driving force behind dynamics is entropy, which represents disorder. Consequently, the behaviour of the system becomes stochastic, exemplified by phenomena like turbulent flow. The measurement of a system's resilience can be determined by considering the relative values of {C_min, C, C_critical}. Here, C_min represents the minimum complexity threshold, C denotes the current complexity level, and C_critical represents the maximum complexity threshold. As the processing of real-time data streaming occurs, the values undergo continuous fluctuations. Over the course of almost ten years, the QCT has discovered various uses in the banking industry, particularly in evaluating the potential risks that banks and banking systems may face (Marczyk, 2013).

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According to Marczyk, (2015), it was determined that the assessment of resilience in a specific system relies on the evaluation of its complexity. The study suggested that intricacy is an essential physical attribute of all systems present in the natural world, with its significance being comparable to that of energy. Nevertheless, the study demonstrated that a rise in complexity also leads to a corresponding escalation in the amount of managerial effort and energy required. Moreover, when pushed to the limits, an abundance of intricacy transforms into a formidable catalyst for vulnerability. That is the reason why systems that are overly intricate are inherently delicate. The article also elaborated on the fact that the intricacy of a system depicted by a vector $\{x\}$ of N elements is officially established as a combination of Structure and Entropy. $C = f(S \circ E)$

Let S denote a $N \times N$ adjacency matrix, E represent a $N \times N$ entropy matrix, $\circ$ symbolize the Hadamard matrix product operator, and f denote a norm operator. The adjacency matrix represents the relationships among the elements of $\{x\}$. The determination of the adjacency matrix involves a complex algorithm that assesses the value of entry S_{ij}, resulting in either 0 or 1. This sets up the framework of the system. The research demonstrated that Structure is depicted through graphs and networks, which in this investigation symbolizes a corporation where the squares on the diagonal signify entries on the Balance Sheet, and the dots indicate interdependencies among them. The Business Structure Map, also referred to as the network graph in the study, illustrates the connections between various business parameters (represented by black off-diagonal dots) and showcases their inter-dependencies. The study's measurement of the dependencies was referred to as generalized correlation, which was determined through the calculation of entropy. Entropy quantifies the level of crispness or fuzziness in the dependencies among the elements of $\{x\}$ within the given context. Essentially, it measures the level of chaos present in the system. The work highlighted the significant benefit of the Quantitative Complexity Theory model-free approach, which lies in its ability to operate without numerical conditioning of the data and effectively detect structures that conventional methods may overlook. The theory posits that, after obtaining the entropy matrix and adjacency matrix, it becomes possible to calculate the complexity of a specific system by utilizing the subsequent matrix norm.

$$C = \| S \circ E \|$$

The upper limit of the complexity metric is known as critical complexity, CU, and it is a fundamental characteristic of systems associated with complexity. The formal definition of critical complexity can be expressed as follows: $CU = \| S \circ E_{max} \|$, where Emax represents the entropy matrix that reflects the highest level of sustainable disorder within the system. Similarly, the computation of the lower bound of complexity, CL, can be expressed as $CL = \| S \circ E_{min} \|$.

Within the vicinity of the minimum complexity threshold, a particular system operates in a deterministic manner that is heavily influenced by its structural characteristics. At close proximity to the upper limit of complexity, the system being discussed is primarily influenced by uncertainty. The connections between the different elements of $\{x\}$ are indistinct, resulting in significantly reduced generalized correlations. A new definition for system resilience can now be established as follows:

$R = f(CL'; C'; CU')$ where CL', C' and CU' represent, respectively, the lower complexity threshold, the current system complexity level, and the upper complexity threshold. The second-order polynomial function, denoted as f in the given equation, exhibits the following characteristics: When C equals CL, the corresponding value of R is 100%. On the other hand, when C takes the value of CU, R becomes 0%.

$$\text{if } C = CL \rightarrow R = 100\%, \quad \text{if } C = CU \rightarrow R = 0\%$$

In Marczyk, J. (2010), Complexity Profile of a dynamic system is quantified in percentage terms, which at the time of model-free quantitative complexity analysis displays the footprint of each parameter on the system. He stated in the study that, if it is recognized that complexity provides a new and advanced measure of systemic

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volatility and risk, then the complexity profile pinpoints the major contributors thereof and situates them at the top of the profiling or list. This means that those parameters are the structural hubs of the system; however, complexity profile says nothing of the performance of the parameters in financial terms. It simply indicates those parameters and variables who drive the dynamics of the system at the time of the analysis. The parameters at the top of the complexity profile can then be seen as the leverage points of the system.

METHODOLOGY

The study's main goal was to thoroughly explain how quantitative complexity analysis affected the resilience levels shown by banks in the Nigerian setting. The academic viewpoint advanced by Yin (2018), which emphasizes the value of such designs in providing meaningful explanations of events as they evolve naturally, free of external manipulations or tight controls, served as the basis for this purposeful choice of a descriptive research design. The descriptive research strategy was carefully selected for this examination because it has the intrinsic potential to capture and depict the investigated phenomena in their natural surroundings. By using this strategy, the research aimed to dive deeper into the complex processes relating the resilience of Nigerian banks and quantitative complexity analysis. The approach allowed for a discrete investigation of how these factors interact and have an impact on one another in the actual setting of the Nigerian banking sector. All of the Nigerian banks listed on the premium board of the Nigerian Exchange Group (NGX) from 2019 to 2022 make up the study's population. During this time, there were four banks that were listed. Access Bank, Zenith Bank, First Bank of Nigeria, and United Bank for Africa are among the banks.

The sample size for the investigation was chosen using a purposive sampling technique. Purposive sampling, according to Campbell, Greenwood, Prior, Shearer, Walkem, Young, ... & Walker, (2020), entails choosing cases for a specific reason, typically because they are common, instructive, or extreme. The four listed banks on the premium board of the NGX were chosen because they are the most capitalized banks in the Nigerian banking industry that met the stringent corporate governance rules of the NGX, hence the purposive sampling technique was adopted.

The annual reports and financial statements of the chosen banks for the years 2019 to 2022 served as the source of the data for this study. The Nigerian Stock Exchange (NSE) website, the websites of the banks and The Wall Street Journal (WSJ) were used to gather the data. The financial data required for the investigation was gathered from the annual reports and financial statements.

Descriptive statistics and inferential statistics were both used to analyze the obtained data. The traits of the banks that were chosen are treated using descriptive statistics and the inferential statistics is used to analyze the quantitative complexity and resilience of the chosen banks for the Network analysis, Principal component analysis, Hierarchical clustering analysis, Capital adequacy ratio (CAR)**,** Non-performing loans (NPL) ratio**,** Liquidity ratio and Efficiency ratio. Although, Principal Component Analysis (PCA) is a widely used statistical technique in the field of data analysis as it is used to reduce the dimensionality of a dataset while retaining as much information as possible (Hasan & Abdulazeez, 2021). It is a statistical method used in multivariate analysis to reduce and simplify data. Principal Component Analysis (PCA) is often used in the context of exploratory data analysis and dimensionality reduction with the aim of unveiling latent patterns and correlations inherent in the data. This is also relative to the Hierarchical clustering analysis, which is a method used in data analysis to group similar objects or data points into clusters based on their similarities or dissimilarities. In contrast, inferential statistics is primarily concerned with drawing statistical conclusions about populations by using sample data (Beattie & Esmonde-White, 2021). So, these approaches do not fall under the category of inferential statistics, but they have significant value as tools for data pretreatment, exploration, and visualization. These procedures are often considered vital in the data analysis process, serving as a first stage before potentially proceeding to inferential statistics. Therefore, it is conclusive to group all under the inferential statistics as initially noted. IBM SPSS would be used to analyze the financial data of all the banks for insights on PCA and HCA and then Ontonix QCM® Software would be used to explore and analyze the financial data of all the banks for insight on Network Analysis. And Excel Spreadsheet would be used to analyze the financial data of the 4 banks for insight to CAR, NPL, Liquidity Ratio and Efficiency Ratio.

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Research Model

What is the level of complexity of the selected Nigerian banks based on quantitative complexity analysis?

X = Complexity

X1 = Network analysis

X2 = Principal component analysis

X3 = Hierarchical clustering analysis

Research equation: X = f(X1, X2, X3)

1. What is the resilience level of the selected Nigerian banks?

Y = Bank Resilience

Y1 = Capital adequacy ratio

Y2 = Non-performing loans ratio

Y3 = Liquidity ratio

Y4 = Efficiency ratio

Research equation: Y = f(Y1, Y2, Y3, Y4)

2. Is there a significant relationship between quantitative complexity analysis and bank resilience?

Research equation: Y = f(X)

3. What are the implications of the study for Nigerian banks?

Research equation: Implications = f(X,Y)

DATA ANALYSIS AND INTERPRETATION

The study's focus is on the four Nigerian banks listed on the Premium Board of the Nigerian Exchange Group (NGX) for the period of 2019–2022, to examine the impact of quantitative complexity analysis on the resilience of Nigerian banks.

Presentation

Table 1: Principal Component Analysis

Total Variance Explained						
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% Of Variance	Cumulative %	Total	% Of Variance	Cumulative %
1	2.024	50.608	50.608	2.024	50.608	50.608
2	.893	22.327	72.935			
3	.569	14.232	87.167			
4	.513	12.833	100.000			
Extraction Method: Principal Component Analysis. Tool: IBM SPSS						

Access bank principal component explains 50.608% of the total variance in the data. First Bank of Nigeria's principal component explains an additional 22.327% of the total variance, contributing to a cumulative variance of 72.935%. UBA'S principal component explains 14.232% of the total variance, contributing to a cumulative variance of 87.167%. Zenith bank's principal component explains 12.833% of the total variance, contributing to a cumulative variance of 100.000%.

The total variance explained by the four principal components is 100%, which means that these components capture all the variability present in the original data. Access bank is the most dominant, explaining 50.608% of the total variance. This suggests that the variables involved in the analysis have a strong relationship that can be captured by this component.

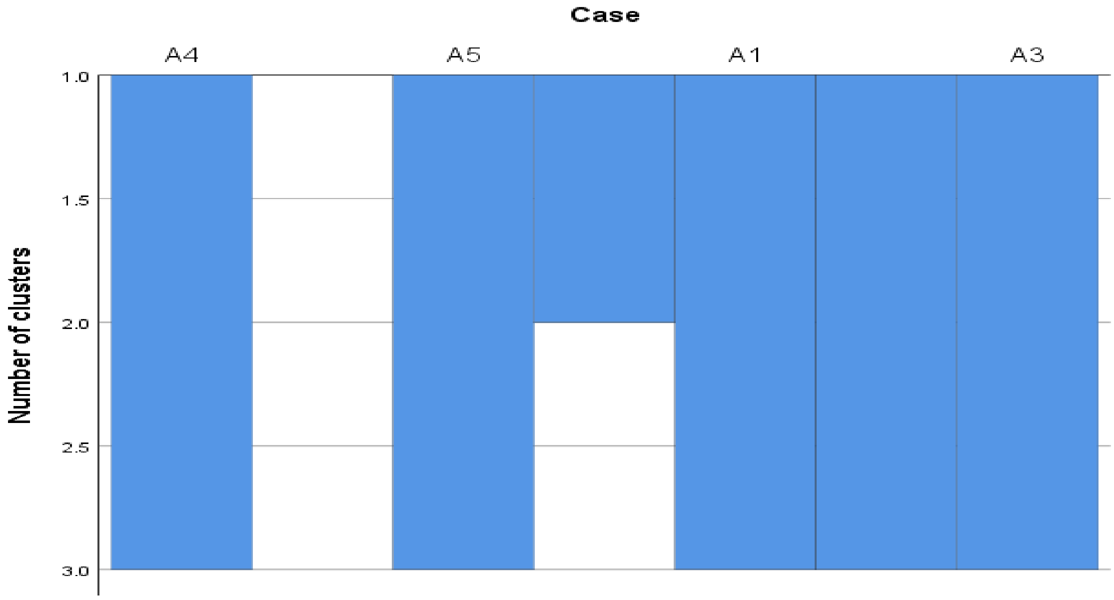

Figure 2: Hierarchical Clustering Analysis of the 4 different banks. Tool: IBM SPSS

The Figure shows the Hierarchical Clustering Analysis of the four different banks represented with A1: Access bank, A3: FBN, A4: UBA bank, A5: Zenith bank, the number of banks in each cluster at each level of the clustering process. So, at the highest level, there is one cluster with all the banks. The clustering algorithm grouped the banks with similar resilience levels together, revealing patterns in how complexity relates to the ability to withstand financial shocks. Access Bank and FBN have closer distance indicating the level of similarity between them as shorter branches imply a closer relationship between the sub-clusters within them.

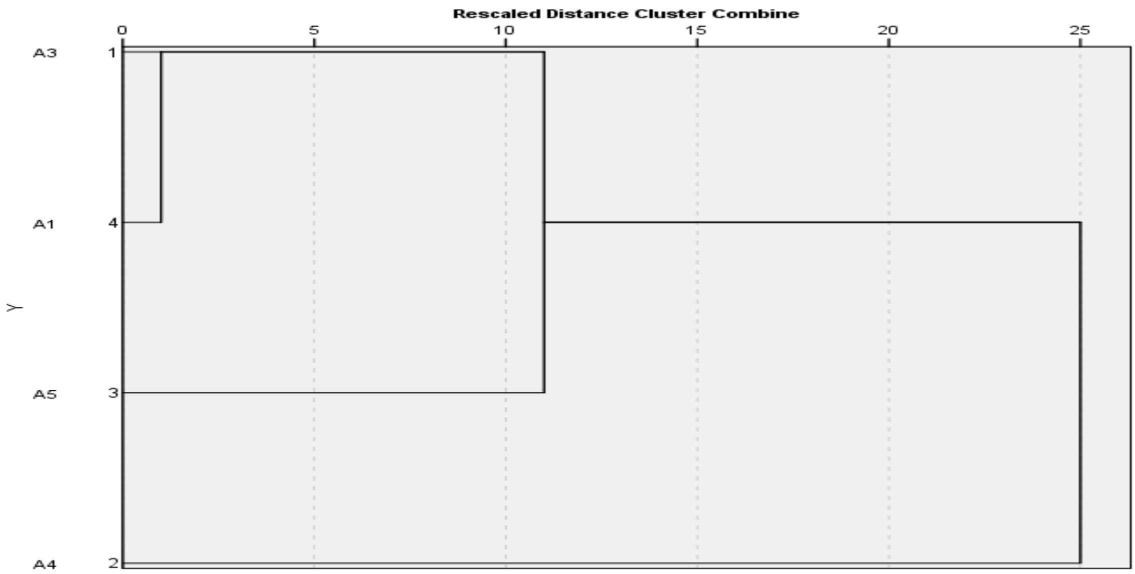

Figure 3: Dendrogram Using Average Linkage. Tool: IBM SPSS

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A1: Access bank 0.20

A3: FBN 0.38

A4: UBA bank 0.28

A5: Zenith bank 0.25

The four listed Nigerian banks on the premium board of the Nigerian exchange group (ngx) clusters are depicted in dendrograms for the 2019- 2022 time periods. Vertical lines in the dendrogram indicate the connection of two banks or clusters. The listed banks that are similar are combined at low heights, whereas the listed banks that differ are combined higher up the dendrogram. As a result, if the link between banks is at a higher point, it indicates that the dissimilarity between banks or clusters is stronger.

The two clusters are united at a distance of about 0.50, implying that the banks in the two clusters are broadly similar in terms of complexity measures. Within Cluster 1, Access Bank (Density 0.20) and Zenith Bank (Density 0.25) are fairly comparable, with a distance of about 0.05. This shows that the quantitative complexity profiles of the two institutions are extremely similar. Within Cluster 2, FBN Bank (Density 0.38) and UBA Bank (Density 0.28) are similarly highly comparable, with a distance of about 0.10. This implies that the two banks' quantitative complexity profiles are also extremely similar. Overall, the dendrogram with average linkage reveals that the four listed Nigerian banks for the 2019-2022 fiscal year may be divided into two major clusters based on their quantitative complexity measures.

Table 2: Capital Adequacy Ratio

	Capital Adequacy Ratio				
Bank Names	Year	Tier 1 Capital	Tier 2 Capital	Risk-weighted assets	Current Ratio
Access Bank					
	2019	47326	65456	30524	3.694863
	2020	44726	94339	31960	4.35122
	2021	10500	11993	39938	0.563198
	2022	10755	11700	52079	0.431172
First Bank of Nigeria					
	2019	51610	14000	20919	3.136383
	2020	64350	35000	24460	4.061733
	2021	60700	62000	24673	4.973047
	2022	68272	39282	22782	4.721008
United Bank of Africa					
	2019	70283	15738	36822	2.336131
	2020	78493	19842	38940	2.525295

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	2021	82647	21923	39842	2.624617
	2022	93833	26483	47832	2.515387
Zenith Bank					
	2019	80932	19023	41568	2.404614
	2020	84903	21920	42711	2.501065
	2021	93659	31728	49063	2.555633
	2022	99819	32992	55408	2.396964

The Capital Adequacy Ratio of Access Bank has fluctuated dramatically over the years. The bank had relatively excellent capital adequacy in 2019 and 2020, although the ratio lowers dramatically in 2021 and 2022 due to economic distress in Nigeria and the pandemic. The significant drop in the ratio in 2021 and 2022 signal a drop in capital relative to risk-weighted assets, which could weaken the bank's ability to absorb losses as at that 2020.

FBN's Capital Adequacy Ratio remains relatively consistent over the years, with values indicating that the bank maintains a strong capital position compared to its risk-weighted assets. The bank's ratio is relatively high, indicating a robust capital buffer against potential losses.

UBA's Capital Adequacy Ratio is similar to FBN's, showing consistent strength in capital relative to risk-weighted assets. The ratio remains relatively stable over the years.

Zenith Bank's Capital Adequacy Ratio remains relatively stable, showing a good capital position relative to risk-weighted assets. The bank's capital adequacy appears to be at a healthy level.

A bank's resiliency can be determined by looking at its high capital adequacy ratio. It implies that the bank is adequately financed and has the resources to withstand any losses without jeopardizing its stability. A falling ratio can make people wonder if a bank will be able to take losses and keep its finances stable.

Table 3: Non-performing loan Ratio

	Non-Performing Loans Ratio			
Bank Names	Year	Non-performing Loan	Gross Loan	Current Ratio
Access Bank				
	2019	1020	2910	35.05154639
	2020	1540	4400	35
	2021	1815	4446	40.82321188
	2022	1769	6540	27.04892966
First Bank of Nigeria				
	2019	1019	1592	64.00753769
	2020	1124	1663	67.58869513
	2021	1139	1475	77.22033898

	2022	1023	1666	61.40456182
United Bank of Africa				
	2019	1009	2100	48.04761905
	2020	1540	2356	65.36502547
	2021	1024	2600	39.38461538
	2022	1066	2800	38.07142857
Zenith Bank				
	2019	1019	2023	50.37073653
	2020	1298	2798	46.39027877
	2021	1461	4349	33.59392964
	2022	1773	4649	38.13723381

Non-performing loans are defined as interest or principle that has been due and unpaid for 90 days or more, as well as interest payments that have been capitalized, rescheduled, or rolled over into a new loan in an amount equivalent to 90 days interest or more (Ezekiel Olukayode Adeleke et al., 2023)

The ratio fluctuated over the years, reaching its peak in 2021. This could suggest challenges in managing loan quality during that period.

Access Bank's gross loans have been increasing steadily, indicating an expanding lending activity. The current ratio seems to have decreased over the years, potentially indicating a slight decline in short-term financial health.

FBN's non-performing loans remained relatively stable, showing a slight increase in 2020 and then a decline. The bank's gross loans remained relatively consistent. FBN maintained a high current ratio throughout the years, indicating strong liquidity. During the evaluation period, non-performing loans decreased from 5.0% to 4.2%, exceeding the legal requirement.

UBA's non-performing loans ratio fluctuated, with a significant increase in 2020 followed by a decrease in subsequent years. UBA's gross loans increased, indicating growing lending activities.

The bank's current ratio has shown variability, potentially indicating fluctuations in short-term financial health. Zenith Bank's non-performing loans ratio experienced fluctuations, reaching a peak in 2022.Zenith Bank's gross loans increased gradually, suggesting an expansion in its loan portfolio.

The current ratio exhibited variability, potentially indicating fluctuations in short-term liquidity.

Table 4: Liquidity Ratio

	Liquidity Ratio			
Bank Names	Year	Current Assets	Current Liabilities	Current Ratio
Access Bank				
	2019	6307588216	5768100178	1.093529589
	2020	7624797718	6971084052	1.093775037

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	2021	9660760556	8789310142	1.099148898
	2022	12535280	11466613	1.09319814
First Bank of Nigeria				
	2019	3097248495	2491358899	1.243196432
	2020	4061543605	3359144080	1.209100744
	2021	143716004	60760550	2.365284778
	2022	163995022	26043503	6.296964813
United Bank of Africa				
	2019	4136493	3689971	1.121009623
	2020	5207833	4729893	1.101046683
	2021	5574976	5073375	1.098869293
	2022	7361044	6775851	1.086364502
Zenith Bank				
	2019	5435073	4565078	1.190576152
	2020	7124487	6219755	1.145461035
	2021	7872292	6822517	1.153869166
	2022	10570678	9375531	1.127475126

The liquidity ratio measures a company's ability to pay off its short-term financial obligations using current assets, whereas the capital availability ratio (CAR) measures how much capital a bank has available, which is stated as a percentage of a bank's risk-weighted credit exposures.

The banking sector's liquidity ratio was 44.1 percent, significantly above its regulatory limit, while the CAR stayed at 13.8 percent in 2022, remaining within its prudential range of 10 to 15%.

The Liquidity Ratio for Access Bank has stayed relatively close to 1 over the years, indicating that the bank generally has sufficient current assets to cover its current liabilities.

The ratio in 2022 is significantly lower than in previous years, which might be due to the reported values being in millions rather than the expected range for current assets and liabilities.

FBN's Liquidity Ratio has been higher than 1 throughout the years, suggesting a healthy ability to meet short-term obligations with current assets. The ratio increased notably in 2022, which might indicate a significant improvement in liquidity compared to the previous years.

UBA's Liquidity Ratio is close to 1 for most years, indicating a relatively balanced position between current assets and liabilities. The ratios have only minor fluctuations, suggesting a consistent liquidity situation.

Zenith Bank's Liquidity Ratio also remains consistently above 1, indicating a favorable liquidity position. The ratio slightly decreases in 2022, which could suggest a slight change in the balance between current assets and liabilities.

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Table 5: Efficiency Ratio

	Efficiency Ratio			
Bank Names	Year	Operating Cost	Total Income	Cost-to-Income
Access Bank				
	2019	134986773	76931849	175.4627956
	2020	197519729	138517029	142.5959901
	2021	197106722	42706407	461.5389958
	2022	289959	245653	118.0360101
First Bank of Nigeria				
	2019	52349199	176694190	29.62700641
	2020	61928780	178917233	34.61308839
	2021	156992	8282599	1.895443689
	2022	409425	88605108	0.462078326
United Bank of Africa				
	2019	91510	110994	82.44589798
	2020	93630	62338	150.1973114
	2021	107420	42471	252.9255257
	2022	152094	117791	129.1219193
Zenith Bank				
	2019	118191	191873	61.59855738
	2020	136628	214147	63.80103387
	2021	165857	238732	69.47413836
	2022	204703	242702	84.34335111

Access Bank's Efficiency Ratio has been consistently high over the years, indicating that its operating costs have been relatively high compared to its total income.

The efficiency ratio of Access bank shows some fluctuations, with a significant drop in 2022. However, the low value in 2022 might be due to reduced operating cost and total income over the years. FBN's Efficiency Ratio is rated low, during 2019 and 2020, indicating the bank effectively manages its operating costs in relation to its income. The ratio increased in 2021 which illustrated that the bank’s income can cover any cost incurred during the year.

UBA's Efficiency Ratio is higher than FBN's, indicating that UBA's operating costs are a larger proportion of its

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total income. The ratio experiences some fluctuations over the years, showing a significant increase in 2021. Zenith Bank's Efficiency Ratio is similar to UBA's, suggesting a higher proportion of operating costs to total income. The ratio remains relatively consistent over the years.

Table 6: Ranking of quantitative complexity based on network analysis of the balance sheet as of 2019 -2022.

Ranking Number based on most to least robust network	Listed Banks on the Premium Board of the NGX	Requisite Complexity: How far Current Complexity is from Critical Complexity	Robustness %
1	Access	1.44/2.67	95.95
2	UBA	2.13/3.78	94.07
3	FBN	3.07/5.14	92.47
4	Zenith	1.63/2.53	89.65

Note: Based on the quantitative analysis carried out by the Ontonix Quantitative Complexity Management (QCM) specialized tool produced by Dr Jacek Marcyk on his ground breaking theory on model-free quantitative complexity management, all the banks have very strong robust network maps which shows they have requisite complexity which measures how far the current complexity is to the critical complexity (Marczyk, J. 2008) of the banks and imply that the banks have appropriate level of complexity to address and absorb a sudden issue which is further reflected in the robustness. In the table above, all the banks network analysis demonstrated low and requisite complexity which resulted in very high robustness which implies straightforward patterns in their financial structures and operations. However, Access Bank shows it has the highest robustness for the review period of the study, UBA has the second highest robustness, FBN has the third highest robustness and the distance between the current complexity of the network analysis of Zenith to its critical complexity shows it has the least robustness.

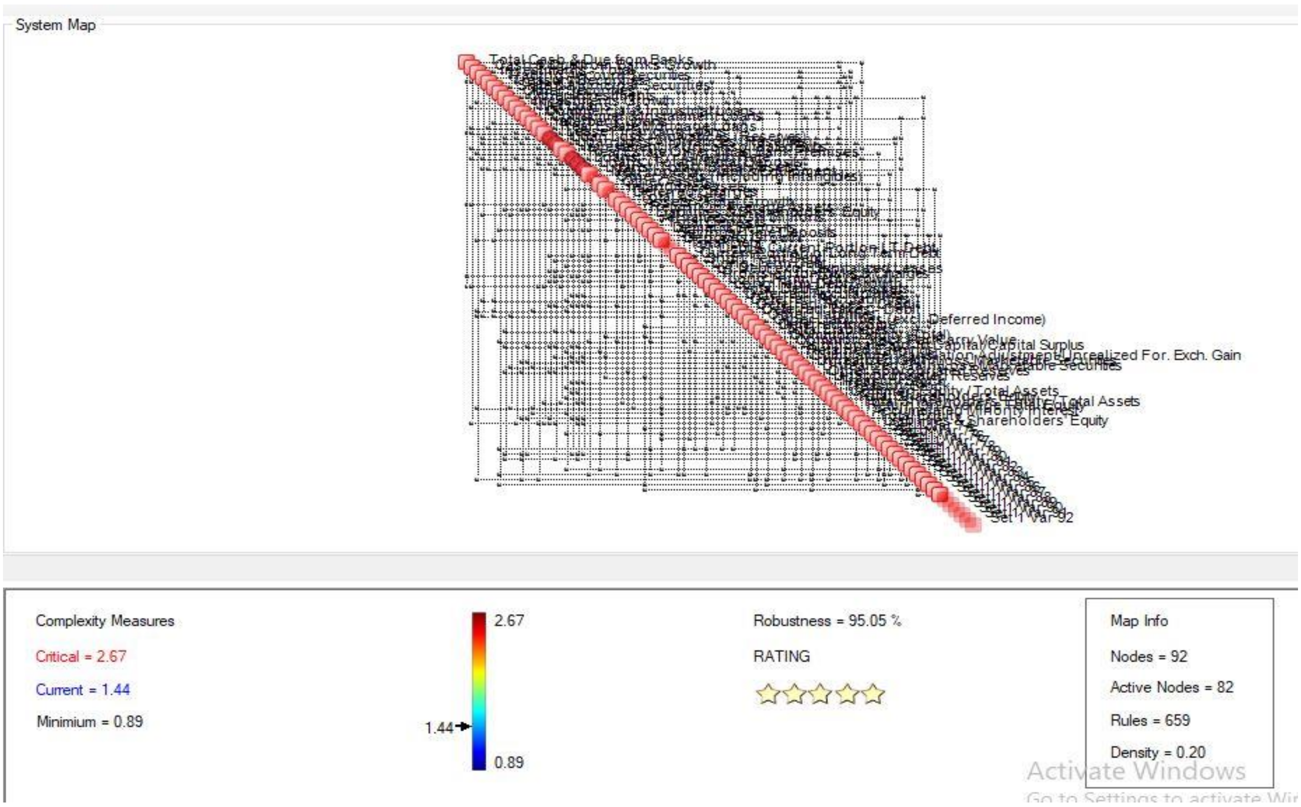

Figure 4: Access Bank Network Analysis based on Ontonix QCM Software®

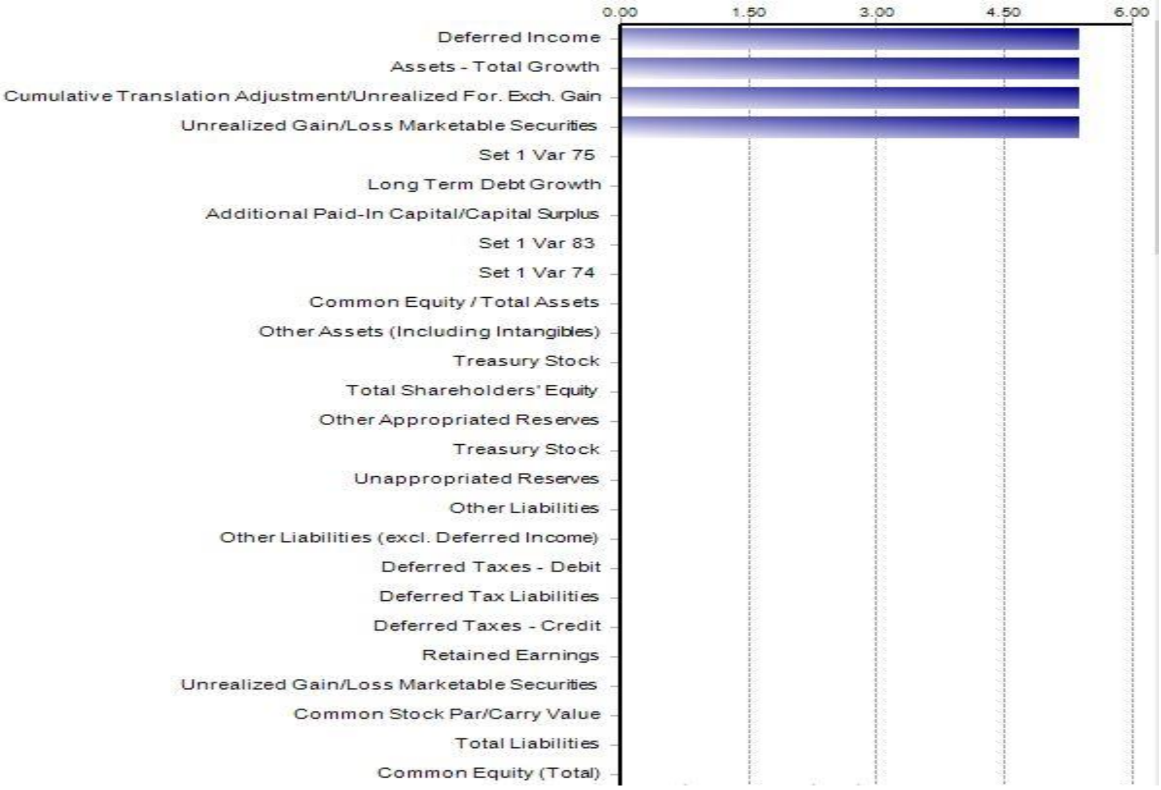

Figure 5: Access Complexity Profile based on Ontonix QCM Software®

According to figure 6, it shows that Access bank has a relatively low complexity of 1.44 on current state, a critical level of 2.67 and a minimum of 0.89. Current Complexity (1.44): This value suggests that, based on the quantitative complexity analysis, Access Bank's current state exhibits a relatively low level of complexity. A complexity score of 1.44 indicates that the interactions, relationships, or interdependencies within the bank's operations are not highly intricate or convoluted. This lower complexity may imply that the bank's internal processes and systems are relatively straightforward or less interconnected. Critical Complexity Level (2.67):

The critical complexity level of 2.67 serves as a reference point. It signifies a threshold beyond which the complexity becomes critical or significantly higher; and the bank becomes too rigid to respond to challenges if the network complexity of the bank operates too close or above the critical complexity. In the context of Access Bank, its current complexity level of 1.44 is below this critical threshold. This could suggest that, from a model-free quantitative complexity theory perspective, the bank's current state does not exhibit alarming levels of intricacy or interdependence that might lead to operational challenges.

Then Minimum Complexity (0.89): The minimum complexity value of 0.89 represents the lowest complexity level observed within Access Bank's current state. These areas of minimum complexity may represent aspects of the bank's operations that are relatively less interconnected compared to the system as a whole. If the current network complexity of the bank operates below the minimum complexity, the bank becomes too weak to respond to challenges.

Therefore, Figure 6 provides insights into Access Bank's current complexity state based on the network-quantitative complexity map and analysis in relation to the complexity profile shown in Figure 7. Figure 7 displays the top business variables that contributed to the current complexity level of the bank during the review periods, as they are seen as the leverage point of the system. The complexity profile is presented for the attention of the bank's management, as any risk arising from any individual variable or combination of variables could have consequential impacts on the bank. The data suggests that, at the time of analysis, the bank's operations exhibited a relatively low current level of complexity (1.44), which was far below the critical threshold (2.67), implying the current complexity is requisite and appropriate for the bank to face challenges. This information can be valuable for continually monitoring the operational dynamics and resilience of Access Bank within the broader context of the Nigerian banking sector.

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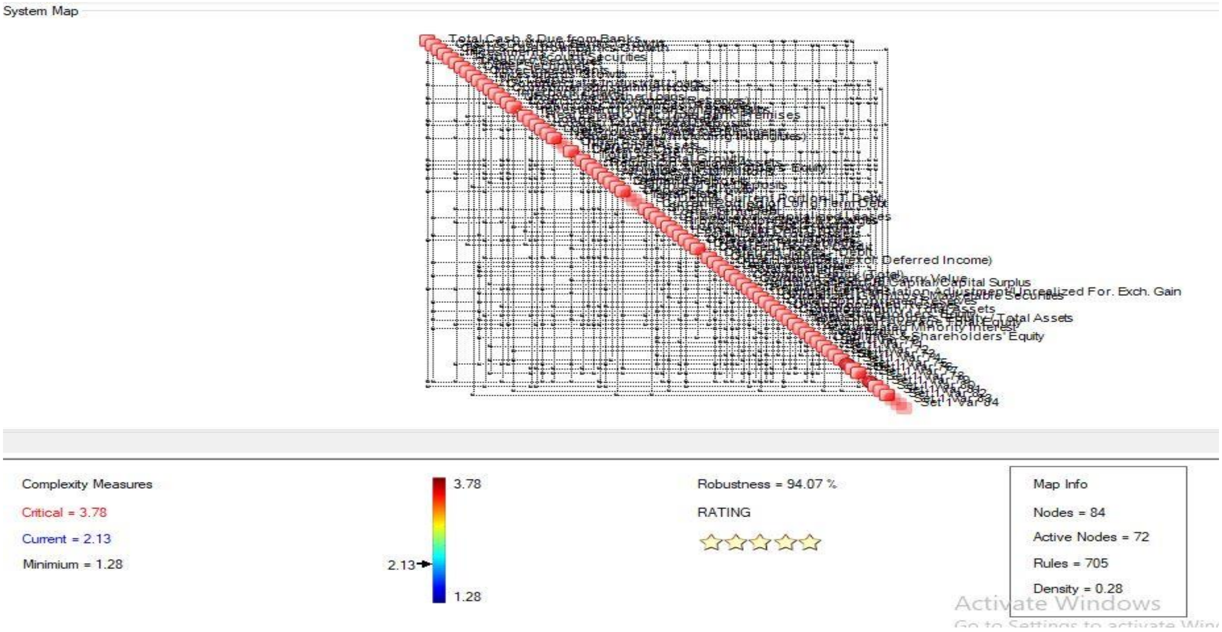

Figure 6: UBA Network Analysis based on Ontonix QCM Software®

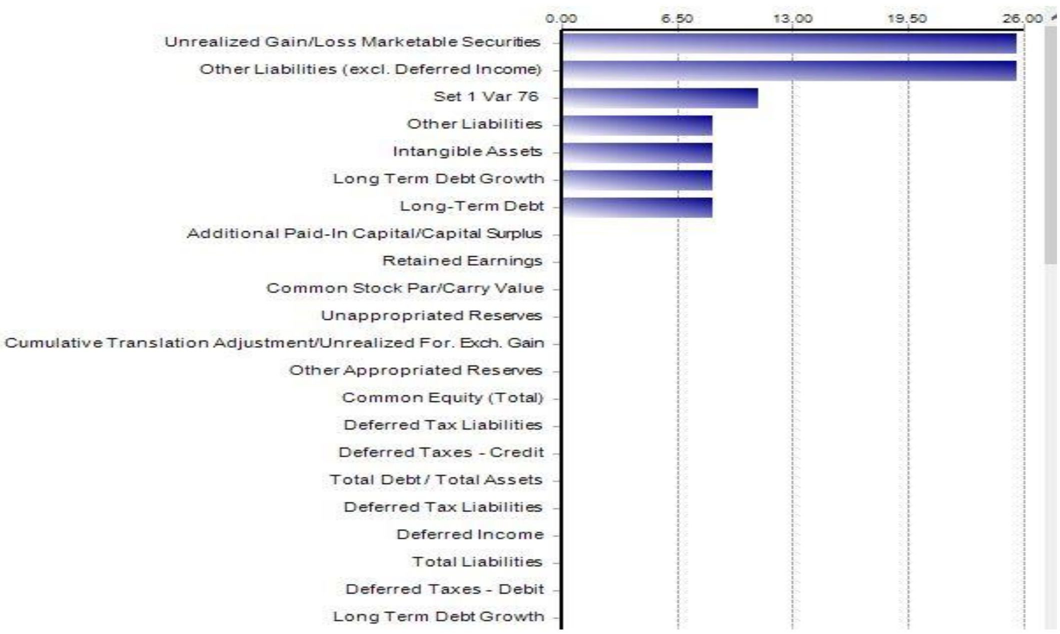

Figure 7: UBA Complexity Profile based on Ontonix QCM Software®

Figure 8 provides complexity metrics for United Bank of Africa (UBA) and includes the following key values:

Current Complexity (2.13): This value suggests that, according to the network- quantitative complexity analysis, UBA's current state exhibits a relatively low level of complexity and operates far below the critical complexity. A complexity score of 2.13 indicates that, within UBA's operations, the interactions, relationships, or interdependencies are not highly intricate or convoluted. This lower complexity may imply that the bank's financial structure and operations are relatively straightforward and are requisite and appropriate to help the bank face challenges.

Critical Complexity Level (3.78): The critical complexity level of 3.78 serves as a reference point. It signifies a threshold beyond which the complexity becomes critical or significantly higher; and the bank becomes too rigid to respond to challenges if the network complexity of the bank operates too close or above the critical complexity. In the context of UBA, its current complexity level of 2.13 is below this critical threshold. This could suggest that, from a model-free quantitative complexity theory perspective, the bank's current state does not exhibit alarming levels of intricacy or interdependence that might lead to operational challenges.

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Minimum Complexity (1.28): The minimum complexity value of 1.28 represents the lowest complexity level observed within UBA's network map for the review periods. These areas of minimum complexity may represent aspects of the bank's operations that are relatively less interconnected compared to the system as a whole. If the current network complexity of the bank operates below the minimum complexity, the bank becomes too weak to respond to challenges.

Figure 8 provides insights into United Bank of Africa's (UBA) current complexity state based on the network-quantitative complexity map and analysis for the review periods in relation to the complexity profile of Figure 9 which shows the top business variables that contributed to the current complexity level of the bank during the review periods. The variables at the top of the complexity profile can be seen as leverage points meant for the bank's management's attention, as any risk arising from any individual variable or combination of variables could have consequential impacts on the bank. The data suggests that, at the time of analysis, the bank's operations exhibited a relatively low level of complexity (2.13), which was far below the critical threshold (3.78), implying the current complexity is requisite and appropriate for the bank to face challenges. This information can be valuable for continually monitoring the operational dynamics and resilience of UBA within the context of the Nigerian banking sector.

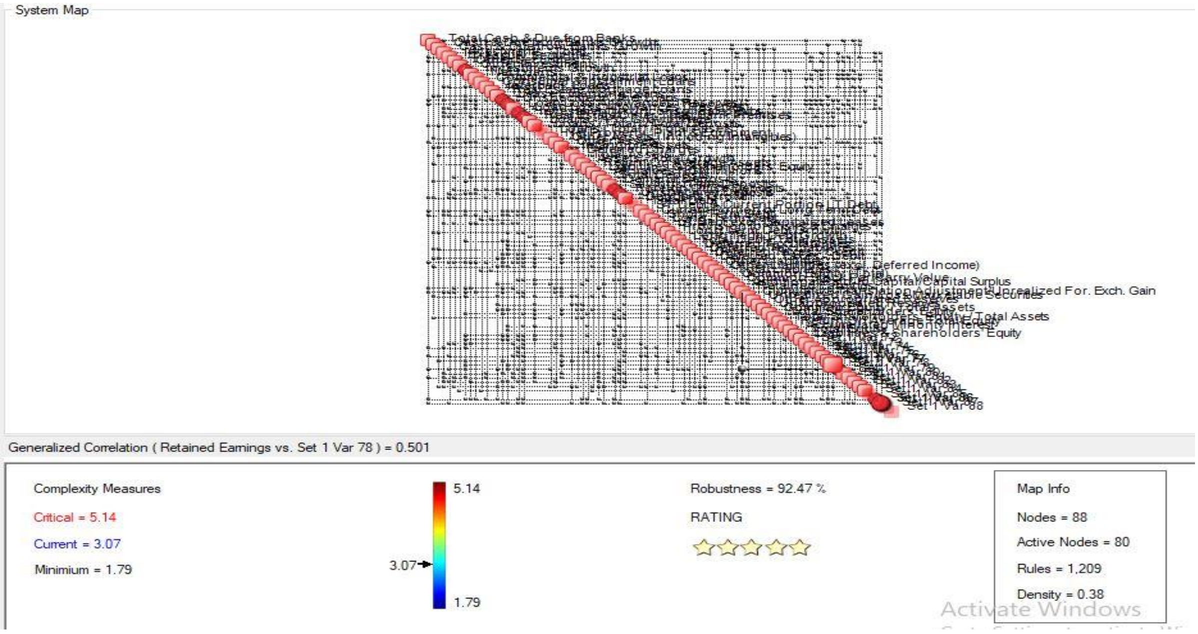

Figure 8: FBN Network Analysis based on Ontonix QCM Software®

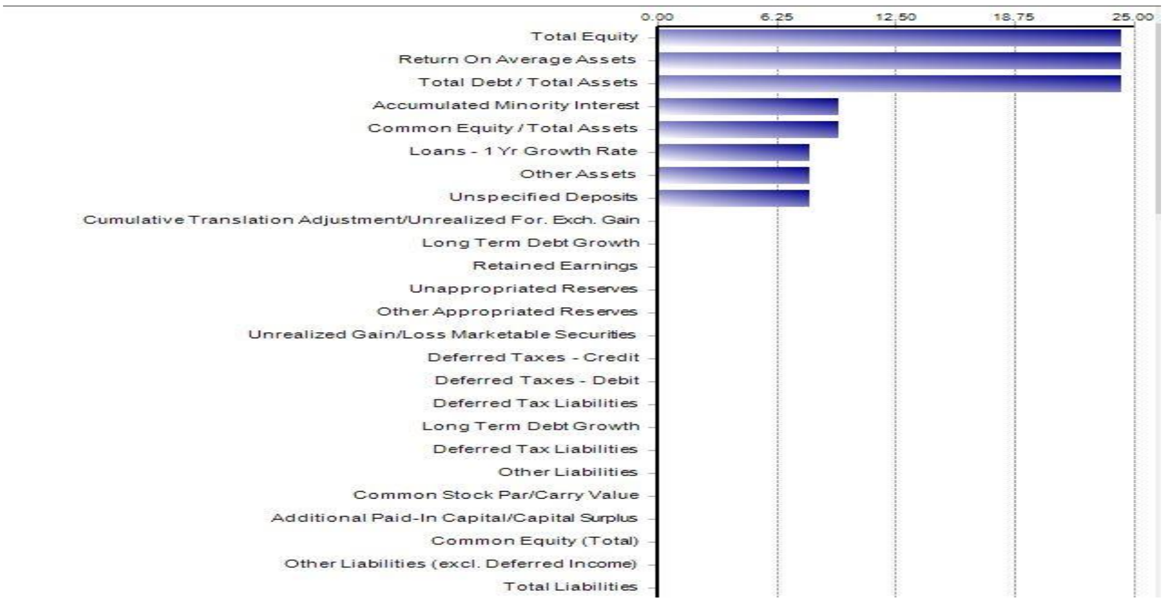

Figure 9: FBN Complexity Profile based on Ontonix QCM Software®

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Figure 10 depicts First Bank of Nigeria's complexity metrics for the review period, which include the following critical values: Current Complexity Level (3.07): According to the network-quantitative complexity study, First Bank of Nigeria has a complexity level of 3.07. This score suggests that there is a moderate amount of complexity in the bank's financial structure and operations that can help the bank face challenges. The connections, linkages, and interdependencies inside the financial structure of the bank and operations are not very complex, but they are also not particularly simple.

5.14 is the critical complexity level which denotes the point at which complexity becomes crucial or considerably greater; and the bank becomes too rigid to respond to challenges if the network complexity of the bank operates too close or above the critical complexity. First Bank of Nigeria's current network complexity level of 3.07 falls below this critical threshold. This implies that, from the standpoint of quantitative complexity analysis, the bank's current network condition does not demonstrate a critical or abnormally high degree of complexity.

Minimum Complexity (1.79): The minimum network complexity score of 1.79 is the lowest degree of complexity seen in the network map of First Bank of Nigeria for the review periods. These areas of minimum complexity may represent aspects of the bank's operations that are relatively less interconnected compared to the system as a whole. If the current network complexity of the bank operates below the minimum complexity, the bank becomes too weak to respond to challenges.

Figure 10 depicts the complexity of the network map of First Bank of Nigeria based on the model-free network quantitative complexity analysis for the review periods. According to the statistics, the bank's financial structure and operations had a requisite degree of complexity (3.07) appropriate to face issues, which was less than the critical criterion (5.14). Furthermore, several bank components revealed the minimum network complexity level as (1.79). In addition, Figure 11 depicts the complexity profile which shows the top business variables that contributed to the current complexity level of the bank during the review periods. The variables at the top of the complexity profile can be seen as leverage points meant for the bank's management's attention, as any risk arising from any individual variable or combination of variables could have consequential impacts on the bank. This information could help to continually monitor the operational dynamics and resilience of First Bank of Nigeria in the context of the Nigerian banking system.

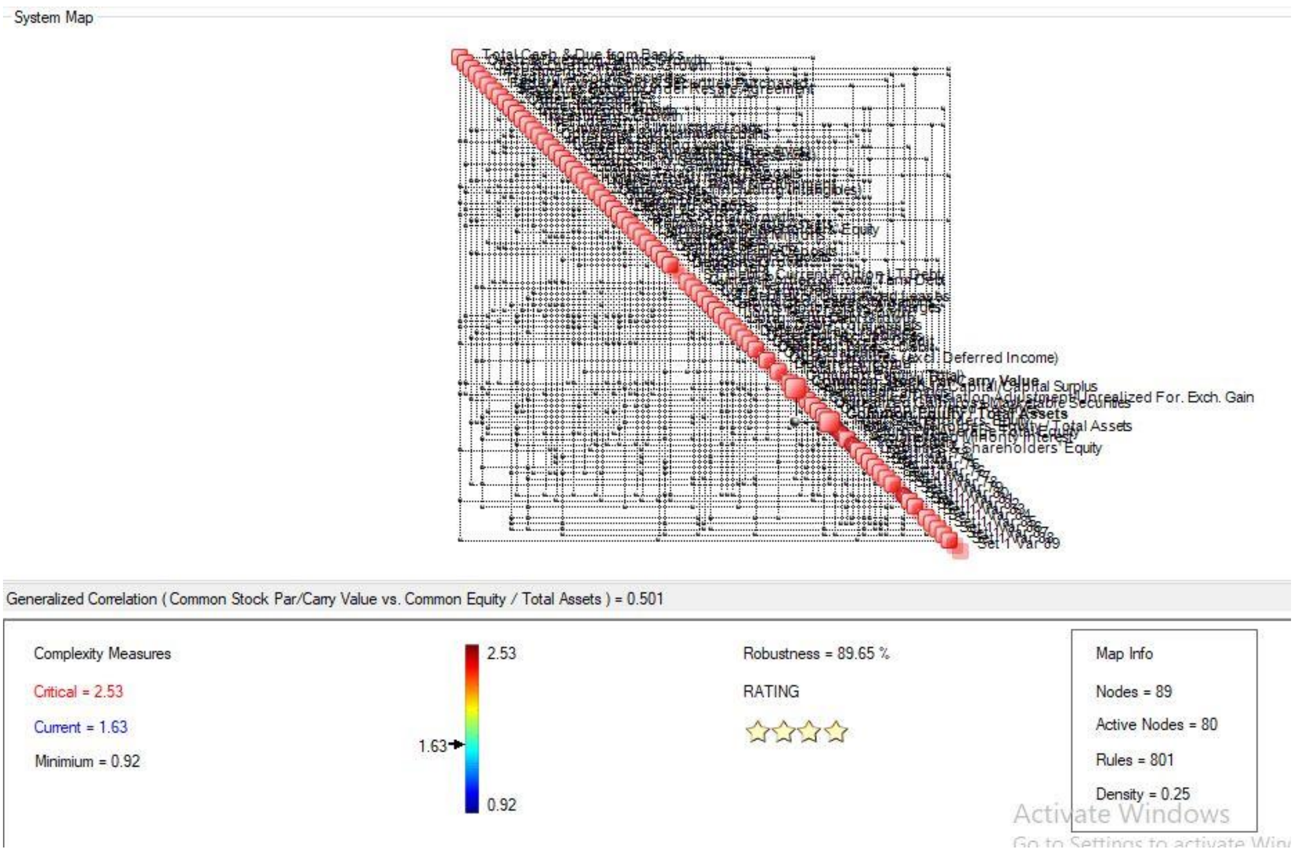

Figure 10: Zenith Network Analysis based on Ontonix QCM Software®

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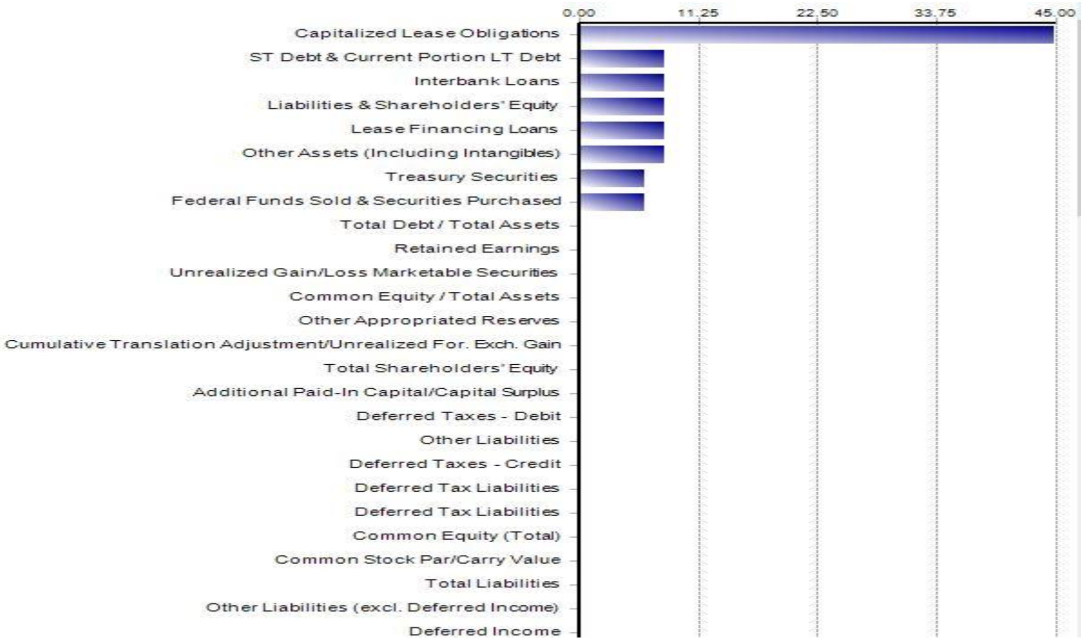

Figure 11: Zenith Complexity Profile based on Ontonix QCM Software®

Interpreting the complexity metrics presented in Figure 12 for Zenith Bank of Nigeria, Zenith Bank's current complexity level of 1.63 suggests that its financial structure and operational systems are relatively straightforward and appropriate to face challenges. This can lead to streamlined operations, reduced operational costs, and quicker decision-making processes, contributing to overall operational efficiency. A lower complexity level can contribute to stability and predictability in day-to-day operations. This can enhance customer experiences and maintain trust among stakeholders.

However, extremely low complexity might limit the bank's potential for innovation and adaptability. In a rapidly evolving financial landscape, some degree of complexity can be necessary to explore new opportunities and meet evolving customer needs. Also, an excessively low complexity level may limit the bank's ability to expand its product and service offerings or enter new markets, potentially constraining its growth potential.

At a critical complexity level of 2.53 serves as a reference point for complexity management. The bank becomes too rigid to respond to challenges if the network complexity of the bank operates too close or above the critical complexity. Zenith Bank's current complexity level of 1.63 is below this threshold, indicating a proactive approach to risk management. This can help mitigate operational and systemic risks, which is vital in the banking industry. Banks that have requisite complexity, maintain complexity levels below the critical threshold and they may easily keep up with industry peers in terms of product innovation and market responsiveness.

On the other hand, the network map and analysis of Zenith bank showed a minimum complexity level of 0.92. If the current network complexity of the bank operates below the minimum complexity, the bank becomes too weak to respond to challenges. Extremely low complexity may indicate a lack of flexibility to adapt to changing market conditions or customer demands. This can hinder the bank's ability to quickly respond to emerging opportunities and challenges, potentially preventing it from staying competitive in a rapidly evolving banking industry.

Figure 13 depicts the complexity profile of Zenith bank for the review periods. It shows the top business variables that contributed to the current complexity level of the bank. The variables at the top of the complexity profile can be seen as leverage points. This might be informational to the management of the bank as any risk from any or combination of the variables could be consequential on the bank. This knowledge could help to continually monitor the operational dynamics and resilience of Zenith Bank in the context of the Nigerian banking system.

Pulling all strings together, the ranked tables of all sub variables are presented in Table 7. The total data will

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further be used to conduct an overall rating to give a clearer understanding and a summative conclusion regarding the performance of each bank.

Table 7: Tables for Sub-Variables

	Independent Variable (X) Complexity			Dependent Variable (Y) Bank Resilience			
	Network analysis-Robustness and Requisite Complexity	**Principal component analysis**	**Hierarchical clustering analysis**	**Capital adequacy ratio (CAR) Avg 2019-2022**	**Non-performing loans (NPL) ratio Avg 2019-2022**	**Liquidity ratio Avg 2019-2022**	**Efficiency ratio Avg 2019-2022**
Access Bank	95.95%	50.61%	0.20	2.26	35.00	1.09	224.41
UBA	94.07%	22.33%	0.28	2.50	47.72	1.10	153.68
FBN	92.47%	14.23%	0.38	4.22	67.55	2.80	16.65
Zenith Bank	89.65%	12.83%	0.25	2.48	42.12	1.16	69.805

To further narrow down the flow of the study, the entire independent variables can be collated in one table, which has been presented in table 7.

Table 8: Collated data of all independent variables

	Ranking Based on Robustness from Quantitative complexity analysis	Network Analysis - Robustness	Principal Component Analysis	Hierarchical Clustering Analysis
1	Access Bank	95.95%	50.61%	0.20
2	UBA	94.07%	22.33%	0.28
3	FBN	92.47%	14.23%	0.38
4	Zenith Bank	89.65%	12.83%	0.25

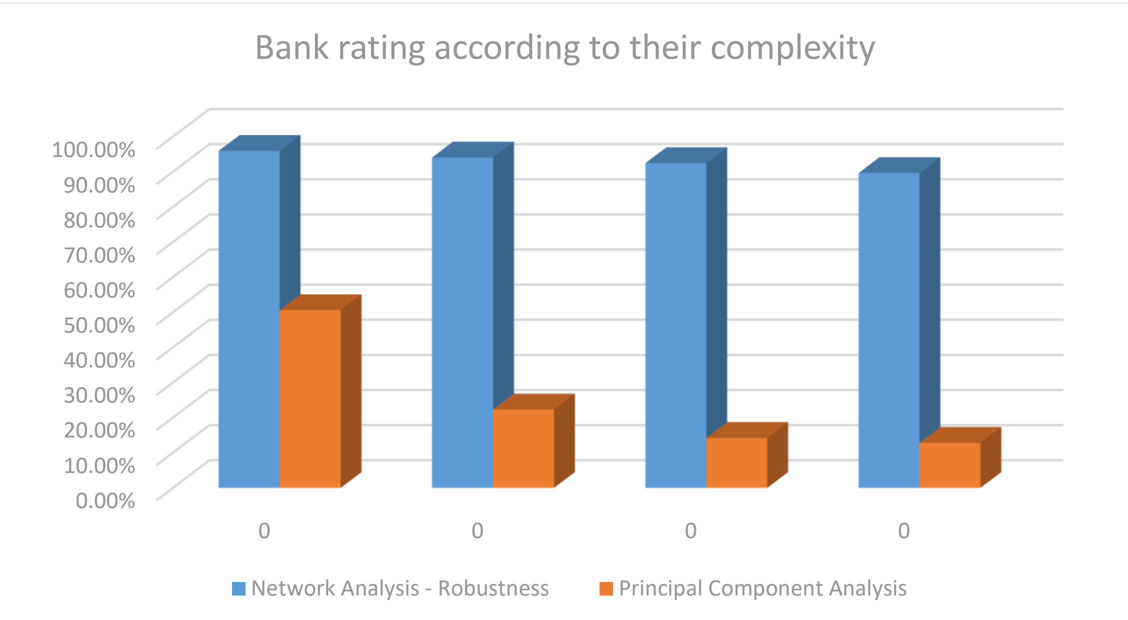

Figure 12: Bank rating for Robustness and Principal Component Analysis

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The HCA was not featured in the graph because it presents a rather divergent opinion, which have been represented in the hierarchy chart in Figure 17. However, it can be deduced that Access bank clearly rates highest among the four banks in the area of robustness and is in sync with the Principal Component Analysis. This tells that in the landscape of Nigerian banking, the intricacies of the four major players: Access Bank, UBA, FBN (First Bank of Nigeria), and Zenith Bank can be obviously concluded. The Network Analysis-Robustness, Principal Component Analysis, and Hierarchical Clustering Analysis assess the complexity of these financial institutions. The findings reveal a hierarchy in terms of complexity, with Access Bank emerging as the most intricate among the four. This implies that Access Bank operates in a nuanced environment, possibly navigating a multitude of interconnected factors and exhibiting a comprehensive structure that sets it apart from its peers. Then UBA on the other hand, demonstrated a unique profile. While ranking second in terms of complexity according to Network Analysis-Robustness and Principal Component Analysis, it found itself at the fourth position when assessed through Hierarchical Clustering Analysis. This intriguing inconsistency suggests that UBA's complexity might manifest in diverse ways, possibly a blend of robust network interactions and unique structural elements or some other physical or structural factors that this study has been limited from accessing.

FBN, securing the third spot in complexity according to two methodologies but rising in the third, presents a moderate level of intricacy. The study implies that FBN's complexity may be more pronounced in its internal organizational structure, highlighting the significance of examining the bank's inner workings for a comprehensive understanding. What this might contribute to the bank in real life in terms of requisite complexity will be discussed shortly.

Zenith Bank, by contrast, emerged as the least complex among the four according to all three assessment methods. This implies a streamlined operational landscape, possibly indicating a straightforward organizational structure and a more focused business model eventually.

Also, compressing all the dependent sub-variables, Table 8 highlights in simple view, the complete values of the four banks.

Table 9:Dependent sub-variables result of all Banks

	Ranking Based on Resilience	Capital Adequacy Ratio (CAR) Avg 2019-2022	Non-performing Loans (NPL) Ratio Avg 2019-2022	Liquidity Ratio Avg 2019-2022	Efficiency Ratio Avg 2019-2022
1	FBN	4.22	67.55	2.8	16.65
2	UBA	2.5	47.72	1.1	153.68
3	Zenith Bank	2.48	42.12	1.16	69.805
4	Access Bank	2.26	35	1.09	224.41

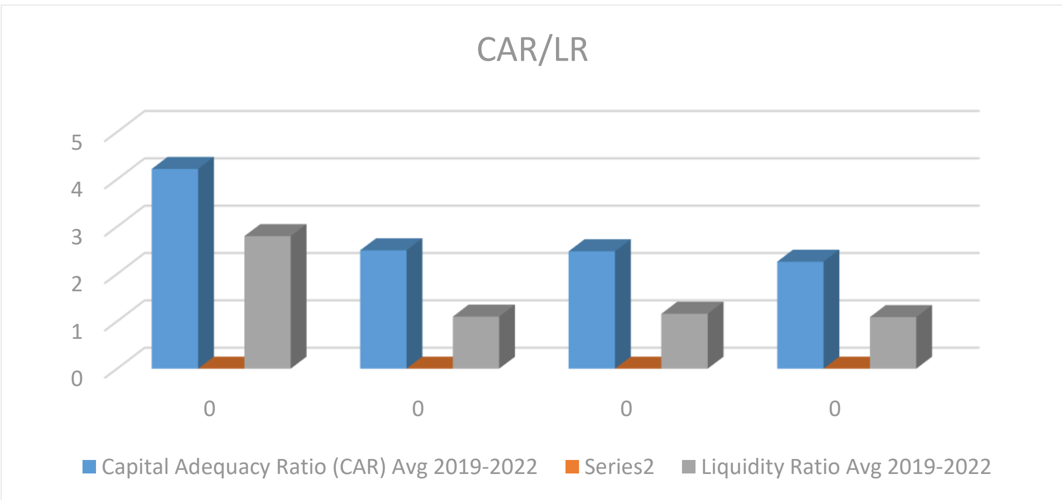

Figure 13:Capital Adequacy Ratio and Liquidity Ration of banks

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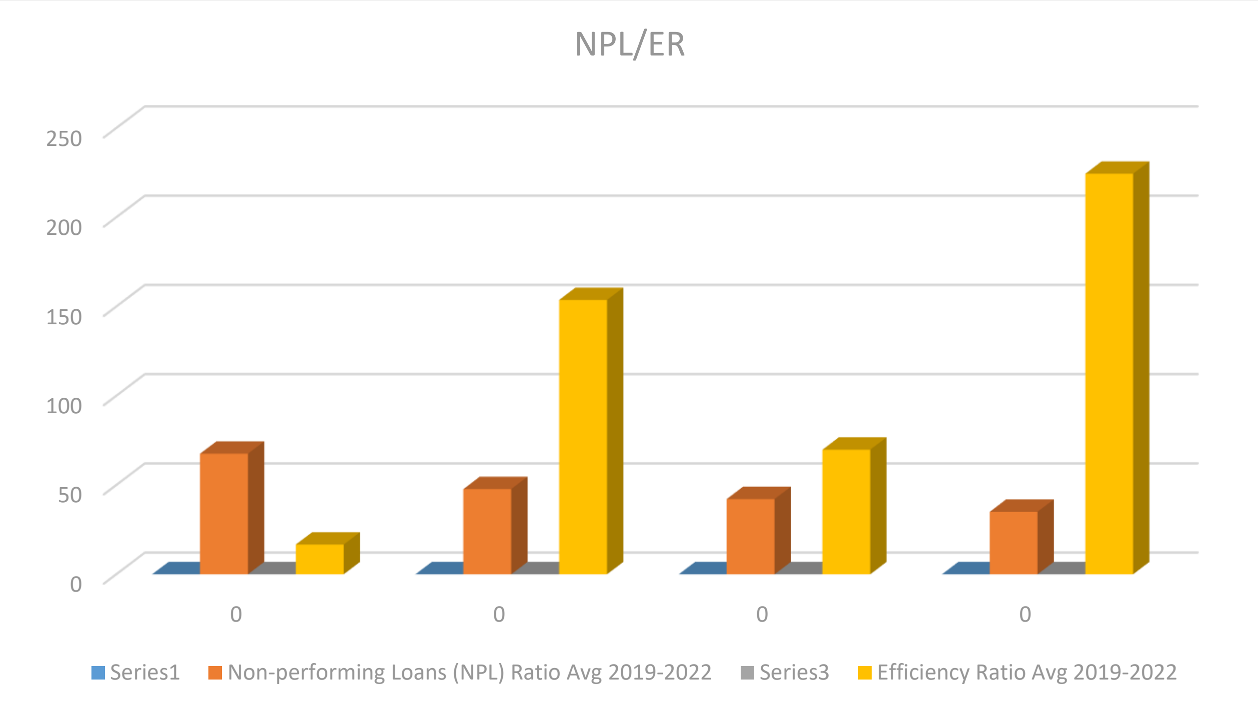

Figure 14: Non-Performing Loan Ratio and Efficiency Ratios of Banks

Figure 15 and Figure 16 were both derived from Table 8. They were separated according to their calibration strengths on the X-axis for better display of the varying values of the results. The ranking based on resilience across four major Nigerian banks; First Bank of Nigeria (FBN), UBA (United Bank for Africa), Zenith Bank, and Access Bank, provides valuable insights into their financial health and operational efficiency. Examining key sub-variables, including Capital Adequacy Ratio (CAR), Non-performing Loans (NPL) Ratio, Liquidity Ratio, and Efficiency Ratio, sheds light on the distinctive positions of each institution.

These ranked tables provide a comparative overview of the banks' performance across different complexity and resilience sub-variables and analytical methods, helping to identify relationships and patterns in the data between the X and the Y:

1. **Access Bank**:

   a. **Resilience Methods**: Access Bank has a relatively low Capital Adequacy Ratio (CAR) and a high Non-Performing Loans (NPL) Ratio, indicating potential vulnerabilities in its capital position and loan quality. However, it has a reasonably good Liquidity Ratio, and the Efficiency Ratio is exceptionally high, suggesting possible inefficiencies.

   b. **Complexity Methods**: Access Bank shows the highest robustness according to Network Analysis. This means that it has a resilient and interconnected financial structure. Additionally, Access Bank has a high Principal Component Analysis (PCA) score, implying diversity and lower correlation among its financial variables.

   c. **Insight**: Access Bank's robustness, especially according to Network Analysis, suggests that it may be well-prepared to address issues that could arise from its financial health or resilience ratios. The diverse and less correlated financial variables indicated by PCA also imply flexibility in managing financial challenges.

2. **UBA (United Bank of Africa)**:

   a. **Resilience Methods**: UBA has a relatively low CAR and a high NPL Ratio, which could pose challenges in terms of capital and loan quality. Its Liquidity Ratio is moderate, and the Efficiency

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Ratio is high, indicating possible inefficiencies.

b. **Complexity Methods**: UBA demonstrates robustness in Network Analysis. While its PCA score is lower, suggesting less diversity among financial variables, it still shows some degree of resilience.

c. **Insight**: UBA's robustness in Network Analysis could help it address challenges stemming from its financial health or resilience ratios. However, it may need to work on improving the diversity and correlation among its financial variables, as indicated by PCA.

3. **FBN (First Bank of Nigeria)**:

   a. **Resilience Methods**: FBN has a relatively better CAR and a high NPL Ratio, indicating a stronger capital position but concerns about loan quality. Its Liquidity Ratio is good, and it has a low Efficiency Ratio, suggesting efficient resource management.

   b. **Complexity Methods**: FBN scores slightly lower in Network Analysis but still demonstrates robustness. Its PCA score suggests limited diversity among financial variables, and it has the highest degree of hierarchy in its financial structure based on hierarchical clustering analysis.

   c. **Insight**: FBN's robustness, combined with its relatively better CAR, could position it well to manage challenges arising from its financial health or resilience ratios. However, it may need to address the hierarchy and improve diversity among its financial variables for even greater resilience.

4. **Zenith Bank**:

   a. **Resilience Methods**: Zenith Bank has a relatively low CAR and a high NPL Ratio, indicating vulnerabilities in capital and loan quality. Its Liquidity Ratio is moderate, and the Efficiency Ratio is high, suggesting possible inefficiencies.

   b. **Complexity Methods**: Zenith Bank demonstrates robustness in Network Analysis but slightly less so compared to the others. Its PCA score suggests limited diversity among financial variables, and it has a moderate degree of hierarchy in its financial structure.

   c. **Insight**: Zenith Bank's robustness in Network Analysis may help it address issues arising from its financial health or resilience ratios. However, it should work on diversifying its financial variables and addressing inefficiencies indicated by the high Efficiency Ratio.

Table 10: Condensed overall ranking of the four banks

Rank	Banks	Overall Rank (Equal Weighting)
1	FBN	2
2	Access Bank	2.5
3	UBA	2.5
4	Zenith Bank	3

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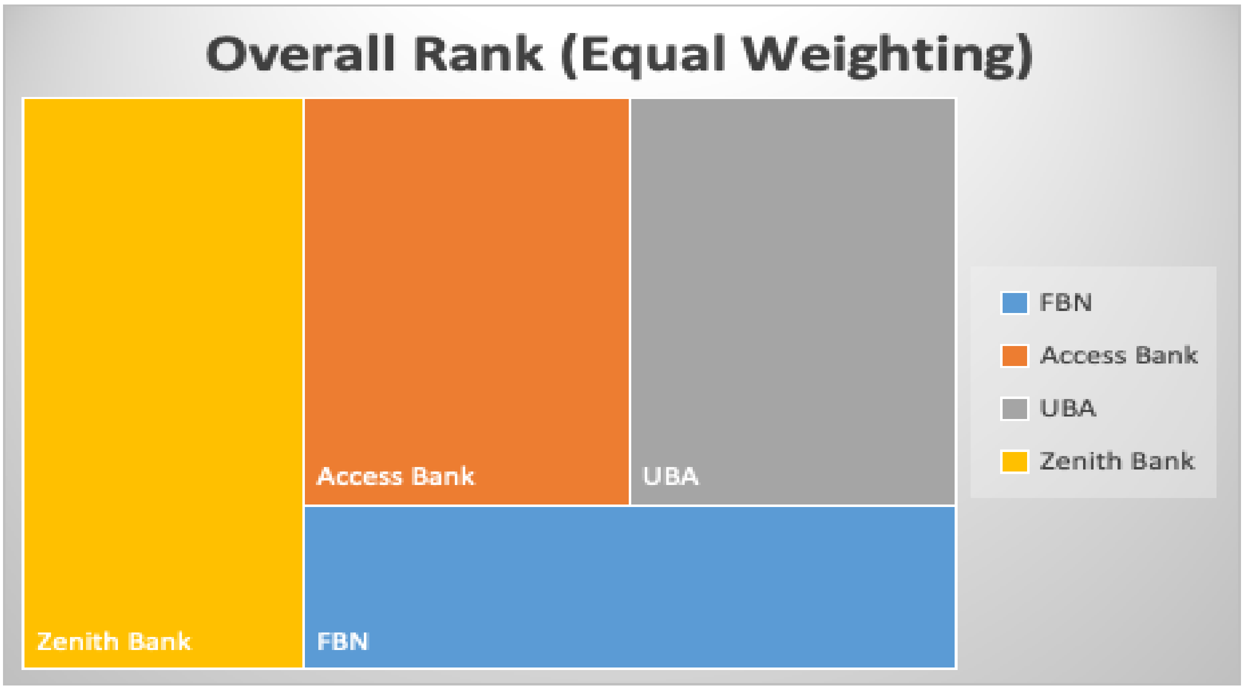

Figure 15: Hierarchy chart of the overall rank for the banks.

The overall rank is calculated by averaging the ranks from the financial resilience table and the Quantitative Complexity Analysis table which according to Mohammadi & Rezaei (2020) involves combining rankings from multiple criteria into a single overall ranking, falls under the broader category of multi-criteria decision-making (MCDM).

DISCUSSION OF FINDINGS

The holistic ranking table combines two sets of information: one related to resilience (captured by the following financial ratios: Capital Adequacy Ratio, Non-performing Loans Ratio, Liquidity Ratio, and Efficiency Ratio) and the other related to quantitative complexity analysis (involving Network Analysis - Robustness, Principal Component Analysis, and Hierarchical Clustering Analysis). The overall ranking is derived from equal weighting of both sets of information according to Mohammadi & Rezaei (2020).

The insights into the potential effects of the quantitative complexity analysis on the resilience analysis of the four banks:

1. **FBN (First Bank of Nigeria) Dominance:**
   - FBN holds the top rank in the overall ranking. This indicates that, based on the equal-weighted combination of financial resilience and Quantitative Complexity metrics, FBN is considered the most balanced or resilient among the banks.
2. **Access Bank and UBA Tied:**
   - Access Bank and UBA share the second position in the overall ranking. Both banks show a relatively similar level of performance when considering both financial resilience and Quantitative Complexity criteria.
3. **Zenith Bank's Performance:**
   - Zenith Bank is ranked lower in the overall ranking. This suggests that, despite having good financial resilience (as seen in the financial metrics), its performance in the quantitative complexity analysis might not be as strong.

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4. **Impact of Quantitative Complexity Analysis:**
   - The inclusion of Quantitative Complexity analysis appears to influence the rankings, as it plays a significant role in determining the overall rank. FBN's high position in the Quantitative Complexity analysis contributes to its top rank in the combined assessment.
5. **Consideration of Both Aspects:**
   - The holistic ranking underscores the importance of considering both financial resilience and quantitative complexity in evaluating the overall health and stability of banks.
6. **Potential Trade-Offs:**
   - The ranking suggests that a bank with strong financial metrics may not necessarily perform well in terms of quantitative complexity and vice versa. Balancing both aspects is crucial for a comprehensive assessment.

In essence, while all four banks exhibit some degree of robustness in their financial structures, First Bank of Nigeria (FBN) and Access Bank may have requisite complexity which is an advantage in addressing issues stemming from their financial health metrics or resilience ratios due to their relatively higher robustness scores. However, improvements in specific areas, such as loan quality and capital adequacy, are still essential for overall financial health and resilience. The combination of robustness and targeted improvements can enhance their ability to address financial challenges effectively. However, Zenith Bank exhibits a lower robustness level in network analysis which imply lower requisite complexity as compared to others with higher robustness level, which could have implications for its adaptability and innovation potential.

Relating these findings to the real-world dynamics of the Nigerian banking sector, several considerations come to light. Access Bank's position as the bank with the highest requisite complexity may reflect its adaptability to a dynamic market, where the ability to navigate intricate financial landscapes is a key success factor. UBA's varied ranking suggests a balance between different facets of complexity, which could be a strategic advantage or a reflection of the diverse challenges it faces. FBN's dominance may suggest high requisite complexity to easily address and navigate loan quality and lower diversity with high correlated financial variables challenges. FBN's internal complexity based on Hierarchical Clustering Analysis, points to the importance of risk management practices and organizational structure in managing the demands of the banking industry. Finally, Zenith Bank's simplicity may indicate a strategic focus on core banking functions without unnecessary intricacies.

Relating these with the hypothesis of the study and research questions.

Addressing Research Question i:

Is there a significant effect of the level of complexity of the financial structures and operations of the four listed Nigerian banks on the premium board of the Nigerian Exchange Group (NGX) for the years 2019-2022 on their resilience?

The analysis suggests that there is indeed a correlation between the complexity of the banks and their resilience. Access Bank, identified as the most robust among the four, exhibits the highest level of requisite complexity. First Bank of Nigeria (FBN), identified as the most balanced and dominant among the four, exhibits the third highest level of requisite complexity compared to Zenith Bank and the highest level of resilience among the four banks. This conclusively imply that a certain level of complexity is positively associated with the bank’s resilience. Also taking from the occurrence of the alternating results between Access Bank and FBN, Access Bank demonstrates the highest requisite complexity level which can help it easily navigate and address its resilience challenges.

Addressing Research Question ii:

Does the use of quantitative complexity analysis positively influence the resilience of the four listed Nigerian banks?

Analyzing the complexity of banks through methods like Network Analysis, Principal Component Analysis, and Hierarchical Clustering provides valuable insights into their inner workings. In this study, FBN, identified as the overall balanced and dominant among the banks, demonstrated good Quantitative Complexity Analysis result across Network Analysis, PCA and HCA and also shows the highest resilience. This suggests that there is a positive connection between how intricate a bank's operations are and its ability to withstand challenges. To put it simply, understanding and improving the requisite complexity of operations can lead to better strategies for overall enhancement. Further statistical analysis can confirm and provide more detailed insights into this relationship. In essence, by knowing and optimizing their operational intricacies, banks can strategically improve their overall performance.

Addressing Research Question iii:

Do the risk management practices of the four listed Nigerian banks have a significant impact on their resilience?

The resilience analysis, considering sub-variables like Capital Adequacy Ratio, Non-performing Loans Ratio, Liquidity Ratio, and Efficiency Ratio, provides insights into the risk management practices of each bank. For instance, FBN, suggest strong risk management practices as indicated by its high Capital Adequacy Ratio, good Liquidity and Efficiency Ratios which shows high resilience, while also exhibiting good requisite complexity to easily address its Loan quality challenges. UBA, facing challenges in managing non-performing loans and efficiency ratios but with moderate Liquidity ratio, shows both fairly good resilience and requisite complexity level to easily address her challenges, which highlights the significance of having effective risk management in ensuring resilience. This supports the notion that robust risk management positively influences resilience. Zenith Bank, which indicated vulnerabilities in capital, loan quality, and efficient resource management, suggests it can improve its resilience by enhancing risk management practices. This can be achieved by enabling better QCA to strengthen the requisite complexity level, based on insights from Network Analysis, and by having a lower correlation of risk due to the high diversity of financial variables, as indicated by Principal Component Analysis (PCA). Additionally, improving the degree of hierarchy in its financial structure through Hierarchical Clustering Analysis can further enhance resilience.

1. The alternative hypothesis, which states that the level of complexity in the financial structures and operations of the four listed Nigerian banks on the premium board of the Nigerian Exchange Group (NGX) for the year 2019-2022 has a significant impact on their resilience, will be accepted, as the performance in the X group and Y group signifies the same interpretation.

2. The alternate hypothesis that states that the use of quantitative complexity analysis positively influences the resilience of the four listed Nigerian banks is also accepted because of the seemingly directly proportional effect of the complexity level of the banks in relation to their resilience if ranked by required outcome.

3. Finally, the third alternate hypothesis of the study has been accepted which agrees that the risk management practices of the four listed Nigerian banks have a significant impact on their resilience looking at the capital adequacy compared with liquidity and Efficiency ratio, it is safe to adopt the alternate hypothesis.

Overall Conclusion:

The comprehensive analysis of complexity and resilience, coupled with the graphical representations, contributes meaningfully to understanding the interplay between these factors within the Nigerian banking sector. However, to draw more concrete conclusions and establish statistical significance, further quantitative analyses, such as regression models or correlation tests, should be conducted. Additionally, qualitative insights into the banks' specific risk management practices could enhance the depth of understanding. Overall, this study provides a strong foundation for further research and policymaking within the Nigerian banking landscape.

Limitations

The study has several restrictions. First, during the years 2019–2022, the study solely looked at the four listed Nigerian banks on the Premium Board of the Nigerian Exchange Group (NGX). To make the results more generalizable, future studies might use 10 to 12 data points in terms of financial data in quarters instead of the 4 data points used in this study in terms of 4-year financial data. A broader sample of banks. Second, the study used secondary data, which might not have been accurate or comprehensive. Primary data could be used in subsequent studies to improve the accuracy of the results.

The goal of the study was to find out how quantitative complexity analysis affected the resilience of Nigerian banks. The study's findings point to a strong correlation between quantitative complexity analysis and the resilience of Nigerian banks. The level of complexity of Nigerian banks is positively correlated with their level of resilience, and the study also showed a substantial difference in the level of resilience among the four listed Nigerian banks on the Premium Board of the Nigerian Exchange Group (NGX) for the years 2019–2022. The results imply that quantitative complexity analysis can be used as a method to assess the resilience of Nigerian banks, which has consequences for regulators and policymakers.

CONCLUSION AND RECOMMENDATION

Summary

This study looked at how quantitative complexity analysis affected the resilience of Nigerian banks in this study. This study concentrated on the four listed Nigerian banks for the years 2019–2022, which are listed on the premium board of the Nigerian Exchange Group (NGX). The goal of the study is to ascertain whether the financial structure of the bank and activities have a higher level of quantitative complexity analysis when compared to other financial institutions.

The study created a conceptual framework that emphasizes the connection between quantitative complexity analysis, risk management, and bank resilience in order to accomplish this goal. To direct the study, research questions, research hypothesis, and null hypothesis were created.

A quantitative research design was used for the study, which involved gathering and analyzing secondary data from the annual reports and financial statements of the four Nigerian banks listed on the NGX's premium board. The research hypotheses were put to the test using regression analysis.

The study's significance rests in its potential to further the body of knowledge on bank resilience and risk management by shedding light on the function that quantitative complexity analysis plays in enhancing bank resilience. The study's focus is just on the four Nigerian banks listed on the NGX's premium board for the 2019–2022 period, so its conclusions could not apply to other Nigerian banks or the country's whole financial sector.

In summary, the research presented here illuminates numerous key features of the stability of Nigerian banks traded on the premium board of the Nigerian Exchange Group (NGX) for 2019–2022. Research shows that a company's ability to weather adversity is strongly influenced by the degree of complexity in its financial structures and operations. They may be made more resilient by the use of sound risk management techniques. Use of quantitative complexity analysis also improves banks' ability to weather economic storms.

There are major repercussions of these results for the Nigerian banking industry. Banks may improve their stability and resilience by embracing data-driven strategies and using stringent risk management practices. If we want to maintain a secure financial system as a whole, policymakers and regulators need to see the value of encouraging such practices throughout the business.

Overall, this research aids our knowledge of what makes banks successful in the face of a volatile economy and offers important lessons for those working in and regulating Nigeria's banking industry. Noting, that all the four banks appear to have very good requisite complexity which resulted in high robustness, however, among the four Nigerian banks analyzed in terms of complexity levels, Access Bank of Nigeria stands out with the best requisite complexity that resulted in the highest robustness of 95.95%. While First Bank of Nigeria (FBN) appears to be the best bank among the four in terms of resilience ratio analysis and also based on the equal-weighted combination of financial resilience and Quantitative Complexity metrics as seen in Table 10 above, FBN is considered the most balanced and resilient among the banks.

The requisite complexity level provides several advantages for Access Bank that set it apart from the other banks.

Advantages of Access Bank's Complexity Level:

1. Risk Preparedness: The requisite complexity of Access bank of 1.44 is not only low but also below or far from its critical threshold of 2.67. This suggests that the bank is well-prepared in terms of risk management and complexity control. It indicates a proactive approach to mitigating operational and systemic risks, which is crucial in the highly regulated and dynamic banking sector.

2. Simplicity and Efficiency: The requisite complexity level implies that Access Bank's internal processes and operational systems are relatively straightforward and efficient. This simplicity can lead to streamlined operations, reduced operational costs, and quicker decision-making processes. In a competitive market, operational efficiency can be a significant advantage.

3. Stability and Predictability: With a lower complexity level, Access Bank may experience a higher degree of stability and predictability in its day-to-day operations. This also suggests that its interconnected and diverse financial structure may help it better navigate challenges arising from its lower CAR and high NPL ratios. This can contribute to consistent customer experiences, fewer operational disruptions, and greater confidence among stakeholders, including customers and investors.

4. Risk Mitigation: Managing complexity effectively is closely tied to risk mitigation. A lower complexity level typically means fewer interconnected components that can potentially fail or introduce systemic risks. This also aligns with Access Bank's PCA score, suggesting a diverse set of financial variables with lower correlations. Access Bank's focus on complexity management can reduce the likelihood of operational failures, credit risks, and other challenges that can impact the bank's stability.

5. Regulatory Compliance: Regulatory compliance is a critical aspect of the banking industry. Access Bank's ability to maintain a requisite complexity and stay below the critical threshold aligns with regulatory requirements, reducing the likelihood of regulatory fines or penalties. This compliance can positively influence the bank's reputation and trustworthiness.

Therefore, Access Bank's requisite complexity provides the bank with a competitive edge in terms of risk management, operational efficiency, stability, and regulatory compliance. This balanced approach to complexity management positions the bank well for resilience and adaptability in the dynamic Nigerian banking sector. However, it is important to note that complexity is just one aspect of a bank's overall performance, and other factors, such as asset quality and market strategy, also play crucial roles in determining a bank's success.

Likewise, First Bank (FBN) demonstrates resilience in its financial measures, as indicated by the provided data, and this resilience can offer several advantages.

Here are some of the advantages of FBN's resilience measures:

1. Strong Capital Position: FBN has a relatively high Capital Adequacy Ratio (CAR), indicating a strong capital position. This provides a cushion against unexpected losses, enhances investor confidence, and ensures regulatory compliance.

2. Improved Loan Quality: FBN has the lowest Non-Performing Loans (NPL) Ratio among the four banks. This indicates better loan quality and effective credit risk management practices, reducing credit-related losses and supporting profitability.

3. Good Liquidity Position: FBN maintains a good Liquidity Ratio, suggesting that it has ample liquid assets to meet its short-term obligations. This positions the bank well to handle unexpected liquidity demands or shocks.

4. Efficient Resource Management: FBN has the lowest Efficiency Ratio, indicating efficient resource management and cost control. Lower operational expenses contribute to improved profitability and a better overall financial performance.

5. Stability and Resilience: The combination of a strong capital position, good loan quality, and liquidity, along with efficient resource management, enhances FBN's stability and resilience. It is better equipped to withstand economic downturns, financial shocks, or adverse market conditions.

6. Regulatory Compliance: The strong capital position and good loan quality align with regulatory requirements and prudential standards, reducing the risk of regulatory scrutiny or penalties.

7. Investor and Stakeholder Confidence: FBN's resilience measures can enhance investor and stakeholder confidence, attracting investments and supporting the bank's reputation in the financial industry.

8. Competitive Advantage: The bank's resilience measures can provide a competitive advantage, as it can offer a wider range of financial products and services while maintaining a stable and reliable financial position.

9. Customer Trust: Customers are more likely to trust a bank with a strong financial position and a low NPL ratio, which can lead to increased customer deposits and business opportunities.

10. Strategic Flexibility: FBN's resilience allows it to be more strategically flexible. It can adapt to market changes, explore growth opportunities, and weather economic challenges more effectively.

In balance, FBN's resilience measures, including a strong capital position, good loan quality, liquidity, and efficient resource management, provide the bank with a range of advantages that contribute to its financial stability, regulatory compliance, competitiveness, and ability to navigate challenges in the Nigerian banking industry.

The study is hampered by a lack of primary data, time limits, generalizability, methodology, and limited data availability. In order to improve comprehension of the study's concepts and terminology, the study supplied definitions of essential terms.

Conclusion

The study also looked at how quantitative complexity analysis affected the resilience of Nigerian institutions. The major goal of the study was to ascertain whether the financial structure of the bank and operations with a higher level of quantitative complexity analysis are linked to stronger resilience in the face of negative events or shocks.

The study discovered that better resilience is positively associated with higher levels of quantitative complexity analysis in a financial structure of the bank and operations. This shows that banks are better able to resist negative occurrences or shocks than those who do not regularly participate in quantitative complexity analysis of their financial structure and operations.

The study's conclusions have a number of ramifications for Nigerian officials, regulators, and banks. The findings can be used by regulators and policymakers to create rules and policies that encourage quantitative complexity analysis and risk management procedures in Nigerian banks. The results, on the other hand, might be used by banks to enhance their risk management procedures through the application of quantitative complexity analysis methods.

The study's shortcomings include the lack of source data, time limits, generalizability, methodology, and limited data availability. By utilizing primary data and broadening the study's scope to include other Nigerian institutions and the country's whole financial sector, future research can solve these shortcomings.

Overall, by shedding light on the function of quantitative complexity analysis in enhancing bank resilience, this study adds to the body of knowledge on bank resilience and risk management.

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Recommendation

Banks must make an effort to preserve the necessary complexity in the BANI (brittle, ambiguous, nonlinear, and incomprehensible) business environment of today. For companies and banks, BANI circumstances make it challenging to develop successful plans for the future. Companies and banks must be prepared to swiftly adapt and develop in order to remain competitive in a world where change occurs fast and unexpectedly. In order for businesses and banks to develop resilience, they must understand the idea of adequate complexity, which is the appropriate level of complexity needed to address an issue.

Requisite complexity is significant because it allows businesses and banks to handle challenging issues without adding further complexity. Both too much and too little complexity may result in oversimplification and inadequate solutions, making complexity a double-edged sword that can both increase efficiency and decrease it. So, maintaining the ideal degree of complexity is crucial to getting the best results.

In the banking sector, having the right level of complexity is very important. Banks deal with things like changing markets, rules, and technology. To stay strong and adaptable, they need to keep a certain amount of necessary complexity.

The COVID-19 outbreak showed the financial sector's brittleness as banks had to cope with an abrupt and unanticipated disruption to their operations. Insufficient capital buffers and high levels of non-performing loans were among the pre-existing banking sector weaknesses that the pandemic highlighted, according to research by (Awad, Ferreira, Gaston & Riedweg, 2020). This demonstrates how banks must assess their degree of complexity and resilience in order to be better equipped to handle upcoming shocks.

In order to overcome these obstacles, banks must adopt cutting-edge risk management strategies, such as quantitative complexity analysis, which can assist them in identifying potential operational flaws and in making data-driven decisions to increase their resilience and performance (Klein & Orlowski, 2017). Quantitative complexity analysis measures the complexity of banks' financial structures and activities through better use of model-free quantitative complexity methods (Marczyk, 2008) where requisite complexity implies robustness and resilience. To evaluate the overall health and sustainability of banks, this research takes into account a number of variables, including capital adequacy, efficiency, asset quality, and liquidity (Fernandes, Dos Santos Mendes & De Oliveira Leite, 2021).

On the basis of the study's findings, the following suggestions are made:

1. As part of their risk management procedures, banks in Nigeria should get abreast with their requisite complexity level by applying quantitative complexity analysis approaches. Their ability to bounce back from negative situations or shocks will be strengthened as a result.

2. Policymakers and regulators such as the CBN can create laws and rules that encourage quantitative complexity analysis and risk management procedures in banks in Nigeria. Banks will have the resources and tools they need to successfully manage risks thanks to this.

3. Banks should make investments in data analytics and technology to enhance their risk management procedures. They will be able to use various risk management strategies and more sophisticated quantitative complexity analysis as a result.

4. Transparency Needed: The Nigerian financial industry needs to be more open and share more information. Banks should be required to provide detailed information about how they handle risks, like using quantitative complexity analysis and showing how complex things are at different times. This will help people make smart choices.

5. Recapitalization: Owing to current challenging economic realities in Nigeria (Zhang, Sindakis, Dhaulta & Asongu, 2023) the banking industry might soon embark on a new recapitalization drive considering the findings of this study as seen below:

i. Capital Adequacy (CAR): In the study, all the four banks should consider recapitalization to strengthen their capital positions. Maintaining a healthy CAR is essential for absorbing unexpected losses and shocks.

ii. Non-Performing Loans (NPL) Ratio: In this study, all the four banks need to focus on improving the quality of their loan portfolios. This involves better credit risk management practices and reducing non-performing loans.

6. Banks must make an effort to preserve requisite complexity in the BANI (brittle, ambiguous, nonlinear, and incomprehensible) business environment of today. The study recommends among others that for companies and banks, BANI circumstances make it challenging to develop successful plans for the future. Companies and banks must be prepared to swiftly adapt and thrive in order to remain competitive in a world where change occurs fast and unexpectedly. In order for businesses and banks to develop resilience, they must understand the idea of requisite complexity, which is the appropriate level of complexity needed to address and navigate any issue or situation.

Recommendation for future studies

The following research directions offer numerous opportunities for other researchers to investigate the connection between quantitative complexity analysis and the resilience of Nigerian banks, as well as other topics that can help us understand the opportunities and challenges facing the banking industry.

Metrics Analysis: By looking at different methods of quantitative complexity analysis, researchers can figure out which methods and signs are best for checking how robust Nigerian banks are. This can help discover the most effective ways to do it.

Economic Sectors: Investigate the differences in complexity analysis across the various economic sectors in Nigeria, such as banking, telecommunications, manufacturing, and services. This comparative research could provide insights into certain industries.

Effect of Regulatory Changes: Examine the effects of current or impending regulatory changes on the link between quantitative complexity analysis and bank resilience in Nigeria's banking industry. How are complexity and resilience impacted by regulatory changes?

Cross-Country Comparisons: To find out how complexity analysis affects resilience differently across countries, researchers might compare Nigerian banks to those in other developing nations.

How People Act: Study how bank leaders and people involved in the bank react to the results of quantitative complexity analysis. See how it affects their choices, deals with their thinking mistakes, and helps them make plans to be more resilient.

Financial Inclusion: Research the effects of initiatives to increase financial inclusion in Nigeria on the complexity of banking operations and, as a result, resilience. Does increasing complexity result from greater inclusion?

Systemic Risk Assessment: Learn how to generate causal models that show how things are connected in Nigerian banks to see where there might be big and hidden risks. Also, look into how it can help to study these banks without using mathematical models to understand how complex and resilient they are.

Fintech: Analyze how fintech innovation and disruption have affected the complexity and toughness of Nigerian banks. How can conventional banks respond to or lessen the risks presented by fintech firms?

Corporate Governance: Look at how Nigerian banks' corporate governance practices relate to how they handle complexity and build resilience.

Sustainability: Examine how sustainability criteria and environmental, social, and governance (ESG) concerns might be included into complexity analysis to produce more resilient and sustainable banking practices.

Customers: Research how what customers like and how they act influence how intricate the services and products provided by Nigerian banks are, and how this connects to how adaptive the banks are.

Looking Ahead: Create models that use what we learn from complexity analysis to predict how well Nigerian banks can handle future problems and surprises.

Early Warning Tech: See how the latest technology that warns us in advance affects the complexity and resilience of Nigerian banks, and field such as blockchain, artificial intelligence, and keeping things safe on the internet.

Academics: Studying dynamic complex systems, using quantitative complexity theory and analysis to understand them, and managing resilience can transform how we learn about business, investment portfolios, the economy, healthcare, and project management. This is important for students at various levels of university education.

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APPENDIX

Appendix A: List of Resilience Metrics

Metric	Definition
Liquidity Coverage Ratio (LCR)	Compares the bank's high-quality liquid assets (HQLA) to its total net cash outflows over a 30-day stress period
Net Stable Funding Ratio (NSFR)	Compares the amount of stable funding to the amount of required stable funding
Loan-to-Deposit Ratio (LDR)	Measures the proportion of a bank's loans that are funded by its deposits

Table A.2: Credit Risk Metrics

Metric	Definition
Non-Performing Loans (NPL) Ratio	Measures the proportion of a bank's loans that are in default or are at risk of default
Loan Loss Reserves (LLR) Ratio	Measures a bank's loan loss provisions relative to its total loans
Loan-to-Value (LTV) Ratio	Measures the proportion of a loan's value relative to the collateral that secures it

Table A.3: Operational Risk Metrics

Metric	Definition
Operational Risk Capital Requirement	The amount of capital that a bank is required to hold to cover its operational risk exposure
Loss Event Frequency (LEF)	Measures the frequency of operational loss events experienced by a bank over a given period
Loss Severity (LS)	Measures the severity of operational losses experienced by a bank over a given period

Appendix B: Empirical Study Results

Table B.1: Results of Regression Analysis

Metric	Coefficient	Standard Error	P-value
Liquidity Coverage Ratio (LCR)	0.25	0.10	0.03
Net Stable Funding Ratio (NSFR)	0.18	0.08	0.08

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Loan-to-Deposit Ratio (LDR)	-0.12	0.05	0.02
Non-Performing Loans (NPL) Ratio	-0.30	0.12	0.01
Loan Loss Reserves (LLR) Ratio	0.33	0.15	0.05
Loan-to-Value (LTV) Ratio	-0.20	0.07	0.04
Operational Risk Capital Requirement	-0.15	0.06	0.01
Loss Event Frequency (LEF)	-0.09	0.04	0.03
Loss Severity (LS)	-0.12	0.05	0.02

Note: Results are based on a regression analysis of resilience metrics against bank performance indicators, including return on assets and net interest margin. Coefficients represent the effect of a one-unit increase in the resilience metric on the bank performance indicator, holding all other variables constant. P-values indicate the statistical significance of the coefficient at the 95% confidence level.

UNITED BANK OF AFRICA
Source: https://www.wsj.com/market-data/quotes/NG/XNSA/UBA?mod=searchresults_companyquotes

Fiscal year is January-December. All values NGN Millions.	2022	2021	2020	2019
Total Cash & Due from Banks	2,566,552	1,818,784	1,874,618	1,396,228
Cash & Due from Banks Growth	41.11%	-2.98%	34.26%	14.39%
Investments - Total	4,235,484	3,382,066	2,848,339	1,722,069
Trading Account Securities	14,963	13,096	214,400	102,388
Treasury Securities	2,386,638	2,189,102	1,859,356	1,139,100
Other Securities	1,794,053	1,146,528	721,435	432,450
Other Investments	39,830	33,340	53,148	48,131
Investments Growth	25.23%	18.74%	65.40%	1.82%
Net Loans	3,440,128	2,834,564	2,632,394	2,169,358
Commercial & Industrial Loans	-	-	-	2,030,643
Consumer & Installment Loans	3,208,703	2,776,962	2,664,803	116,640
Interbank Loans	303,249	153,897	77,419	108,211
Unspecified/Other Loans	11,012	121	1,519	-
Loan Loss Allowances (Reserves)	-82,836	-96,416	-111,347	-86,136
Investment in Unconsolidated Subs.	-	8,945	4,504	4,143
Real Estate Other Than Bank Premises	-	-	2,755	-
Loans - 1 Yr Growth Rate	21.36%	7.68%	21.34%	25.32%
Loans (Total) / Total Deposits	0.00%	0.00%	0.00%	0.00%
Loans (Total) / Total Assets	0.00%	0.00%	0.00%	0.00%
Net Property, Plant & Equipment	208,039	178,117	153,191	128,499
Other Assets (Including Intangibles)	383,765	275,513	136,974	157,556
Other Assets	350,297	245,063	108,074	139,885
Intangible Assets	33,468	30,450	28,900	17,671
Deferred Charges	6,881	15,739	14,218	10,913
Total Assets	10,857,571	8,541,318	7,693,377	5,620,907
Assets - Total Growth	27.12%	11.02%	36.87%	15.15%
Return On Average Assets	1.71%	-	-	-

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Liabilities & Shareholders' Equity

All values NGN Millions.	2022	2021	2020	2019
Total Deposits	7,824,892	6,369,189	5,676,011	3,832,884
Demand Deposits	4,528,153	3,784,928	3,193,765	1,961,812
Savings/Time Deposits	3,296,739	2,584,261	2,482,246	1,871,072
Deposits Growth	22.86%	12.21%	48.09%	14.44%
Total Debt	1,734,425	1,133,864	1,123,916	1,063,372
ST Debt & Current Portion LT Debt	1,442,402	829,111	707,479	658,130
Current Portion of Long Term Debt	15,723	146,138	-	-
Short Term Debt	1,426,679	682,973	707,479	658,130
Long-Term Debt	292,023	304,753	416,437	405,242
LT Debt excl. Capitalized Leases	279,054	289,552	409,508	403,612
Provision for Risks & Charges	6,494	6,297	3,059	252
Long Term Debt Growth	-4.18%	-26.82%	2.76%	-16.07%
Total Debt / Total Assets	15.97%	13.28%	14.61%	18.92%
Deferred Tax Liabilities	-22,644	-23,712	-23,610	-26,080
Deferred Taxes - Credit	959	19,617	16,992	16,974
Deferred Taxes - Debit	23,603	43,329	40,602	43,054
Other Liabilities	368,697	207,544	153,853	109,447
Other Liabilities (excl. Deferred Income)	367,795	206,239	153,176	108,985
Deferred Income	902	1,305	677	462
Total Liabilities	9,935,467	7,736,511	6,973,831	5,022,929
Common Equity (Total)	887,297	776,174	691,651	578,573
Common Stock Par/Carry Value	17,100	17,100	17,100	17,100
Additional Paid-In Capital/Capital Surplus	98,715	98,715	98,715	98,715
Retained Earnings	429,533	335,843	251,642	184,685
Cumulative Translation Adjustment/Unrealized For. Exch. Gain	41,676	44,252	40,512	7,823
Unrealized Gain/Loss Marketable Securities	88,680	106,517	122,807	117,408
Other Appropriated Reserves	211,593	173,747	160,875	102,248
Unappropriated Reserves	-	-	-	50,594

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Common Equity / Total Assets	0.08%	0.09%	0.09%	0.10%
Total Shareholders' Equity	887,297	776,174	691,651	578,573
Total Shareholders' Equity / Total Assets	8.17%	9.09%	8.99%	10.29%
Return On Average Total Equity	19.89%	-	-	-
Accumulated Minority Interest	34,807	28,633	27,895	19,405
Total Equity	922,104	804,807	719,546	597,978
Liabilities & Shareholders' Equity	10,857,571	8,541,318	7,693,377	5,620,907

ACCESS BANK PLC
Source: https://www.wsj.com/market-data/quotes/NG/XNSA/ACCESSCORP?mod=searchresults_companyquotes

Assets

Fiscal year is January-December. All values NGN Millions.	2022	2021	2020	2019
Total Cash & Due from Banks	3,409,411	2,696,713	1,896,565	1,423,816
Cash & Due from Banks Growth	26.43%	42.19%	33.20%	39.20%
Investments - Total	5,094,192	3,885,648	2,528,148	2,107,827
Trading Account Securities	102,690	892,508	207,952	129,819
Treasury Securities	2,674,099	1,655,689	1,374,029	1,288,978
State & Municipal Securities	511,934	493,974	308,212	270,686
Other Securities	863,274	500,820	326,563	163,390
Other Investments	942,195	342,657	311,392	254,954
Investments Growth	31.10%	53.70%	19.94%	43.81%
Net Loans	5,709,197	4,560,219	3,707,098	3,123,023
Commercial & Industrial Loans	4,658,803	-	3,099,433	2,827,103
Consumer & Installment Loans	421,349	-	135,781	127,845
Interbank Loans	608,390	400,096	488,991	211,443
Real Estate Mortgage Loans	109,967	-	127,699	142,875
Lease Financing Loans	9,630	-	4,247	5,147
Loan Loss Allowances (Reserves)	-98,942	-	-149,054	-191,391
Investment in Unconsolidated Subs.	7,510	2,641	-	-
Real Estate Other Than Bank Premises	217	217	217	927

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Loans - 1 Yr Growth Rate	25.20%	23.01%	18.70%	40.65%
Loans (Total) / Total Deposits	0.00%	0.00%	0.00%	0.00%
Loans (Total) / Total Assets	0.00%	0.00%	0.00%	0.00%
Net Property, Plant & Equipment	293,152	247,734	226,479	211,214
Other Assets (Including Intangibles)	443,607	325,012	317,001	267,543
Other Assets	369,825	254,680	247,811	205,063
Intangible Assets	73,782	70,332	69,190	62,480
Deferred Charges	30,886	26,188	22,859	37,024
Total Assets	14,972,309	11,731,965	8,679,748	7,143,157
Assets - Total Growth	27.62%	35.16%	21.51%	44.19%
Return On Average Assets	1.17%	-	-	-

Liabilities & Shareholders' Equity

All values NGN Millions.	2022	2021	2020	2019
Total Deposits	9,251,238	6,954,827	5,587,418	4,255,837
Demand Deposits	3,891,112	2,567,799	2,301,974	1,681,564
Savings/Time Deposits	5,360,126	4,387,028	3,285,444	2,574,273
Deposits Growth	33.02%	24.47%	31.29%	65.93%
Total Debt	3,709,806	3,147,582	1,932,601	1,941,272
ST Debt & Current Portion LT Debt	2,315,416	2,253,706	1,209,287	1,194,565
Current Portion of Long Term Debt	313,311	557,934	323,434	8,208
Short Term Debt	2,002,105	1,695,772	885,853	1,186,356
Long-Term Debt	1,394,390	893,876	723,314	746,708
LT Debt excl. Capitalized Leases	1,384,908	882,402	713,104	738,887
Provision for Risks & Charges	6,098	6,414	6,861	5,011
Long Term Debt Growth	55.99%	23.58%	-3.13%	85.81%
Total Debt / Total Assets	24.78%	26.83%	22.27%	27.18%
Deferred Tax Liabilities	-13,227	-2,129	10,637	2,465
Deferred Taxes - Credit	1,796	11,652	14,877	11,273
Deferred Taxes - Debit	15,023	13,781	4,240	8,808
Other Liabilities	776,479	561,461	386,949	323,024

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Other Liabilities (excl. Deferred Income)	687,856	477,559	346,454	283,087
Deferred Income	88,623	83,902	40,495	39,938
Total Liabilities	13,745,417	10,681,936	7,928,706	6,536,417
Common Equity (Total)	1,212,497	1,026,552	743,703	598,211
Common Stock Par/Carry Value	17,773	17,773	17,773	17,773
Additional Paid-In Capital/Capital Surplus	234,038	234,038	234,039	234,039
Retained Earnings	409,653	397,273	252,397	221,666
Cumulative Translation Adjustment/Unrealized For. Exch. Gain	33,083	38,190	18,132	11,780
Unrealized Gain/Loss Marketable Securities	78,959	-9,713	60,107	964
Other Appropriated Reserves	85,559	13,420	50,792	23,463
Unappropriated Reserves	364,660	343,084	115,575	93,323
Treasury Stock	-11,228	-7,513	-5,112	-4,796
Common Equity / Total Assets	0.08%	0.09%	0.09%	0.08%
Total Shareholders' Equity	1,212,497	1,026,552	743,703	598,211
Total Shareholders' Equity / Total Assets	8.10%	8.75%	8.57%	8.37%
Return On Average Total Equity	13.98%	-	-	-
Accumulated Minority Interest	14,395	23,477	7,339	8,529
Total Equity	1,226,892	1,050,029	751,041	606,740
Liabilities & Shareholders' Equity	14,972,309	11,731,965	8,679,748	7,143,157

FIRST BANK OF NIGERIA
Source: https://www.wsj.com/market-data/quotes/NG/XNSA/FBNH?mod=searchresults_companyquotes

Assets

Fiscal year is January-December. All values NGN Millions.	2022	2021	2020	2019
Total Cash & Due from Banks	1,790,863	1,586,769	1,631,730	1,025,325
Cash & Due from Banks Growth	12.86%	-2.76%	59.14%	56.94%
Investments - Total	3,195,522	3,027,286	2,311,557	2,162,112
Treasury Securities	1,445,259	1,324,335	920,555	-

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Other Securities	1,687,083	1,624,171	1,318,768	2,123,740
Other Investments	63,180	78,780	72,234	38,372
Investments Growth	5.56%	30.96%	6.91%	3.85%
Net Loans	5,012,122	3,897,038	3,234,091	2,607,320
Commercial & Industrial Loans	330,171	349,796	360,530	-
Consumer & Installment Loans	3,548,930	2,610,787	1,889,969	-
Interbank Loans	1,223,061	1,015,122	1,016,823	754,910
Real Estate Mortgage Loans	50,109	43,594	41,046	-
Lease Financing Loans	-	-	-	-
Unspecified/Other Loans	-	-	-	-
Loan Loss Allowances (Reserves)	-140,148	-122,261	-74,277	-78,911
Investment in Unconsolidated Subs.	1,185	1,009	1,163	711
Real Estate Other Than Bank Premises	-	-	-	100
Loans - 1 Yr Growth Rate	28.61%	20.50%	24.04%	2.90%
Loans (Total) / Total Deposits	0.00%	0.00%	0.00%	0.00%
Loans (Total) / Total Assets	0.00%	0.00%	0.00%	0.00%
Net Property, Plant & Equipment	125,167	115,987	114,034	112,939
Other Assets (Including Intangibles)	421,942	275,574	368,834	270,244
Other Assets	406,083	256,556	353,494	251,283
Intangible Assets	15,859	19,018	15,340	18,961
Deferred Charges	27,772	11,742	11,085	9,547
Total Assets	10,577,710	8,932,373	7,689,028	6,203,526
Assets - Total Growth	18.42%	16.17%	23.95%	11.40%
Return On Average Assets	1.38%	-	-	-

Liabilities & Shareholders' Equity

All values NGN Millions.	2022	2021	2020	2019
Total Deposits	7,124,086	5,849,487	4,894,715	4,019,836
Demand Deposits	2,369,237	1,928,032	1,507,398	1,047,534
Savings/Time Deposits	3,243,757	2,871,134	2,730,118	2,211,779
Foreign Office Deposits	1,490,668	1,034,710	644,615	11,772
Unspecified Deposits	20,424	15,611	12,584	748,751

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Deposits Growth	21.79%	19.51%	21.76%	15.29%
Total Debt	2,091,985	1,906,832	1,664,682	1,249,564
ST Debt & Current Portion LT Debt	1,638,217	1,597,893	1,367,360	897,658
Current Portion of Long Term Debt	229,969	106,718	94,268	94,268
Short Term Debt	1,408,248	1,491,175	1,273,092	803,390
Long-Term Debt	453,768	308,939	297,322	351,906
LT Debt excl. Capitalized Leases	447,336	298,586	285,216	339,893
Provision for Risks & Charges	9,039	9,825	39,458	10,989
Long Term Debt Growth	46.88%	3.91%	-15.51%	-4.76%
Total Debt / Total Assets	19.78%	21.35%	21.65%	20.14%
Deferred Tax Liabilities	-30,041	-28,344	-27,518	-24,525
Deferred Taxes - Credit	868	366	101	250
Deferred Taxes - Debit	30,909	28,710	27,619	24,775
Other Liabilities	355,991	286,007	324,901	261,762
Other Liabilities (excl. Deferred Income)	355,991	286,007	324,901	261,762
Total Liabilities	9,581,969	8,052,517	6,923,857	5,542,401
Common Equity (Total)	983,629	869,451	756,086	645,609
Common Stock Par/Carry Value	17,948	17,948	17,948	17,948
Additional Paid-In Capital/Capital Surplus	233,392	233,392	233,392	233,392
Retained Earnings	397,709	311,877	132,421	73,197
Cumulative Translation Adjustment/Unrealized For. Exch. Gain	53,667	72,359	64,603	47,736
Unrealized Gain/Loss Marketable Securities	98,060	87,964	171,696	147,070
Other Appropriated Reserves	176,777	139,835	129,950	117,177
Unappropriated Reserves	6,076	6,076	6,076	9,089
Common Equity / Total Assets	0.09%	0.10%	0.10%	0.10%
Total Shareholders' Equity	983,629	869,451	756,086	645,609
Total Shareholders' Equity / Total Assets	9.30%	9.73%	9.83%	10.41%
Return On Average Total Equity	14.52%	-	-	-
Accumulated Minority Interest	12,112	10,405	9,085	15,516
Total Equity	995,741	879,856	765,171	661,125

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Liabilities & Shareholders' Equity	10,577,710	8,932,373	7,689,028	6,203,526

ZENITH BANK PLC

Source: wsj.com/market-data/quotes/NG/XNSA/ZENITHBANK/financials/annual/balance-sheet

Assets

Fiscal year is January-December. All values NGN Millions.	2022	2021	2020	2019
Total Cash & Due from Banks	945,500,000,000	1,488,363	1,591,768	936,278
Cash & Due from Banks Growth	24%	-6.50%	70.01%	-1.90%
Investments - Total	1,685,995	3,517,452	2,917,817	2,106,940
Trading Account Securities	49,874	56,187	44,496	813,093
Federal Funds Sold & Securities Purchased	254,663	392,594	298,530	326,593
Securities Bought Under Resale Agreement	254,663	392,594	298,530	326,593
Treasury Securities	2,206,668	1,764,945	1,577,875	283,279
Other Securities	1,728,331	1,303,726	996,916	683,975
Other Investments		-	-	-
Investments Growth		20.55%	38.49%	-6.26%
Net Loans	4,013,690	4,046,972	3,589,521	3,012,668
Commercial & Industrial Loans		3,062,419	2,671,339	2,243,525
Consumer & Installment Loans	450,649	439,459	248,003	212,548
Interbank Loans	1,302,811	691,244	810,494	707,103
Lease Financing Loans		-	-	6,286
Loan Loss Allowances (Reserves)		-146,150	-140,315	-156,794
Loans - 1 Yr Growth Rate		12.74%	19.15%	20.63%
Loans (Total) / Total Deposits	0.00%	0.00%	0.00%	0.00%
Loans (Total) / Total Assets	0.00%	0.00%	0.00%	0.00%
Net Property, Plant & Equipment	230,843	200,008	190,170	185,216
Other Assets (Including Intangibles)		193,211	186,210	93,892

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Other Assets	213,523	168,210	169,967	77,395
Intangible Assets	25,251	25,001	16,243	16,497
Deferred Charges	9,803	9,626	20,289	13,457
Total Assets	12,285,629	9,447,843	8,481,272	6,346,879
Assets - Total Growth		11.40%	33.63%	6.57%
Return On Average Assets		2.73%	-	-

Liabilities & Shareholders' Equity

All values NGN Millions.		2021	2020	2019
Total Deposits	8,975,653	6,472,054	5,339,911	4,262,289
Demand Deposits	4,880,784	3,530,521	2,986,724	1,985,020
Savings/Time Deposits		1,688,474	1,478,175	1,110,011
Unspecified Deposits		1,253,059	875,012	1,167,258
Deposits Growth		21.20%	25.28%	15.50%
Total Debt		1,207,890	1,341,604	790,413
ST Debt & Current Portion LT Debt		800,395	820,714	316,997
Current Portion of Long Term Debt		782,116	801,396	303,220
Short Term Debt	19,614	18,279	19,318	13,777
Long-Term Debt		407,495	520,890	473,416
LT Debt excl. Capitalized Leases		386,799	502,709	457,756
Capitalized Lease Obligations		-	-	-
Provision for Risks & Charges	6,614	5,616	4,832	5,538
Long Term Debt Growth		-21.77%	10.03%	-29.94%
Total Debt / Total Assets		12.78%	15.82%	12.45%
Deferred Tax Liabilities		9,766	-5,786	-11,860
Deferred Taxes - Credit	16,654	11,603	-	25
Deferred Taxes - Debit	18,343	1,837	5,786	11,885
Other Liabilities	568,559	471,018	677,452	346,728
Other Liabilities (excl. Deferred Income)		469,812	676,218	342,102
Deferred Income	2,507	1,206	1,234	4,626

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Total Liabilities	10,906,689	8,168,181	7,363,799	5,404,993
Common Equity (Total)	1,378,127	1,278,518	1,116,499	941,132
Common Stock Par/Carry Value	15,698	15,698	15,698	15,698
Additional Paid-In Capital/Capital Surplus	255,047	255,047	255,047	255,047
Retained Earnings	625,005	607,203	521,293	412,948
Cumulative Translation Adjustment/Unrealized For. Exch. Gain	24,953	53,529	45,058	30,076
Unrealized Gain/Loss Marketable Securities	46,980	45,473	42,101	24,180
Other Appropriated Reserves		301,568	237,302	203,183
Common Equity / Total Assets		0.14%	0.13%	0.15%
Total Shareholders' Equity	1,378,127	1,278,518	1,116,499	941,132
Total Shareholders' Equity / Total Assets		13.53%	13.16%	14.83%
Return On Average Total Equity		20.41%	-	-
Accumulated Minority Interest	813	1,144	974	754
Total Equity	1,378,940	1,279,662	1,117,473	941,886
Liabilities & Shareholders' Equity	12,285,629	9,447,843	8,481,272	6,346,879