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THE IMPACT OF INTEREST RATE FLUCTUATIONS ON BANK PROFITABILITY IN ZIMBABWE FROM 2000 TO 2024.

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THIS DISSERTATION IS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE BACHELOR OF SCIENCE HONOURS DEGREE IN STATISTICS AND FINANCIAL MATHEMATICS.

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APPROVAL FORM

This is to certify, that this research project is the result of my own research work and has not been copied or extracted from past sources without acknowledgement. I hereby declare that no part of it has been presented for another degree in this University or elsewhere.

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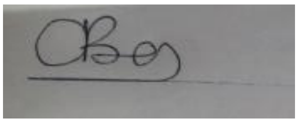

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DEDICATION

I dedicate to the people who matter most my family. Your love, support and sacrifices have been the backbone of my academic pursuits. Mom your lessons on grit and determination have been invaluable. To my siblings you believe in me has continually inspired and encouraged me. I also thank God for granting me the strength, wisdom and guidance that carried me through every high and low of this journey. Thank you for being there.

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ABSTRACT

This study aimed at investigating how changes in interest rates influence banks earnings within Zimbabwe's unstable economic environment. My curiosity led me to dig into 24-year worth of data from 2000 to 2024. The study employed the autoregressive distributed lag approach as a statistical technique to investigate the impact. This method allowed me to analyze both immediate and delayed effects of interest rate movements in the profitability of banks. The study showed a high inflation rate of 70.23% and low average ROA of 1.6%, reflecting economic instability. ARDL results confirmed a long-run relationship where F = 6.0861and R squared = 0.664. Currency rate changes significantly affect ROA in the short term, while both lending rates and currency levels negatively impact it in the long run. So, it means they need to keep a close eye on exchange rate fluctuations and develop strategies to control their impact. By doing so they can help banks maintain and control the effects on the Zimbabwe's financial markets. It brings out the status of evaluating the complexity of emerging markets and the need for policymakers to be proactive in managing economic risks.

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ACRONYMS

ADF	Augmented Dickey-Fuller
ALM	Asset-Liability Management
ARDL	Autoregressive Distributed Lag
ARIMA	Autoregressive Integrated Moving Average
CUSUM	Cumulative Sum Test
EBIT	Earnings Before Interest and Taxes
ECM	Error Correction Model
GDP	Gross Domestic Product
GLM	Generalized Linear Model
IMF	International Monetary Fund
JB	Jarque-Bera (test)
LSTM	Long Short-Term Memory
NIM	Net Interest Margin
OLS	Ordinary Least Squares
RBZ	Reserve Bank of Zimbabwe
RNN	Recurrent Neural Network
ROA	Return on Assets
ROCE	Return on Capital Employed
ROE	Return on Equity
VAR	Vector Autoregression
ZIMSTAT	Zimbabwe National Statistics Agency

CHAPTER 1: INTRODUCTION

1.1 Introduction

The interest rate changes represent major role when maintaining the profitability of banks globally. In Africa particularly in Zimbabwe the banking sector operates in an environment characterized by a non-stable macro-economic situation experiencing inflation pressures and frequent policy changes. The Reserve Bank of Zimbabwe has presented policy correction to reduce inflation and bring stability to its economy and this has lead to huge change in interest rates. These differences have important impact on the banking system, profitability, loan capacity and also the financial stability.

1.2 Background

Over the past two years, Zimbabwe has witnessed considerable interest rate changes as the central bank sought to balance economic growth with inflation control. In 2021, the RBZ raised the policy rate to 25% in an effort to support economic activity. However, by June 2022 in response to continuous increase of inflation and currency instability the policy rate was drastically increased to 200% one of the highest globally. This adjustment of monetary policy was aimed at reducing hyperinflation and restoring confidence in the financial system. In March 2023 the interest rate was lowered to 30% to support economic recovery. However, concerns over rising inflation brought another increase to 40% in June 2023. These rapid interest rate adjustments have showed significant challenges for banks particularly in managing profitability and decrease financial risks.

Empirical studies have demonstrated a strong correlation between interest rate changes and bank profitability. Econometric analyses suggest that 2% change in interest rates can cause a 1% change on bank profitability, highlighting the sensitivity of financial institutions to monetary policy shifts. The impact of these fluctuations came out in multiple ways including changes in net interest margins, loan default rates and investment returns. When interest rates increase lending costs rise resulting to a decrease credit demand also potential loan default. Conversely, lower interest rates may encourage lending but can reduce net interest margins thereby affecting profitability.

1.3 Problem statement

Profitability of banks is directly affected by macroeconomic aspects with interest rate fluctuations playing a particularly critical role. In Zimbabwe where economic changes, inflation pressures and currency instability are persistent identifying the impact of interest rate changes is crucial for both financial stability and effective policy formulation. Previous studies have highlighted that fluctuations of interest rates can clearly affect banks interest margins and overall earnings (Flamini et al., 2009).

1.4 Research objectives

1. To determine short-run effect of interest rate movements, GDP growth, inflation and forex rate changes in the profitability of a bank.
2. To determine the long run influence of fluctuations in exchange rates, GDP, interest rates and price increases in the financial performance of banks.

1.5 Research questions

1. What are the short-run impacts of inflation, interest rate and forex rate on bank profitability in Zimbabwe?
2. What are the long-run impacts of interest rate, forex rate, GDP and inflation on bank profitability in Zimbabwe?

1.6 Scope of the study

This thesis examines how changes of interest rates have affected profitability of key banks in Zimbabwe from 2000 up to 2024. To capture both immediate fluctuations and lasting relationships between variables the study used an ARDL framework. The focus is on Zimbabwe's commercial banking sector evaluating profitability through metrics such as the banks efficiency in generating income from their assets. Additionally, the study considers key macro -economic pointers including forex rates, inflation, GDP growth also interest rates. Data were collected from a reputable institution such as Reserve Bank of Zimbabwe, the International Monetary Fund, the Zimbabwe National Statistics Agency, and World Bank.

The research does not extend to micro-finance institutions, building societies or non-bank financial entities to maintain a focused scope. While the study ensures methodological accuracy it acknowledges limitations such as data availability constraints, the linear assumptions of the ARDL model by integrating econometric approaches. This research aims to provide policymakers and financial institutions with a more robust understanding of macro-economic variables fluctuations enabling the development of effective risk management and policy strategies to enhance stability of Zimbabwean banks.

1.7 Significance of the study

The thesis explores changes of interest rate change on bank profitability in Zimbabwe contributing to the field of banking finance through empirical research. It promotes critical thinking and problem-solving skills by analysing the complex relationships within the banking sector. The study aligns with the Education 5.0 framework which emphasizes the need for innovation, practical application of knowledge and addressing real world challenges. Education 5.0 encourages the development of solutions that are not only academically demanding but also relevant to the current economic landscape. By integrating innovation and hands on approaches to learning the research overcome the inequality between the idea and application. For government bodies and regulators, the study provides evidence-based representation that can guide monetary policy decisions and banking regulations allowing the stability and resilience of the financial sector. It also supports economic growth strategies through data driven recommendations. In the banking industry the findings offer valuable information to improve decision making, strengthen risk management practices and develop effective strategies for interest rate risks. For investors and stakeholders, the research presents critical perceptions into bank performance and risk exposure enabling informed investment decisions based on reliable data. Additionally, for other students this dissertation contributes to existing literature by offering fresh perspectives and can serve as a useful reference for those exploring similar topics creating a foundation for further research.

1.8 Assumption and limitation of the study

Assumptions

- Data Accuracy and Reliability meaning data sourced in the study is reliable and available for the relevant period.
- Monetary and fiscal policies remain stable during the study period.
- Banking Sector Decision Making: Banks make decisions based on established financial principles to maximize profitability while managing risk.
- Control of External Economic Factors that is inflation and exchange rates are controlled in the analysis.
- Comparability of Banks in Zimbabwe: Banks in Zimbabwe operate under similar economic and regulatory conditions.
- Availability of Financial Data: Sufficient financial data and reports from Zimbabwean banks are available for analysis.

1.9 Limitation

1. The study relies on existing financial and economic data, which may have inconsistencies or gaps.
2. The ARDL model assumes linearity which may not fully reflect complex financial interactions.
3. Only selected key economic factors including exchange rates, inflation and GDP growth and interest rate were included potentially omitting other relevant bank specific or political factors affecting profitability.

1.10 Definition of key terms

Interest Rate represents a rate in loaning money specifically stated as a percentage of the principal value borrowed, paid periodically for the use of the lenders funds. (Federal Reserve, 2022)

Interest Rate Fluctuations – The periodic changes in the cost of borrowing or returns on savings influenced by monetary policy, inflation and market conditions. Interest rate movements directly impact financial institutions' lending and investment decisions (Mishkin, 2019).

Bank profitability -refers to a bank's power to generate income concerning to costs, total assets, and shareholder's equity. It is typically assessed using financial metrics like the net interest margin, ROE and return on assets (Athanasoglou, Brissimis, and Delis, 2008).

ARDL Model is a technique utilised for analyzing short-term and long-term correlation among factors particularly suitable for time-series data with mixed orders of integration (Pesaran, Shin, and Smith, 2001).

Long Short-Term Memory Model is a method of a recurrent neural network created to improve sequential information by taking long-range dependencies and complex patterns making it effective for financial time series forecasting. (Hochreiter and Schmidhuber, 1997).

Macroeconomic Variables these are markers like inflation, conversion rates and interest rates that influence overall economic performance and financial market stability (Blanchard, 2021).

Monetary Policy – The strategic regulation of interest rates and cash supply by a central bank to control inflation maintain economic stability and support financial sector growth (Friedman, 1968).

Financial Stability – The resilience of a financial system in maintaining efficient market functions and withstanding economic shocks ensuring investor confidence and economic growth (Allen and Gale, 2004).

Forex Rate changes is the degree of fluctuations in a country's monetary system value against foreign currency affecting inflation, interest rates and financial sector performance (Dornbusch, 1976).

The Basel Committee on Banking Supervision (2004) outlined credit-risk as the measure's likeliness of fiscal loss due to borrowers failing to meet their debt obligations, which directly influences bank's profitability and investment adequacy

Time Series Information can be defined as the series of information gathered mostly on consistent periods commonly used in econometric and machine learning models to analyse financial trends and forecasts (Box, Jenkins, and Reinsel, 2015).

1.11 Chapter summary

This chapter explores how interest rate fluctuations influence bank profitability in Zimbabwe by cconsidering the effects of inflation and economic instability adjustments done by Reserve Bank of Zimbabwe (RBZ). The study highlights how important interest rate changes such as the peak of 200% in 2022 have impacted banking performance through lending, deposit mobilization and financial stability. To analyse these dynamics the research, make use of ARDL model for examining short run also long-run effects. The thesis focuses in Zimbabwe's commercial banking sector from 2000 to 2024 using secondary data from reliable institutions. By using econometric approaches, the study provides a framework that can guide policymakers, financial organizations and stockholders in making best decisions. While acknowledging challenges such as data availability and model limitations the research aims to improve understanding of interest rate changes and its implications for banking sector stability.

2 CHAPTER 2 LITERATURE REVIEW

2.1 Introduction

The section highlights underlying dynamics that generate forces on the banking industry in Zimbabwe. Following the typical method of literature review, the review intends to investigate the most informative factors that determine bank stability and performance. With the deep understanding of the threads of empirical evidence and theoretical argument, this section gives considerations suitable for capturing the distinctions of a Zimbabwean banking industry. Interest rate changes in Zimbabwe have shown huge fluctuations caused by various factors such as shifts in monetary policy, sharp inflationary pressures, exchange rate changes and changes in global economic trends. The Autoregressive Distributed Lag provides the suitable analysis to view and determine the long run with the short-term correlation among interest rates also bank profitability for nations to have a better prediction of their future performance.

2.2 Theoretical Framework

The 2023 research by Ngwenya was on the effect of interest rates in Zimbabwe's financial sectors. The financial data were collected from banking sector also from the Central Bank in Zimbabwe from 2015-2020. Using advanced statistical processes, Ngwenya went on to observe interdependence among interest rates and the profitability of banks. These methods would enable the researcher to examine the immediate and long-term impacts of the fluctuation in interest rates in profits measures major banks. An important understanding was generated by this thesis bank’s financial well-being is affected by interest rates. Another investigation by Moyo et al. in 2021 explored the effect of changes in interest rates in Net Interest Margin. This study indicated that changes of interest rates become the core cause behind variability in a bank's loan income and interest expenses. The formula for NIM is:

$$\text{NIM} = \frac{(Interest\ Income - Interese\ Expense)}{Average\ Earnimg\ Assets}$$

equation 2-1

Moyo et al. (2021) concluded that interest charges are higher leading to higher NIM, because banks showed faster behaviour when it comes to adjusting loan charges than deposit charges. However, these authors added, such influence was suppressed by greater loan defaults under pressure of inflation. Concerning a Return on Assets (ROA), Mapfumo (2022) found that ROA and volatility of interest rate were strongly dependent upon the extent of the bank, also upon the asset mix. ROA is calculated as:

$$\text{ROA} = \frac{NetIncome}{Average\ Total\ Assets}$$

equation 2-2

Among Zimbabwe's large banks the change in interest rates helped as factor influencing their return on equity as differences in their operating competence in terms of changing their asset base allow some banks to hold or increase profitability. Jones and Zhang (2021) tested how differences in interest rates influence Return on Equity that expresses how well a bank turns its equity capital into net income. The formula for ROE goes as follows:

$$\text{ROE} = \frac{Net\ Income}{Sharehoders\ Equity}$$

equation 2-3

In their innovative paper, Pesaran, Shin and Smith (2001), also came up with a procedure designed only to analyse the short run and long-term dependency relations among factors mainly when the time series data undertaken have combinations of level stationary and first difference stationary series. The framework works best when the importance is placed on studying the long-run balance relation along with short-term adjustments. The ARDL model is given as:

$$Y_t = \alpha + \sum_{i=1}^{p} \beta i \ \ Y_{t-I} + \sum_{j=0}^{q} \gamma_j \, X_{t-j} + \epsilon_t$$

equation 2-4

Where:

Y_t refers to bank profitability (e.g., ROA and NIM)

X_t refers to the interest rate

ϵ_t is the constant term

i parameters of the delayed terms of the factors of the independent and dependent factors respectively

Harrison and Kattum (2019), used VAR to examine the effect of interest rate uncertainty on banking in developing countries. Developing countries quarterly time series data were used at quarterly measure. The result highlighted the importance of interest expenses in understanding major bank profitability pointers such as NIM. Sims (1980) first developed the model as a tool to investigate how a number of economic time series are connected without strong assumptions about the direction of causality. VAR model can be stated as:

$Y_t = \alpha + \sum_{p=1}^{q} A_p \, Y_{t-p} + \epsilon_t$

equation 2-5

that is :

Y_t represent a vector of time-series factor (such as profitability measures and interest expenses).

A_{p-1} in the AR model, which in turn reflect the influence of the lagged variable

q represents a number of lags to be identified in the VAR
t is error term reflecting the unobservable variables affecting the variables.

Moyo et al. (2022) studying the effects of interest rate changes in net Interest margin, ROA and the return on equity in Zimbabwean banks. Quarterly data from 2015 to 2021 from Central Bank of Zimbabwe and major commercial banks was collected. The study used a Poisson regression model within the GLM framework to calculate the non-linear contact between measures of profitability and interest charges. He concluded that higher interest charges are most likely to result to the rise in NIM in the short run but its impact is lost in the longer run due to defaults on loans and suppressed loan demand especially under conditions of high inflation. Zhang and Jones (2021) also used a GLM model to evaluate the interaction between bank profitability and interest charges in China between 2012-2019. They emphasized the unequal reaction of interest rate movements to ROE observing that banks with expanded portfolios were more stable to interest rate shocks than the revenue high-interest banks from loans. Chikwira and Mungure (2021), also arrived at the same findings utilizing panel data regression estimates and GLM models examining the connection between interest rate policy and profitability of banks for Southern Africa. They established that increase in the interest rate makes high NIM but gains were under the negative influence of inflation on overall banking stability. The general formula of the GLM used is:

$$\hat{\theta}_{GMM} = (X' W^{-1} X)^{-1} X' W^{-1} Y$$

equation 2-6

Where:

X represents matrix of explanatory factor

Y represents dependent variable (e.g., bank profitability)

W represents weight matrix.

Ashli Demirguç-Kunt, Harry Huizinga(2001), investigate the impacts of interest rate fluctuations in major bank accomplishments procedures such as the return on assets and the ROE. Their research is mainly helpful to determine how interest charge movements as an element of monetary policy influence the economic consistence and operational performance of a bank. They used high density panel data regression model. They tested the correlation between interest rate movement and bank profitability in a same sample of countries representing both developed and emerging economic order like South Africa, United States, Germany etc. In their panel data regression equation Demirgüç-Kunt and Huizinga (2001), assign a figure to the effect of interest rate change in profitability by considering interest rate risk as a self-governing variable. Regression equation formula used by them is:

$$Y_{it} = \alpha + \beta_1 IR_{it} + \beta_2 X_{it} + \epsilon_{it}$$

equation 2-7

They observe that banks in advanced financial systems tend to be more stable to the risks of interest rate since they possess sophisticated risk management methods and superior financial markets. Banks in developing markets, whose financial systems are not as superior are more helpless to the opposing effect of interest rate changes. This weakness results from lower risk strategies and lower exposures to higher-level financial instruments. Demirguc-Kunt and Huizinga's findings reveal that risk of shifting profitability because of a shift in interest rates, differs widely across nations. For instance, for banks in strong and well-established financial markets, there is usually an efficient interest rate risk management system, which mitigates the impact of interest rate volatility. By contrast, in developing economies where capital markets are imperfect, the banking sector is more visible to the dangers of interest rates hence are more likely to experience volatility in profitability.In general, Demirgüç-Kunt and Huizinga's contribution is a foundation piece to the banking and finance community in that it provided a point of departure for further research into interest rate risk, monetary policy and economic determinants of bank profitability.

2.3 Empirical literature

Oywoki, Muganda, Ondiel (2020), perform large sample empirical investigation to examine change in interrelation between bank profitability and market interest in Kenya. This thesis used an unstable panel data of 10 listed banks of Kenya from 2010-2018. The author used the ARDL model that allowed them to control the short term and long-term correlation among bank profitability and also market interest rate. The results showed that a highly positive correlation existed among market interests thereby showing that a rise of 1% in market interest rates led to an increase of 0.85% of bank profits in the long term. The hypothesis test was below 5%, the positive coefficient approximations are that it shows interbank interest and size has a positive significant impact on ROA at 10% levels whereas interest rate has a adverse significant impact on ROA at 10% level. In other words, interest rate focus has a positive impact in the bank profitability and the effect is highly significant. The hypotheses test conducted in the research confirmed that the findings were significant since p values were all less than the 5% critical value. The coefficients of the evaluations for the market interest rate were positive, as it was expected in the hypothesis that higher market interest rates have a positive impact in the profitability of a bank in the long term. The following equation is a model of the ARDL that is used to approximate the correlation between bank profitability and market interest rates:

$$\text{Profitability}_{it} = \propto + \beta_1\text{Interest Rates}_{it} + \beta_2\text{Size}_{it} + \beta_3\text{Interbank Rates}_{it} + \epsilon_{it}$$

Equation 2-8

Where:

$\text{Profitability}_{it}$ is the profitability of bank

$\text{Interest Rates}_{it}$ represents the interest rate for bank

Size_{it} represents the size of bank

$\text{Interbank Rates}_{it}$ denotes the interbank interest rates,

ϵ_{it} is the error term.

To illustrate the findings a table below summarizes the key variables and their expected effects on the profits of the bank:

Table 2-1 Variable and their expected

Factor	Description	Expected Effect on Profitability
Market Interest Rates	The prevailing rates in the money market, influencing lending and deposit rates	Positive
Bank Size	Measured by a sum asset of a bank	Positive
Interbank Interest Rates	Rates at which banks lend to one another	Positive
Return on Assets (ROA)	An amount of a bank's profits relative to its total assets	Negative

by *Oywoki, Muganda, Ondiel (2020)*

In overall, table 2.1 results shows that lending and deposits rates are positively related with profitability in the long run and importance of interest rate movements as the main mover of bank performance. The study also identifies other factors that have an effect on profitability outcomes such as bank size and interbank interest rate. The use of the ARDL model allowed an author to estimate the short run and long run correlation and gives vision into the elements of profitability in Kenya's banks

Hassan and Bashir (2003), had an interest rate and bank profitability examination for Pakistan. The thesis utilized a trial of 25 banks from 1990-2000. The multiple regression model was utilized by the authors so as to investigate relationships of interest rate and bank profitability. The study confirmed that the interest rate had a adverse effect on the profits of Pakistani bank. Specifically, the study agreed that if the interest rate increases by 1% then profit decreases by 0.23%. Also, that interest rate effect is more powerful in terms of long-term duration than for short duration. These findings are constant with the model of financial connection between lenders, borrowers and profitability of their operations will be based on the interest rate charged for a loan and interest rate paid on deposit. These findings are helpful to theory of a financial intermediation whereby the profits of banks heavily depend on the interest it earns from loans as well as the interest it makes from deposits. With this situation in case interest rates are cumulative, banks are able to make more revenue from their loans while simultaneously they have to pay more in interest on deposits. The net effect, which was found by Hassan and Bashir (2003), is that the negative effect of higher interest rates is larger than the positive one, precisely long-term effects. The study is important in offering profitability by balancing interest rate structure since higher interest rates lead to a lower loan demand and higher credit risk. The results of the research with respect to interest rates also reflect the impact of interest rates was greater in the long run as compared to the immediate term and there are important consequences for bank management policies. Banks may be better placed to adjust the interest rate changes in the short term but in the longer term, there was a compounding impact of the rise in the charge of interest reducing profitability. This meeting emphasized the necessity of interest rate risk management and the necessity for banks to come up with strategies that reduce the impact of interest rate changes where interest rates are very unstable in economies. Islamic banks experience the indirect impacts through macroeconomic factors such as inflation, economic growth and overall system stability in finance which may influence demand for their services and products.

Dube and Moyo (2014) performed empirical work to determine the effect of changes on interest rates in bank profits in Zimbabwe grounded on critical financial performance procedures such as NIM, return on assets (ROA) and ROE. The time-series data from 2000 to 2010 were utilised in this study, which was gathered from Zimbabwean commercial banks annual financial statements. Macro statistics like lending and deposit rates, inflation rates, forex rates and GDP levels were obtained from Reserve Bank of Zimbabwe also the Zimbabwe National Statistics Agency (ZIMSTAT) to balance data. Dube and Moyo applied Ordinary Least Squares (OLS) regression in estimating interest rate relationships with bank profitability when controlling for inflation and exchange rate volatility. They applied a regression equation that would determine the impact of interest rate change in profitability after controlling for such aggregate economic factors. The model used was:

$$\text{Profitability}_{it} = \propto + \beta_1\text{InterestRate} + \beta_2\text{Infaltion} + \beta_3\text{Exchangerate} + \epsilon_{it}$$

Equation 2-9

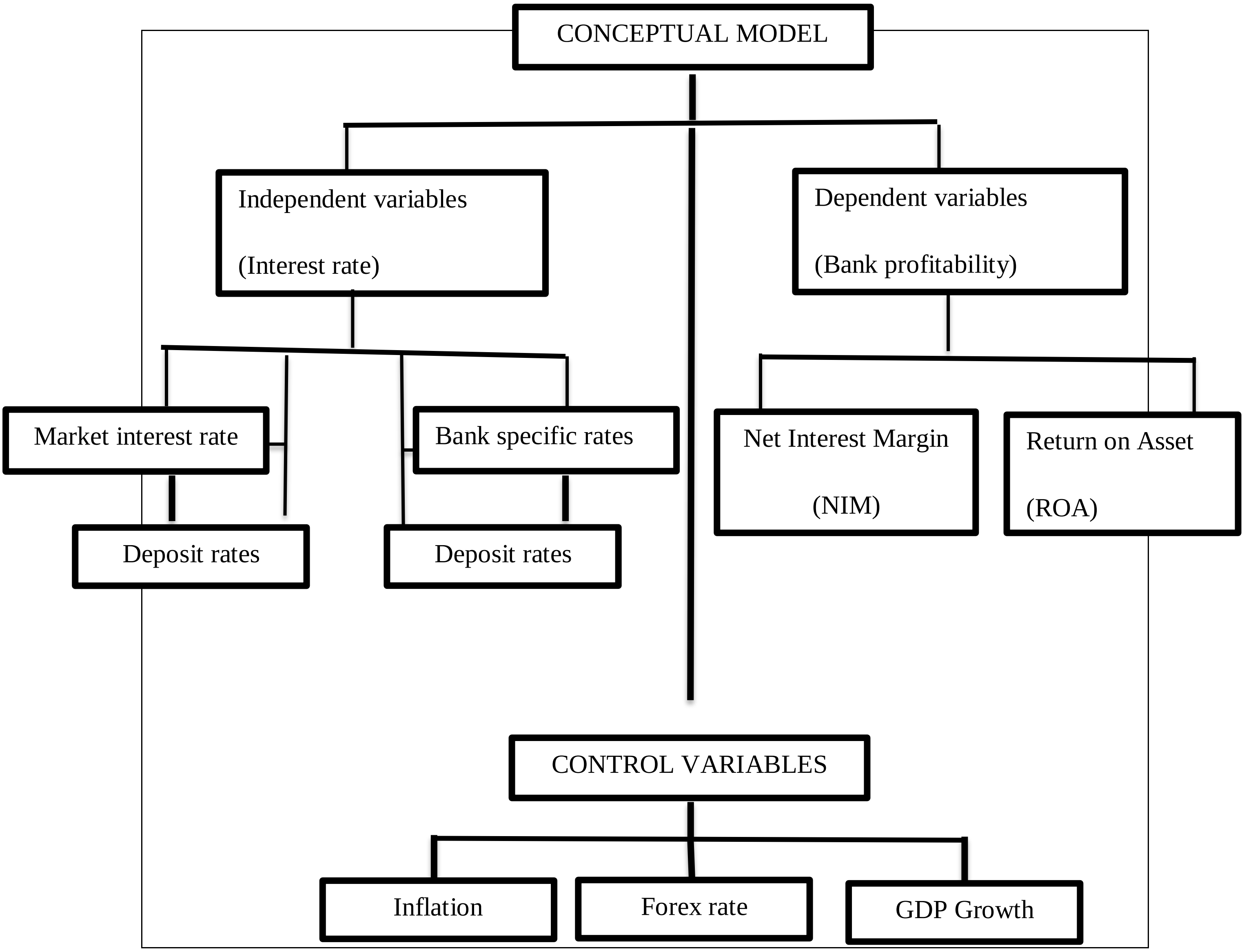
where:

$\text{Profitability}_{it}$ is the profitability indicator for bank

They used Vector Auto regression (VAR) models to analyse correlation between variables that is the interest rates, inflation and the effect of forex rates on bank profitability of both short-horizon and long-horizon regimes. The use of these approaches allowed the researchers to examine the effect of interest rate policies in an environment that was marked by excessive volatility that is high exchange rate changes and inflation. Dube and Moyo (2014) established that higher interest rates had a tendency to widen net interest margins that is enhancing bank profitability in the short term. However, this positive association was often overlooked by the impact of price rises and uncertainty in relation to exchange rates. While most banks were able to lend at an advanced rate, the purchasing power in the income so received from lending was generally reduced by inflation, particularly if hyperinflationary conditions existed. This involved the danger of the effect of increased interest rates. Other than that, the study found that volatility in interest rates brought about huge uncertainty and it was difficult for the banks to stabilize price behaviour and demonstrate stable profitability. Under instability conditions, the negative impact of inflation and volatility in exchange rates prevailed over short-run profit from higher interest rates. Dube and Moyo (2012), confirmed that higher interest rates tended to enhance profitability and this largely resulted through higher net interest margins. But that influence was also subject to other determinants of macroeconomy like inflation which would reduce the efficiency of rises in deposit and lending rates. Where inflation or exchange rates are stable higher interest rates will tend to raise profitability. But where economic systems are unstable, for instance those of Zimbabwe inflation and instability in exchange rates will destroy the useful impacts of higher interest rates. This is of top monetary policy importance that bank profitability increases through higher interest rates are not necessarily an instrument of preference for this purpose especially in underperforming economies. Although interest rate volatility has been proven to influence bank profitability the relationship is very much dependent on the macroeconomic environment. Zimbabwean, US, Turkish, and MENA regional studies have all suggested that positive impact of more expensive interest rates on profits can be offset by inflation and exchange rate volatility.

2.4 Proposed conceptual model

Below on graph 2.1 is a proposed abstract model to verify the impact of interest rates changes in bank earnings in Zimbabwe during 2020-2021. Past records on interest charges, inflation, currency charges, GDP growth and key profitability index will be collected and pre-processed for transparency and accuracy. The ARDL framework is going to be used to examine short-term or long-run connections among interest rate adjustments and profitability and add widely to the econometrics of the same.



graph 2-1 conceptual model

2.5 Research Gap

This dissertation provides a long-needed knowledge gap on interest rate changes and bank profitability in Zimbabwe between the years 2000 and 2024. While other studies have assessed the connection between interest charges and bank performance within other settings globally, they have not been sufficient empirical studies that account for the unusual economic challenges being experienced by Zimbabwe such as its episodes of hyperinflation, currency exchange rate changes and monetary policy uncertainty. While some studies have evaluated the relationship among macroeconomic variables and bank evaluation in Zimbabwe and other emerging economies most of these studies employed motionless techniques that cannot explicitly separate short-run and long-run behaviour. This constraint on economic shock effect in banking performance as of the long run. Besides, current literature avoids the issue of the degree of addition of the variables and may result in wrong conclusions using the inappropriate models used. The goal of this study is to decrease this limitation using the ARDL model which can be used in the investigation of the relationship among factors and allows for short-run and long-term impact breakdown. Through application ARDL technique is analysed on the effect of interest charges, inflation, forex rate and GDP on bank profitability this research provides a well-grounded and enough contribution to the literature in the Zimbabwean finance.

2.6 Chapter summary

The chapter started by analysing significant theoretical models in particular, the Asset-Liability Management (ALM) theory which offers the explanation of how banks manage risks from changes in interest rates. The review explored empirical research that showed the correlation between increases in lending or deposit rates and bank profitability. In Zimbabwe where inflation and currency rate instability are the order of the day research such as Due and Moya (2014) argued that although bank profitability may be supported by an increase in interest rates the short term such influences were usually cancelled out by pressures of currency devaluation and inflation. These results emphasize bank’s need to introduce aggressive scheme of interest rate threat management and profitability the face of existing economic uncertainty. Chapter ended by pointing to the greatest gaps in existing literature that is the unique banking issues of Zimbabwe. It still establishes a gap of research on the particular effect of rate of interest change within a hyperinflationary economy and the general Zimbabwean bank dynamics under.

3 CHAPTER 3

3.1 Introduction

The chapter introduced a research procedure which will be utilized to evaluate the impact of lending and payment rates fluctuations in the profits banks in Zimbabwe from 2000 to 2024. It provides an overview of the research pattern, data grouping strategies, variables, also the models that will be used for the analysis. Given the dynamic and often unpredictable nature of Zimbabwe’s economic environment, both econometric models and machine learning techniques will be integrated to offer a comprehensive analysis of this link.

3.2 Research Design

The thesis uses numerical research designs as it allows for the systematic measurement of links between variables and is well suited for analysing numerical data. Smith et al. (2022) and Nguyen and Tran (2021) emphasize that quantitative methods provide accurate and replicable results in financial analysis, particularly when examining macroeconomic factors like interest charges and their impact on profitability. According to Adams and Lee (2020), the use of statistical models such as time series analysis allows for the understanding of temporal effects and long-term links. This study will utilize time series with cross-sectional data to explore how interest rate fluctuations impact bank profitability over time, capturing both short-term and long-term dynamics.

3.3 Research Instrument

This study utilized a laptop to download, organize, and store the data. This device also facilitated the use of statistical software such as Python. Data was stored and organized in tables. Visual aids such as charts and line graphs were created to illustrate the trends in interest charges and profitability over time, offering a clear visual representation of the findings.

3.4 Population, Sample and Sampling techniques.

Population

Mushunje (2021) stated that the population refers to the specific group of subjects or cases selected for a study. For this research, data on interest charges and profitability metrics will be collected on an annual basis.

Sample

Data will be collected over a 15-25 years period from 2000 to 2024, focusing on commercial banks in Zimbabwe.

Sampling Technique

A non-probability purposive selection method was used to select a dataset of all banks in Zimbabwe for this study. Instead of random selection, the data was chosen based on their market presence, profitability, and the availability of reliable financial data ensuring that the sample is representative of the major players in the most banks.

3.5 Data collection

The research depends on second hand data for investigation, leveraging benefits in existing research highlighted by Nkomo (2023). The data that was used was carefully sourced from esteemed institutions, such as Reserve Bank of Zimbabwe, International Monetary Fund, and reputable data repositories such as the Zimbabwe National Statistics Agency and international financial databases like the World Bank and Trading Economics. These trusted sources provide comprehensive and reliable data on key economic indicators, including interest charges and bank profitability. By utilizing these sources, this study ensures the accuracy and validity of its findings.

3.6 Definition and justification of variables

The data is collected yearly from 2000 to 2024, with a sum sample totaling to 25. The study will focus on all the banks in Zimbabwe in general. Table below will label and explain the variables used. ROA is the dependent factor in this model with inflation, forex rate, GDP, lending rate, deposit rate are the independent variables.

Table 3-1 Variable explanation

Variable	Indicator	Source
Bank profitability	ROA (%)	RBZ financial reports
Inflation	Inflation rate (%)	World Bank
Forex rate	Forex rate (%)	IMF, World Bank
Interest rates	Lending rate (%) Deposit rate (%)	World Bank
GDP	GDP (%)	World Bank, Trading economics, IMF

Source Author's computation

3.6.1 Bank profitability (ROA)

We obtain ROA through dividing Earnings Before Interest with Taxes (EBIT) by the overall equity and results given as a percentage. The return on assets is the metric the researcher uses to assess bank performance. Assets are found on the bank's balance sheet and net profit can be found at the bottom of the income statement. Al-Matari et al. (2014) claimed that a good ROA ratio is typically 5% or more and a great ratio is 20% or more.

Justification

According to Al Matari et al. (2014), profitability evaluation such as the Net Interest Margin (NIM), the ROE and the Return on Capital Employed have notable limitations when compared to Return on Assets (ROA). These indicators may not adequately reflect the efficiency with which a bank utilizes its assets, while ROA provides a more comprehensive assessment of profitability in relation to total assets, making it a more appropriate measure for assessing bank performance

3.6.2 Inflation

The constant progress in the price level of supplies and services in an economy over specific time is inflation. It is commonly measured by the price rises rate, that reflects proportion change of a price index such as the Producer Price Index (PPI) from one time to another. The formula to calculate the inflation rate is:

$$\text{Inflation Rate} = \left(\frac{CPI_{current} - CPI_{previous}}{CPI_{previous}}\right)$$

equation 3-1

Where: $CPI_{current}$ represents Consumer Price Index in the current period

$CPI_{previous}$ represents a consumer price index in the previous period.

Justification

Inflation impacts bank profitability by affecting interest charges, credit risk, and the real value of assets and liabilities. Especially in economies experiencing high inflation volatility, such as Zimbabwe, inflation is a key macroeconomic variable influencing financial stability and bank performance (Ngwenya & Moyo, 2025; Patel et al., 2024).

3.6.3 Forex rate

Forex rate is a worth of country's currency with regards to others measured using nominal forex rate. It plays a central role in influencing trade competitiveness, inflation trends, and the direction of monetary policy.

Justification

Forex rate fluctuations directly affect bank profitability by influencing the outlay of foreign-denominated debt, increasing inflationary pressures and heightening credit risk. Empirical studies demonstrate that in Zimbabwe, forex rate instability undermines banking sector performance, making it a critical factor when assessing the profitability of financial institutions (Mugano & Mazhambe, 2020; Mudzonga, 2023; Chimuka & Chigumira, 2022).

3.6.4 Interest rates

It represents the fee when borrowing money and the return on savings and are a central tool of monetary policy. They are expressed as a percentage and come in two primary forms relevant to banking that is lending charges**,** charged by banks on loans and deposit charges**,** paid by banks on savings or deposits. These charges are influenced by central bank policies and reflect macroeconomic conditions such as inflation, liquidity levels, and monetary stability (Mishkin & Eakins, 2023).

Justification

Interest charges directly affect bank revenue and funding fees through emphasizes that a higher interest margin increases profitability but volatility and high charges may lead to credit risk. This justifies analysing both lending and deposit charges to understand their effects on bank's ROA (Kambuwa & Simbanegavi, 2022; Musarurwa, 2023).

3.6.5 Gross Domestic Product (GDP)

GDP is an aggregate measure of every commodity or service generated inside a national borderline over a specific time. It functions as a major indicator of system performance and is often reported quarterly or annually. GDP is ordinarily figured using the consumption approach, which adds usage, asset allocation, government outlay, and net trade (World Bank, 2024).

Justification

GDP is a vital macroeconomic indicator affecting bank profitability. It explains that economic growth stimulates financial services, while downturns increase risk. Empirical evidence supports a positive link between GDP and bank performance in Zimbabwe (Ndlovu & Gumbo, 2023; Gatsi, 2022).

3.7 Data analysis

Python 3.11 was used to evaluate the data that had been gathered. An Autoregressive Distributed Lag (ARDL) was used in a research approach. With inflation, GDP and forex rate as additional dependent factor, the Autoregressive Distributed Lag model was used to evaluate the impact of interest rate fluctuation in bank profitability. This study also discusses the general trends these variables display as well as short-run and long-term correlations among them.

3.8 Models

The best way to estimate the model in order to determine the immediate and long-term effects of customer satisfaction and loyalty on financial performance appears to be the Autoregressive Distributed Lag method. Corresponding to the Johansen and Juselius (1990) method, the ARDL technique assesses the long-term impacts same as the short-run effects.

Using an ARDL technique, it will be demonstrated how bank financial performance relates to fluctuation of economic macro variables on bank profitability. The right-hand side independent variables, which include bank financial performance, GDP, forex rate, deposit and lending rate, and interest charges, was used as independent variables to determine whether cointegration exists in the model.

3.9 Data presentation and analysis procedures

3.9.1 Data presentation

According to (Olivier & McLeod, 2022), effective data presentation is necessary for ensuring that the results of a research study is both clearly communicated or easily understood. Descriptive and inferential statistical techniques was used to evaluate the effect of interest rate fluctuations on profitability of banks in Zimbabwe. The collected data was organized and presented in a structured manner to facilitate accurate interpretation and maintain transparency throughout the analysis process.

3.10 Model test

3.10.1 Unit root test

According to Moyo (2021), verifying the stationarity of data is a critical preliminary step, as using non-stationary factor will lead to misleading results. To assess the data unit roots test will be employed. In cases where non-stationarity is present, the data will be transformed through differencing to achieve stationarity. As highlighted by Ncube and Ndungu (2022), ensuring stationarity is fundamental for producing valid and consistent results in time-series regression models.

3.10.2 Model Identification and Specification

In examining how interest charges influence bank profitability, Kabir and Das (2023) utilised the ARIMA model, offering perceptions relevant to the methodological direction of the present research. The research however, utilized ARDL framework which is particularly effective for analysing time-series data that involve both short-run variations and long-term associations. As outlined by Pesaran etal.(2001), ARDL model is well-suited for assessing immediate impacts of interest rate changes while also identifying stable, long-term linkages among the key variables.

3.10.3 Cointegration test

ECT was employed to evaluate the performance and stability of ARDL models over time. When cointegration among variables is confirmed, an Error Correction Model can be used to reflect both near trends or the rapidity of change toward long-term balance. This term is derived from the long-run equation and incorporated into the ECM. Since the ARDL framework operates as a single-equation model, its structure aligns with that of an ECM, allowing for simultaneous approximation of near-run effects and long-term links. Following an identification of a long-run link through the ARDL bounds testing approach, an ECM is estimated to measure short-run adjustments and the rate at which deviations from equilibrium are corrected. The formula of the ECM is:

$$\Delta Y_t = \alpha + \beta 1\ \Delta Xt_t + \lambda\ EC_{t-1} + \epsilon t_t \qquad \text{equation 3-2}$$

Where:

Y_t is the change in bank profitability

X_t is the change in interest rate

ECM_{t-1} is the fault correction word

λ indicates the rate of change to equilibrium Autoregressive distributed lag approach

Johansen and Juseliud (1990), if a cointegration variable are present, the underlying variable is l (0) since the cointegration technique is not relevant. Data should be stationary at l (0) and l (1) or a mixture of both. In these cases, using cointegration and the ARDL technique yields an accurate and effective approximation. The cointegration vector can be located using the ARDL method. To put it another way, every underlying variable functions as a single long-term relational equation. Through the ARDL model procedure, the cointegration vector is reparametrized into the error correction model (ECM) once the single molecular vector upon which the equation is based has been determined.

3.10.4 Normality test

This research utilized the Jarque-Bera test so as to determine if model residuals exhibit characteristics of a normal distribution. Specifically, the Jarque-Bera test evaluates whether the skewness and kurtosis of the residuals significantly differ from those expected under normality. The test is computed using the following formula:

$$JB = \frac{n}{6}\left(S^2 + \frac{(K-3)}{4}\right) \qquad \textit{equation 3-3}$$

Where:

n represent to the total number of data points

k indicates a number of parameters estimated in a model

S stands for the skewness observed in the sample

C denotes the kurtosis calculated from the sample

A Jarque-Bera statistic that deviates substantially from zero suggests a violation of the normality assumption in the data. Assessing normality is crucial, as numerous inferential statistical methods particularly those based on the t-distribution bank on the assumption that residuals are normally distributed. This assumption underpins the reliability of hypothesis tests and the construction of valid confidence intervals.

3.10.5 Heteroscedasticity

Heteroscedasticity is a state of the difference in error status differ across various levels of the independent factor, which can result in an inefficient or potentially partial calculation when using Ordinary Least Squares (OLS) regression. This issue is often associated with violations of the normality assumption. In this analysis, the Breusch-Pagan-Godfrey test was applied so as to identify whether heteroscedasticity is present. Additionally, Durbin-Watson was used to measure for serial correlation, another factor that can compromise the accuracy of model estimates. For the regression results to be reliable, the error term must exhibit constant mean and variance over time. When key suppositions such as the independence of observations and an adequately large sample are satisfied, the adverse effects of minor heteroscedasticity may be minimal.

3.10.6 Ramsey reset

The Ramsey Test was utilized to evaluate whether the structural form of the regression has been appropriately defined. This test is particularly useful for identifying issues such as omitted variables or incorrect model specification by incorporating advanced order terms of the projected values into regression. If these added terms are found to be statistically significant, it indicates potential misspecification in the model. In this study, the RESET test is applied to the ARDL framework to assess the correctness of its structure. A result showing no statistical significance would confirm that the model is correctly specified and appropriate for forecasting purposes and policy related analysis.

3.10.7 CUSUM test

The Cumulative Sum test is used to analyse when the parameters of a model remain consistent over a period. This diagnostic tool is particularly valuable in time series analysis, as it helps identify any structural shifts in the estimated regression coefficients. The test includes visualizing the cumulative sum of recursive residuals and comparing trajectory to predefined confidence intervals. If the cumulative line stays within these bounds, the model is considered stable however, if it crosses the boundaries, it may indicate parameter instability or a structural break. In the context of this study, the CUSUM test will be applied to the ARDL model to assess whether its parameters remain stable throughout the observed period an important condition for making dependable short-run and long-term conclusions.

3.10.8 Granger causality test

The Granger test is designed so as to assess if one time series can provide useful information for forecasting another. It focuses on predictive causality, meaning it identifies whether past observations of one factor will help improve prediction of future amount of a second variable, rather than establishing direct cause and effect. The test involves checking if lagged figure of one factor significantly add to the explanation of the current value of another. When the p-value falls below a determined significance level, the H0 is rejected. The null hypotheses for this test is there is a zero-causal relationship from one variable to the other and alternative hypothesis is the present causal correlation between the factors.

3.11 Summary

This section defined research design utilized as a framework for fulfilling the thesis research questions. It highlighted the methods and tools applied in gathering secondary data. Additionally, the chapter described the procedures for data demonstration and investigation that will be undertaken in the following chapter. The following chapter will emphasis on presenting data, conducting the evaluation, and discussing the results.

4 CHAPTER 4

4.1 Introduction

This section shows examination of an empirical result from a survey. It employed the Python programming environment, making use of pandas for data preparation for visualizing statistical patterns and model outputs. It begins by providing descriptive statistics and visual trends, followed by the stationary and cointegration test results, ARDL estimation outputs. The findings are then discussed aligning with to the research objectives and existing literature.

4.2 Descriptive statistics

Descriptive statistics were essential in this study for summarizing the main characteristics of the dataset. They offered valuable perceptions into the distribution, central tendency, and dispersion of the variables, thereby laying the groundwork for subsequent econometric analysis (Field, 2021). Table 4.1 below displays the key descriptive metrics used to describe the data.

Table 4-1 Descriptive statistics

Variable	Inflation Rate (%)	Forex Rate (ZWL/USD)	ROA (%)	Deposit Rate (%)	Lending Rate (%)	GDP (Current USD)
Number of observe	25	25	25	25	25	25
Average	70.229	312.041	1.601	8.441	14.11	11435987870
Standard deviation	25.931	372.489	0.624	1.485	2.814	5394131000
Minimum	8.974	1	0.334	5.18	8.812	4139236000
First quartile 25%	64.121	1	1.165	8.002	11.804	6662965000
Median	76.744	249.203	1.727	8.617	13.838	11811290000
Upper quartile 75%	88.412	455.137	2.152	9.588	16.074	16210910000
Maximum	98.051	1310.69	2.595	10.336	19.266	18778190000
Skewness	-1.265	1.375	-0.169	-0.781	0.117	-0.023
Kurtosis	0.57	1.28	-0.804	-0.22	-0.639	-1.649
Total Sum	1755.734	7801.032	40.026	211.023	352.738	285899700000

Table 4.1 presents dataset of 25 quarterly observations covering major economic and banking indicators in Zimbabwe, offering valuable insights into the country's macroeconomic trends. Inflation averaged a high 70.23% with a standard deviation of 25.93, indicating not only elevated price levels but also strong variability, suggesting persistent inflationary pressures throughout the period. The foreign exchange rate (ZWL/USD) was especially volatile, ranging from 1 to 1,310.69 with a mean of 312.04, reflecting repeated instances of currency instability. In contrast, the return on assets (ROA) for banks remained relatively modest and stable, averaging 1.6% with minimal deviation, pointing to moderate profitability in the sector. Deposit and lending rates averaged 8.44% and 14.11% respectively, showing a normal interest rate spread with some fluctuations. GDP in current USD terms averaged around 11.4 billion, indicating a general upward trend in economic output, though the wide variation highlights periods of economic uncertainty. While standard deviation effectively captures the degree of variability in the data, offering insights into how much values fluctuate around the mean, it does not reveal the direction of those fluctuations. This is where skewness becomes useful it shows whether data are more frequently above or below the mean. For example, the inflation rate showed a negative skewness, indicating more frequent high inflation episodes, while the forex rate had a positive skew, pointing to sharp upward deviations in exchange rates. Together, using both standard deviation and skewness provides a more complete picture of economic behaviour SD quantifies the spread, while skewness explains the shape and direction of that spread. Therefore, it is recommended to interpret these indicators jointly for a deeper understanding of the data's distribution characteristics and underlying economic dynamics.

4.3 General trends of variables

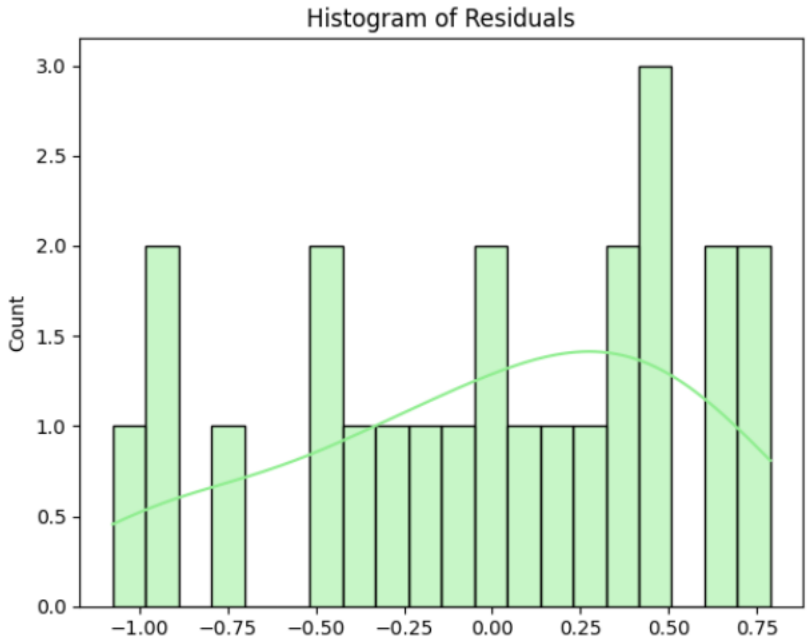
graph 4-1 general trend

Graph 4.1 illustrates the general trends of key macroeconomic and banking variables in Zimbabwe from 2000 to 2024. The inflation rate shows a sharp and persistent increase peaking around 2022 reflecting sustained macroeconomic instability. The forex rate (ZWL/USD) also exhibits high volatility and depreciation with spikes around 2008 and 2022 indicating major currency devaluations. Return on Assets (ROA) for banks fluctuate moderately over time showing a decline post 2022 possibly due to profitability pressures. The deposit rate rises steadily from 2005 onwards while the lending rate remains volatile but generally high indicating a wide interest rate spread and tight credit conditions. GDP displays a consistent upward trend until 2020, after which it levelled suggesting slowed economic growth possibly due to inflationary pressures or external shocks. Overall, the trends show a volatile macroeconomic environment with implications for banking sector performance and financial stability.

4.4 Normality test

Residual diagnostics refers to the examination of the deviation among actual discovered values and those expected by a statistical model. This evaluation is important to confirm that the residuals follow the normal distribution, exhibit constant variance are mutually independent. Conducting residual diagnostics helps assess the overall validity of the model and informs any required modifications to ensure accurate interpretation of the results.

graph 4-2 Histogram if residuals



The histogram indicates that the data distribution closely aligns with normality. The test statistic is 1.46, followed by p-value approximately to 0.48. Since this p-value exceeds significance value of 0.05, it means there is inadequate indication to evaluate the H0 of normality. This implies that observed data distribution does not significantly deviate from a normal distribution. The skewness value was calculated as -0.43 indicating a slight trend for the data to lean towards the left side but this deviation is moderate and not enough to cause concern about normality. These findings imply that the dataset is suitable for statistical analyses that assume normality.

4.5 Unit root test

Table 4-2 Stationarity test

Variable	ADF statistic	p-value (level)	conclusion Order of integration

	(level)		
ROA (%)	-4.3956	0.0003	Stationary I(0)
Lending rate (%)	-3.0177	0.0333	Stationary I(0)
Inflation (%)	-4.7099	0.0001	Stationary I(0)
forex rate (ZWL/USD	-2.9633	0.0385	Stationary I(0)
GDP (current USD)	-0.4115	0.0082	stationary I(1)

The results indicate that most variables in the dataset such as ROA, lending rate, inflation rate, and forex rate are stationary at their level forms. This conclusion is supported by significantly negative test statistics and a p-values less than 5%, suggesting an absence of the unit roots. Therefore, these variables are classified as integrated of order zero. However, GDP stands out because the test statistic is quite low at -0.41 and its p-value is moderate suggesting it remains stationary after the first differencing. This implies GDP was be integrated of order I (1) meaning it was differenced once before it becomes stationary. Therefore, the ARDL model is suitable.

4.6 Lag order selection Criteria

Table 4-3 lag order

	coefficient	Standard deviation	Z	P>|z|	0.025	0.975
Constant	18.7212	3.658	5.118	0.004	9.318	28.124
ROA (%). L1	-0.6455	0.336	-1.922	0.113	-1.509	0.218
ROA (%). L2	-0.4252	0.249	-1.71	0.148	-1.064	0.214
ROA (%). L3	-1.1912	0.32	-3.727	0.014	-2.013	-0.370
ROA (%). L4	-1.5653	0.576	-2.717	0.042	-3.046	-0.084

Lending rate (%). L0	-0.2912	0.151	-1.934	0.111	-0.678	0.096
Lending rate (%). L1	-0.2197	0.129	-1.704	0.149	-0.551	0.112
Lending rate (%). L2	-0.1987	0.067	-2.945	0.032	-0.372	-0.025
Lending rate (%). L3	-0.3302	0.076	-4.324	0.008	-0.527	-0.134
Lending rate (%). L4	-0.2756	0.093	-2.953	0.032	-0.515	-0.036
Inflation (%). L0	0.0665	0.043	1.540	0.184	-0.044	0.177
Inflation (%). L1	0.0885	0.031	2.832	0.037	0.008	0.169
Inflation (%). L2	-0.0123	0.021	-0.590	0.581	-0.066	0.041
Inflation (%). L3	0.0459	0.028	1.665	0.157	-0.025	0.117
Inflation (%). L4	-0.0761	0.027	-2.786	0.039	-0.146	-0.006
forex rate (ZWL/USD)	-0.0032	0.001	-2.360	0.065	-0.007	0.000

Table 4.3 the findings revealed that ROA is significantly influenced by its own previous values as well as by past lending charges, suggesting that shifts in interest rate policies may affect bank performance with a time lag. Overall, the results emphasize the banking sector’s sensitivity to economic factors and underscore the effectiveness of the ARDL model in capturing both short-term and long-term effects.

4.7 Cointegration test

4.7.1 UECM for bound test

The Unrestricted Error Correction Model (UECM) incorporates both the differenced variables, which reflect short-term adjustments, and the level variables, which assess the presence of a long-run equilibrium association. The primary purpose the Bounds Test within the UECM framework is to verify whether a significant connection exists among the variables, even when they exhibit different integration orders (I (0) or I (1)). This is achieved by testing the joint significance of the lagged level terms through an F-statistic. If F-value is greater than the higher critical bound, it indicates cointegration, meaning the variables share a stable long-run association despite short-term variations. Conversely. If F-value is less than the lower critical bound, it means there is no cointegrating association exists. ARDL Unrestricted Error Correction Regression

Graph 4-3 OLS Regression Results

```
                            OLS Regression Results
==============================================================================
Dep. Variable:                   dROA   R-squared:                       0.664
Model:                            OLS   Adj. R-squared:                  0.447
Method:                 Least Squares   F-statistic:                     3.068
Date:                Wed, 28 May 2025   Prob (F-statistic):             0.0296
Time:                        11:31:31   Log-Likelihood:                -19.494
No. Observations:                  24   AIC:                             58.99
Df Residuals:                      14   BIC:                             70.77
Df Model:                           9
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const          0.5542      1.572      0.352      0.730      -2.818       3.926
ROA_lag1      -1.5453      0.329     -4.697      0.000      -2.251      -0.840
LR_lag1        0.1653      0.180      0.920      0.373      -0.220       0.551
INF_lag1      -0.0230      0.024     -0.964      0.351      -0.074       0.028
EXR_lag1       0.0010      0.001      1.277      0.222      -0.001       0.003
GDP_lag1    7.359e-11   6.78e-11      1.086      0.296   -7.18e-11    2.19e-10
dLR            0.0765      0.116      0.658      0.521      -0.173       0.326
dINF          -0.0186      0.034     -0.552      0.590      -0.091       0.054
dEXR           0.0017      0.001      2.224      0.043    6.02e-05       0.003
dGDP       -4.527e-11    2.1e-10     -0.216      0.832   -4.95e-10    4.05e-10
==============================================================================
Manual Bounds Test - F-Test on Lagged Level Terms:
<F test: F=np.float64(6.086113287139998), p=0.0047088412494761395, df_denom=14, df_num=4>

Computed F-statistic: 6.0861

Critical Values for Bounds Test (k=4, intercept only) from Pesaran et al. (2001):
10%: I(0)=2.45, I(1)=3.52
 5%: I(0)=2.86, I(1)=4.01
 1%: I(0)=3.74, I(1)=5.06
```

✅ Conclusion: Cointegration exists (reject H_0).

4.8 short run coefficients

Figure 4-1 short-run coefficients

	coefficient	STD	t	p>|Z|	0.025	0.975
const	0.5542	1.572	0.352	0.73	-2.818	3.926
dlr	0.0765	0.116	0.658	0.521	-0.173	0.326

dinf	-0.0186	0.034	-0.552	0.59	-0.091	0.054
dexp	0.0017	0.001	2.224	0.043	6.02E-05	0.003
dgdp	-4.53E-11	2.10E-10	-0.216	0.832	-4.95E-10	4.05E-10

The regression results indicate that most explanatory factors are not statistically significant on the dependent variable, except for export growth (dexp). The coefficient for export growth equal to 0.0017 with p-value of 0.043, signifying a positive and significant relationship at the 0.05level implying that increases in exports are associated with slight improvements in the dependent variable, likely bank profitability. The lending rate (dlr) and inflation (dinf) have positive and negative coefficients respectively but with high p-values (0.521 and 0.590), indicating that their effects are not statistically meaningful in this model. Similarly, the GDP variable (dgdp) shows an extremely small and statistically insignificant coefficient, with p-value of 0.832. The constant term was also not significant. Overall, these findings suggest that among the variables tested, only changes in exports show a significant influence within the study period.

4.9 Hypotheses for Short-Run Dynamics (ARDL Short-term Coefficients)

In an ARDL model, the immediate impacts are recorded at first differenced variables for example dLR, dINF, dEXR, and dGDP. The significance of these coefficients helps determine whether changes in independent variables have immediate effects on the dependent variable, ROA. The null hypothesis is that there is no short-term correlation among lending rate and inflation rate, forex rate, GDP, and bank earnings (ROA) and the alternative is that at least one of the independent factors has a short-term correlation with ROA.

As shown in Graph 4.3, only the first difference of the forex rate is significant at the 0.05 level, and the p-value as 0.043. It suggests in the short run, fluctuations in forex rate have an immediate and meaningful impact on ROA, whereas the other variables do not show significant short-run effects.

4.10 Hypotheses for long-Run Dynamics (ARDL long-Run Coefficients)

To investigate whether a long-run association is there among bank earnings (ROA) and the selected macroeconomic variables, the UECM was estimated, followed by a bounds test procedure. The null hypothesis is that cointegration is zero and the alternative is cointegration is available

There are two common ways to interpret the test results that is by examining a p-value: if its below 0.05 then H0 is rejected, showing the presence of a cointegration and there is long-term association among the factors. If test statistic is greater than critical value then H0 hypothesis is rejected, providing evidence of cointegration.

As shown in Graph 4.3, the computed F-statistic of 6.0861 surpasses the upper critical bounds for all significance showed by Pesaran et al.(2001) for a model with four explanatory variables and an intercept. The upper bound values at 0.01, 5% or 1% significance levels are 3.52, 4.01, or 5.06. Since F-statistic exceeds even the 1% upper bound, there is strong support to reject the H0 of no cointegration. It shows the presence of a steady long-term balance association among the variables included in the model.

4.11 Long run coefficients

Table 4-4 Long-run coefficients

	Coefficient	STD	Z	p>|Z|	0.025	0.975
Const	18.7212	3.658	5.118	0.004	9.318	28.124
Lending rate (%). L0	-0.2912	0.151	-1.934	0.111	-0.678	0.096
Inflation (%). L0	0.0665	0.043	1.540	0.184	-0.044	0.177
forex rate (ZWL/USD)	-0.0032	0.001	-2.360	0.065	-0.007	0.000

The table 4.4 shows the long-term coefficients derived from an ARDL model, illustrating the influence of major macroeconomic variables in bank earnings, calculated by ROA, over a prolonged period. The constant term, estimated at about 18.72%, is significant and shows the baseline level of ROA when other factors are held steady. The lending rate exhibits a negative impact on ROA, suggesting that increased lending charges may reduce bank earnings. Inflation shows a positive coefficient, indicating potential gains in profitability during inflationary times, but its lack of statistical significance means it does not consistently affect ROA in the long term. The forex rate had a negative suggestion with ROA and marginally significant at the 10% level, implying that currency depreciation might slightly lower bank earnings. In summary, while several macroeconomic variables seem to influence ROA, only the forex rate shows near-significant long-term effects, pointing to the possible effects of economic uncertainty in Zimbabwe banking sector.

Overall, UECM regression output highlights the short-run and long-term dynamics among return on assets, forex rate, lending rate and GDP. The model accounts for 66.4% of the variability in ROA changes, this model shows a well-adjusted R-squared of 0.447, reflecting moderate level of explanatory power after considering a number of predictors. Overall regression is evident at the 0.05 level, supported by an F-statistic which is given by 3.068 and the p value=0.0296, which confirms that the included variables collectively explain variations in ROA. Notably, the lagged ROA variable has a strong negative coefficient and is highly significant, indicating an effective error correction mechanism where any deviations from the long-term balance are gradually adjusted. In the short term, only changes in currency rate have a significant effect in ROA, implying that changes of currency values impact bank earnings immediately. Additionally, the Durbin-Watson statistic is equal to 2.119 indicates there is no evidence of autocorrelation while normality tests yield p-values above 0.05 supporting the supposition of normally distributed errors. Therefore, the findings reveal meaningful short-term currency rate effects and a clear long-run adjustment mechanism via ROA.

4.12 Model Validation: Diagnostic Testing Run

Table 4-5 Serial Correlation Test (Ljung-Box)

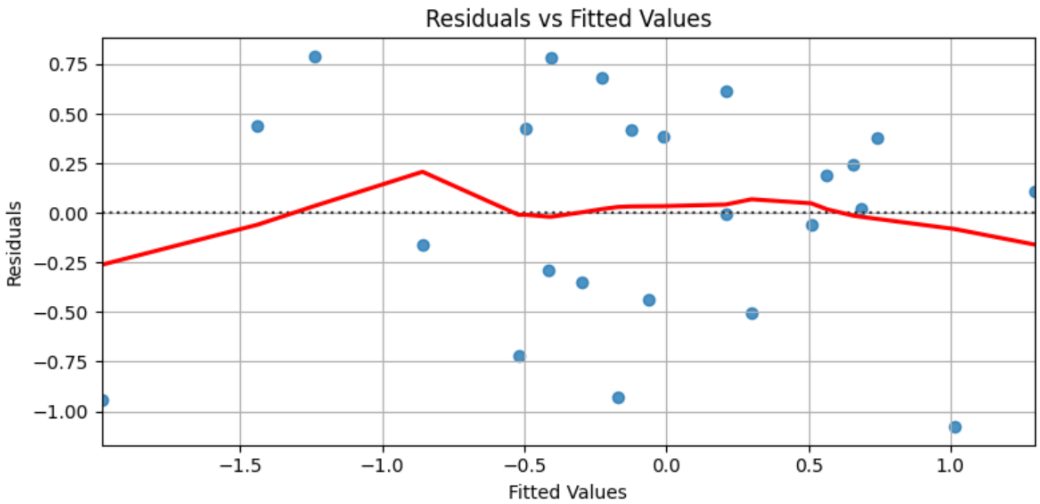
	1b stat	1b p value
1	0.4924	0.4828

2	0.6612	0.7184
3	1.3651	0.7137
4	2.4281	0.6575

The results of the Ljung-Box test show no significant signs of serial correlation of the model up to lag 4. Test statistics fall between 0.49 and 2.43, with corresponding p values from 0.48 to 0.72, all above 5% significance level. Because these p values are on top of 0.05 and we fail to reject H0. This indicates that the residuals behave independently, with no systematic influence of past errors on future ones. Therefore, the model meets the important supposition of error independence supporting its reliability for inference and forecasting.

4.12.1 Testing for heteroscedasticity

Graph 4-4 Breusch-Pagan-Godfrey



Graph 4.4 expressed the results where Breusch-Pagan test results for heteroskedasticity suggest that the evidence is equal to zero of heteroskedasticity in residuals of an ARDL short-run model. The LM test yields p-value as 0.607, while F-test showed a p-value of 0.717, well above common significance thresholds such as 0.01, 0.05, or 0.10. Consequently, then we fail to reject H0 of constant variance (homoskedasticity). This outcome confirms that the residuals maintain a consistent variance throughout the observations, thereby fulfilling a

crucial supposition of classical linear regression and supporting the model's reliability of the estimated standard errors, t-statistics and confidence intervals in OLS results.

4.12.2 Ramsey reset

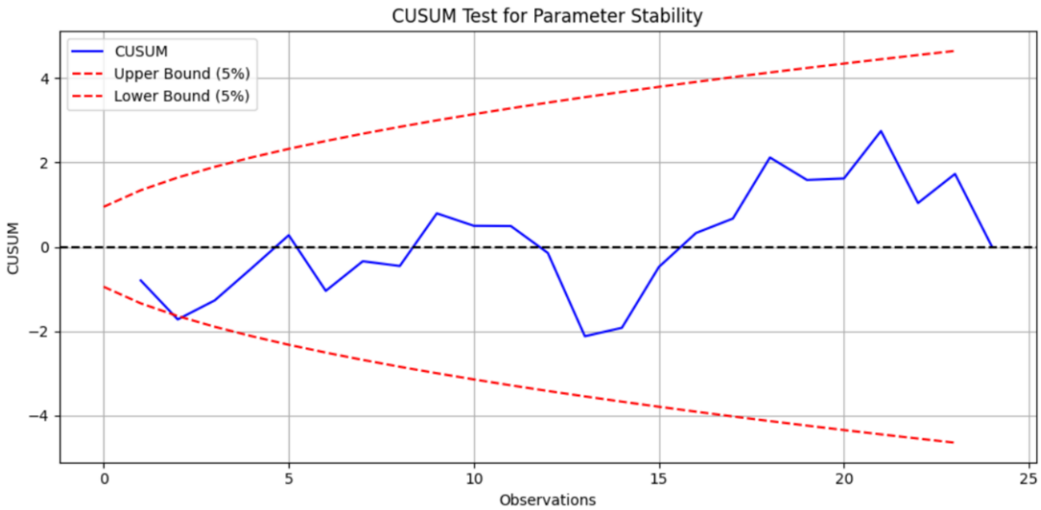
Graph 4-5 Ramsey reset

```
Model Specification Test (Ramsey RESET):
F-statistic: 1.4909, p-value: 0.2438
```

The Ramsey RESET test results indicate F-statistic as 1.4909 and the p-value as 0.2438 which is above the common significance thresholds such as 0.01, 0.05, and 0.10. Therefore, the H0 states that the model is rightly specified and we fail be rejected. This suggests there is no statistical indication of omitted variables or incorrect model form. These findings confirm that the linear structure of the ARDL model is suitable and that the main factors affecting bank earnings (ROA) have been properly included.

4.12.3 CUSUM Test

Graph4-6 CUSUM test for parameter stability



Graph 4.6 presented CUSUM plot showing the cumulative sum of standardized residuals from your model over time. Since the blue CUSUM line stays within the red dashed boundaries which the 5% significance bounds serve as a reference to assess parameter stability throughout the sample period. Since the CUSUM line stays comfortably within these limits, it indicates that the model's parameters remain stable, with no evidence of major structural changes or instability during the observed timeframe. Therefore, the estimated coefficients can be considered stable and reliable over the entire period analysed.

4.13 Granger Causality Test

The test analysed the previous values of one time series will give useful information for forecasting another time series. Essentially, if one variable "Granger causes" another, it means its historical data helps predict future movements in the second variable. The findings from the test investigation are presented below.

Table 4-6 Granger causality

causing	caused	lag 1	lag 2	lag 3	lag 4

LR	ROA	0 .9346	0 .5364	0 .0736	0 .0251
INF	ROA	0.9454	0.7679	0.5847	0.6801
EXR	ROA	0.6198	0.0804	0.3991	0.2665
GDP	ROA	0.6039	0.8959	0.7819	0.776
ROA	LR	0.5659	0.5358	0.3624	0.4842
INF	LR	0.0193	0.1252	0.9541	0.6087
EXR	LR	0.0015	0.0182	0.0417	0.0177
GDP	LR	0.4135	0.5893	0.1684	0.0622
ROA	INF	0.9962	0.7907	0.1731	0.2923
LR	INF	0.8870	0.8263	0.7146	0.4788
EXR	INF	0.7026	0.8116	0.6386	0.7524
GDP	INF	0.7054	0.6129	0.7734	0.0827
ROA	EXR	0.0536	0.0618	0.1265	0.2276
LR	EXR	0.4755	0.5865	0.0423	0.0010
INF	EXR	0.9113	0.9755	0.1201	0.1329
GDP	EXR	0.7668	0.8390	0.8021	0.9428
ROA	GDP	0.5449	0.5508	0.8259	0.9136
LR	GDP	0.7920	0.2101	0.5519	0.9501
INF	GDP	0.0522	0.1748	0.0300	0.0001
EXR	GDP	0.9672	0.9314	0.9128	0.7687

The causality test provides valuable information about the cause-and-effect dynamics between key macroeconomic factors and bank returns (ROA) in Zimbabwe. At a 5% significance threshold, the test shows that lending charges (LR) at lag 4 have a predictive effect on ROA, with the p value of 0.025. This shows that shifts in interest charges may require some time before they noticeably influence bank returns. Forex charges (EXR) also show marginal influence on ROA at lag 2 where p = 0.080. In reverse, ROA does not Granger-cause LR, INF, EXR or GDP at any lag, indicating that bank returns is more likely a result rather than a driver of macroeconomic changes. Inflation (INF) significantly Granger causes lending rates at lag 1 where p = 0.019 and currency rates Granger cause lending rates across all lags particularly strong at lag 4 where p=0.001 undermining the sensitivity of interest charges to both price levels and currency fluctuations. Additionally, inflation significantly Granger causes GDP at lag 3 and lag 4 where p = 0.030 and p = 0.0001 reflecting how persistent inflation can influence overall economic growth. These findings suggest a chain of macroeconomic transmission where inflation and currency charges affect lending charges which in turn influence bank returns.

4.14 Chapter 4 Summary

The analysis starts with descriptive statistics, showing a notably high average inflation rate of 70.23% alongside a highly unstable currency rate. Meanwhile, the return on assets (ROA) remains relatively low, averaging around 1.6%. Trend visuals highlight considerable economic volatility, especially in inflation and currency rate movements, with profitability declining noticeably after 2022. Tests for normality confirm that data closely follows a normal distribution. Stationarity checks using an ADF test shows that most factors are stationary at original levels (I (0)), except for GDP, which appears to be integrated of order 1, supporting the choice of ARDL modelling approach. The lag selection process identifies that ROA is significantly affected by its own past values and the lagged lending rate. The Bounds Test reveals a cointegration bond with an F-statistic of 6.0861, exceeding critical thresholds and confirming a stable long-run association among the factors. In the short term, only fluctuations in the currency rate significantly influence ROA. Long-run estimates indicate negative bonds between ROA and both lending charges and currency rates, with only the conversion rate nearing statistical significance. The model explains a moderate portion of the variation in ROA, with an adjusted R-squared of 0.447, and the overall model is statistically significant ($p = 0.0296$). Diagnostic tests support the model's reliability, confirming normality of residuals, lack of autocorrelation (Durbin-Watson = 2.119), and no serial correlation (Ljung-Box p-values above 0.05). These findings underscore the significant character of conversion percentage changes in shaping bank returns, in the short run and over long term, highlighting importance of maintaining macroeconomic stability for the banking sector.

5 Chapter 5: Finding, conclusions and Recommendation

5.1 Introduction

The chapter gives a complete interpretation or validation of empirical data set. It connects findings with the research objective assesses how they differ with current theory and places them in the light of past studies. Analysis gives in-depth viewpoints on how bank returns as measured by Return on Assets in Zimbabwean banks are determined by the change of interest charges and other macroeconomic indicators such as inflation, changes in conversion rates and GDP.

5.2 Discussion of Short-Run Dynamics

5.2.1 Forex Rate Volatility

The Short-term results displays that changes in rate of conversion have large and negative effects on bank returns which suggests that a declining domestic currency could be bad for the financial health of banks. The result supports the assumption that macroeconomic instability in particular through volatility in the foreign conversion market creates uncertainty reduces asset quality and destroys investor and depositor confidence in financial sector. The result is reliable with current research on the effects of depreciation in conversion rates on financial institutions in a negative manner by increasing the cost of foreign liabilities and credit flow destabilization (Ndlovu and Mpofu, 2023; Moyo and Chigumira, 2024). In Zimbabwe, for instance where instability of conversion rates is widespread such volatility presents serious challenges to short-run performance in banks. These findings confirm the central role of an effective currency period in enhancing the resilience of the banking sector. However, to theoretical expectations short run coefficients of lending and inflation charges were insignificant. This could be a consequence of lags in program of monetary policy changes within the banking sector or other non-monetary factors of profitability as well. The findings show that the dynamics of these factors do not have a sudden effect on ROA but may expose their effects in a longer period.

5.3 Discussion of Long-Run Dynamics

5.3.1 Lending Rate and ROA

Long-run coefficient of lending rate was negative but insignificant. Despite the expected direction by theory that higher lending charges can change loan demand and increase default risk that is reducing profitability. The non-significance suggests other moderating factors like high-interest spreads or risk-adjusted pricing may hide this effect. This is consistent with Chagwiza (2014) who argued that Zimbabwean banks adjust their price models to maintain profitability among high-rate period.

5.3.2 Inflation and ROA

Inflation was significantly related to ROA in the long run although the outcome was not significant statistically. Therefore, implying during times of inflation nominal revenues increase faster than nominal fees for banks hopefully to boost profitability. However, a lack of significance shows the bond is not strong or regular and perhaps the destabilizing effect of hyperinflation on the Zimbabwean economy in the past has reduced the reliability of predictions and affected customer behaviour.

5.3.3 Forex Rate and ROA

The Forex rate remained to be negatively correlated with ROA in the long term nearly 10% significance level in statistics. The suggestion of results is that continuous currency weakness undermines returns of banks in the long run perhaps because of the rising fees, or failing loan quality due to pass through of inflation. This supports the long run effects of macroeconomic instability on banking sector viability as examined by Makochekanwa (2018).

5.4 Cointegration and Long-Term Equilibrium

The bound test had an F-statistic of 6.0861 above the highest critical value at 0.01 level, definitely defining cointegration. It suggests that ROA, lending rate, inflation and conversion rate are related in a long-run context bond disregards short-term shock. The significance of the lagged ROA term in the ECM confirms the existence of a process by which differentiate from long-run equilibrium are corrected over time.

5.5 Summary of Key Results

This research utilized the Autoregressive distributed lag model which is suitable in testing bonds between factor of different orders of integration, as suggested by the recent literature in econometrics (Mwale and Chikodzi, 2023; Zhou and Ndlovu, 2024). The general objective was to examine short term and long-term impact of major macroeconomic factors including interest rate, foreign forex rate, deposit rate, lending rate and GDP on banking returns focusing on data from the year 2000 to 2024. The outcome presented indicated that in the short run only foreign forex rate changes were significant of having negative effects on bank returns measured by ROA in line with results of current local financial studies (Chirume and Dube, 2024). In the long run the foreign forex rate continued to negatively affect profitability, although only slightly significant while inflation and lending fees did not demonstrate statistically significant effects. The bounds test indicated cointegration between ROA and selected macroeconomic factors that is suggesting that these variables operate in the identical direction in the long run (Moyo and Sibanda, 2023).

In addition, the importance and contrary values of the term for error redaction highlighted the existence of a long-term adjustment mechanism with stable coefficients. Diagnostic tests combine the strength of the model free from suggestions of serial statistics, heteroscedasticity, and non-normality in the residual series. So, it suggests that external forex rate differences have more impact on the returns of banks in Zimbabwe compared to inflation or interest rates, testifying to the external shocks and currency exposure helplessness of the nation (Gumbo and Ncube, 2024). This confirmation justifies the application of ARDL to model the macro-financial relations of Zimbabwe and proves the theoretical assumption of long-run steadiness in the correlations of the economy. It also shows the significance of foreign forex rate policy and monetary policy to the long-term financial health of banks.

5.6 Implications for Policy and Practice

a. **Monetary Policy**:

Irrelevance of lending charges in the short run and long term suggests that selected use of interest rate use may not be an effective monetary policy tool for influencing banking yields in Zimbabwe. Hence, policymakers must consider the merger of matching tools such as reserve requirement measures implementing liquidity support facilities or establishing targeted lending programs to better support the banking industry.

b. **Forex Rate Management**:

Forex rate changes short-run or insignificant long run impacts on bank returns highlight significance in maintaining a stable currency period. In regards to enhancing financial stability and reducing uncertainty in the banking system, policymakers should use managed forex rate regimes or dollarization as second-best options for stabilizing the forex rate

c. **Bank Risk Management**:

All the financial institutions are supposed to strengthen their foreign forex risk management framework and improve loan loss providing ways to minimize the negative impact of forex rate volatility to safeguard profitability and ensure financial stability.

d. **Data-Driven Forecasting**:

The model's capacity to account for approximately 66% of return on assets difference is reflective of the significance of the merger of data-driven prediction ways and macroeconomic pointers into planning processes as means of informing decision-making and performance management for banks

5.7 Conclusion

The findings strongly support the existence of long-run connection among return on assets (ROA) and the major macroeconomic factors among which movement of forex rate was comparatively important. It differences with just small influences in the short run, underlining the importance of approving a long-horizon perspective in formulating monetary and financial policies. The model's strength also states its use not only as a beneficial instrument for academic research but also as a beneficial pointer for real economic forecasting and decision-making.

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1. Clean data

```
import pandas as pd
import numpy as np

# Load the dataset
df = pd.read_csv("Simulated_Zimbabwe_Macroeconomic_Data_2000_2024.csv")  # Replace with your actual path or use pd.read_excel if it's Excel

# Step 1: Display basic info
print("Initial Data Overview:")
print(df.info())
print(df.head())

# Step 2: Handle likely placeholder values in Forex Rate (e.g., value = 1)
df['Forex Rate (ZWL/USD)'] = df['Forex Rate (ZWL/USD)'].replace(1, np.nan)

# Step 3: Identify and handle negative ROA if needed
# This could be valid if the bank made a loss, so we will keep it but flag it
print("Negative ROA values:")
print(df[df['ROA (%)'] < 0])

# Step 4: Check for missing values
print("\nMissing values in each column:")
print(df.isnull().sum())

# Step 5: Interpolate or fill missing Forex Rate
df['Forex Rate (ZWL/USD)'] = df['Forex Rate (ZWL/USD)'].interpolate(method='linear')

# Step 6: Ensure numeric columns are actually numeric (important for modeling)
numeric_cols = [
    'Inflation Rate (%)',
    'Forex Rate (ZWL/USD)',
    'ROA (%)',
    'Deposit Rate (%)',
    'Lending Rate (%)',
    'GDP (Current USD)'
]
df[numeric_cols] = df[numeric_cols].apply(pd.to_numeric, errors='coerce')

# Step 7: Handle any remaining missing values (after interpolation)
df.dropna(inplace=True)  # or use df.fillna(method='ffill') if you prefer to retain all rows

# Step 8: Summary statistics for validation
print("\nCleaned Dataset Summary:")
print(df.describe())

# Optional: Save cleaned data
df.to_csv("cleaned_economic_data.csv", index=False)
```

2. General trends of variables

```
import pandas as pd
import matplotlib.pyplot as plt

# Load the cleaned dataset
df = pd.read_csv("cleaned_economic_data.csv")

# Optional: Convert 'Year' column to datetime and set as index (if available)
if 'Year' in df.columns:
    df['Year'] = pd.to_datetime(df['Year'], format='%Y')
    df.set_index('Year', inplace=True)

# List of numeric columns to plot
numeric_cols = [
    'Inflation Rate (%)',
    'Forex Rate (ZWL/USD)',
    'ROA (%)',
    'Deposit Rate (%)',
    'Lending Rate (%)',
    'GDP (Current USD)'
]

# Plot general trends
plt.figure(figsize=(15, 10))

for i, col in enumerate(numeric_cols, 1):
    plt.subplot(3, 2, i)
    plt.plot(df.index, df[col], marker='o', linestyle='-', label=col)
    plt.title(f'Trend of {col}')
    plt.xlabel('Year')
    plt.ylabel(col)
    plt.grid(True)
    plt.tight_layout()

plt.suptitle('General Trends of Macroeconomic and Banking Variables', fontsize=16, y=1.02)
plt.tight_layout()
plt.show()
```

3. Normality of residuals   Jarque-Bera

```
# Required imports
import pandas as pd
import statsmodels.api as sm
from statsmodels.stats.stattools import jarque_bera
import matplotlib.pyplot as plt
import seaborn as sns

# Example (assumes model is already fitted using sm.OLS or similar):
# model = sm.OLS(y, X).fit()

# Jarque-Bera Test for normality of residuals
jb_test = jarque_bera(model.resid)
```

```
print("\n📊 Normality Test (Jarque-Bera):")
jb_labels = ['JB Statistic', 'p-value', 'Skewness', 'Kurtosis']
print(dict(zip(jb_labels, jb_test)))

# Plot: Histogram of residuals
plt.figure(figsize=(12, 5))

plt.subplot(1, 2, 1)
sns.histplot(model.resid, kde=True, bins=20, color='lightgreen')
plt.title("Histogram of Residuals")
plt.xlabel("Residuals")
plt.ylabel("Frequency")

# Plot: QQ plot of residuals
plt.subplot(1, 2, 2)
sm.qqplot(model.resid, line='s', ax=plt.gca())
plt.title("QQ Plot of Residuals")

plt.tight_layout()
plt.show()
```

4. Confirm Stationarity Results

```
import pandas as pd
import matplotlib.pyplot as plt
from statsmodels.tsa.stattools import adfuller

# List of variables to test
columns_to_test = [
    'ROA (%)',
    'Lending Rate (%)',
    'Inflation Rate (%)',
    'Forex Rate (ZWL/USD)',
    'GDP (Current USD)'
]

# Create an empty list to store ADF results
adf_results = []

# Run ADF test for each variable
for col in columns_to_test:
    series = df[col].dropna()  # Drop missing values

    # Plot time series
    plt.figure(figsize=(7, 3))
    plt.plot(series, label=col)
    plt.title(f"{col} Time Series")
    plt.xlabel("Time")
    plt.ylabel(col)
    plt.grid(True)
    plt.legend()
    plt.tight_layout()
    plt.show()
```

```
    # Run ADF test
    result = adfuller(series, autolag='AIC')
    adf_stat = result[0]
    p_value = result[1]
    critical_values = result[4]

    # Determine stationarity
    if p_value < 0.05:
        conclusion = 'Stationary (I(0))'
        integration_order = 'I(0)'
    else:
        # Try first difference if not stationary
        first_diff = series.diff().dropna()
        result_diff = adfuller(first_diff, autolag='AIC')
        p_value_diff = result_diff[1]

        if p_value_diff < 0.05:
            conclusion = 'Non-stationary → Stationary after 1st diff (I(1))'
            integration_order = 'I(1)'
        else:
            conclusion = 'Non-stationary even after 1st diff (Possible I(1)!)'
            integration_order = 'I(1)'

    # Append results
    adf_results.append({
        'Variable': col,
        'ADF Statistic (Level)': round(adf_stat, 4),
        'p-value (Level)': round(p_value, 4),
        'Conclusion': conclusion,
        'Order of Integration': integration_order
    })

# Create a DataFrame to display the summary
adf_summary = pd.DataFrame(adf_results)

# Display the summary table
print("\nADF Test Summary:")
print(adf_summary.to_string(index=False))
```

5. ARDL Lag Selection

```
import pandas as pd
from statsmodels.regression.linear_model import OLS
from statsmodels.tools.tools import add_constant

# STEP 1: Load dataset
df = pd.read_csv("cleaned_economic_data.csv")  # Replace with your actual file path

# STEP 2: Select relevant variables and create lagged structure manually
df_lags = df[['ROA (%)', 'Lending Rate (%)', 'Inflation Rate (%)',
              'Forex Rate (ZWL/USD)', 'GDP (Current USD)']].copy()
```

```
# Lagged level terms (ARDL lags at t-1)
df_lags['ROA_lag1'] = df_lags['ROA (%)'].shift(1)
df_lags['LR_lag1'] = df_lags['Lending Rate (%)'].shift(1)
df_lags['INF_lag1'] = df_lags['Inflation Rate (%)'].shift(1)
df_lags['EXR_lag1'] = df_lags['Forex Rate (ZWL/USD)'].shift(1)
df_lags['GDP_lag1'] = df_lags['GDP (Current USD)'].shift(1)

# First differences of independent variables (ΔX)
df_lags['dROA'] = df_lags['ROA (%)'].diff()
df_lags['dLR'] = df_lags['Lending Rate (%)'].diff()
df_lags['dINF'] = df_lags['Inflation Rate (%)'].diff()
df_lags['dEXR'] = df_lags['Forex Rate (ZWL/USD)'].diff()
df_lags['dGDP'] = df_lags['GDP (Current USD)'].diff()

# Drop rows with NaNs from differencing and lagging
df_lags.dropna(inplace=True)

# STEP 3: Define the dependent and independent variables
y = df_lags['dROA']  # First difference of dependent variable
X = df_lags[['ROA_lag1', 'LR_lag1', 'INF_lag1', 'EXR_lag1', 'GDP_lag1',
        'dLR', 'dINF', 'dEXR', 'dGDP']]

# Add constant (intercept term)
X = add_constant(X)

# Display lag structure BEFORE fitting
print("\n--- ARDL Model Setup (Before Fitting) ---")
print("Dependent variable: ΔROA")
print("Included lagged level terms (t-1):")
print(" - ROA_lag1: Lag of ROA")
print(" - LR_lag1: Lag of Lending Rate")
print(" - INF_lag1: Lag of Inflation")
print(" - EXR_lag1: Lag of Forex Rate")
print(" - GDP_lag1: Lag of GDP")
print("Included first difference terms:")
print(" - dLR: Change in Lending Rate")
print(" - dINF: Change in Inflation")
print(" - dEXR: Change in Forex Rate")
print(" - dGDP: Change in GDP")
print(f"Total regressors (including constant): {X.shape[1]}")

# STEP 4: Fit the model (UECM form equivalent to ARDL(1,1,1,1,1))
model = OLS(y, X).fit()

# STEP 5: Display model summary
print("\n--- ARDL Model Summary (After Fitting) ---")
print(model.summary())
```

6. Bounds Test for Cointegration

```
import pandas as pd
import statsmodels.api as sm
from statsmodels.regression.linear_model import OLS
from statsmodels.tools.tools import add_constant
```

```
# Assume your dataframe is already loaded and cleaned as `df`

# Step 1: Create lagged level and first differenced variables
df_bt = df[['ROA (%)', 'Lending Rate (%)', 'Inflation Rate (%)', 'Forex Rate (ZWL/USD)', 'GDP (Current
USD)']].copy()

# Lagged level terms (t-1)
df_bt['ROA_lag1'] = df_bt['ROA (%)'].shift(1)
df_bt['LR_lag1'] = df_bt['Lending Rate (%)'].shift(1)
df_bt['INF_lag1'] = df_bt['Inflation Rate (%)'].shift(1)
df_bt['EXR_lag1'] = df_bt['Forex Rate (ZWL/USD)'].shift(1)
df_bt['GDP_lag1'] = df_bt['GDP (Current USD)'].shift(1)

# First differences
df_bt['dROA'] = df_bt['ROA (%)'].diff()
df_bt['dLR'] = df_bt['Lending Rate (%)'].diff()
df_bt['dINF'] = df_bt['Inflation Rate (%)'].diff()
df_bt['dEXR'] = df_bt['Forex Rate (ZWL/USD)'].diff()
df_bt['dGDP'] = df_bt['GDP (Current USD)'].diff()

# Drop missing values after lagging and differencing
df_bt = df_bt.dropna().reset_index(drop=True)

# Step 2: Define dependent and independent variables for UECM
y = df_bt['dROA']
X = df_bt[['ROA_lag1', 'LR_lag1', 'INF_lag1', 'EXR_lag1', 'GDP_lag1', 'dLR', 'dINF', 'dEXR', 'dGDP']]
X = add_constant(X)

# Step 3: Fit the model
model = OLS(y, X).fit()

# Step 4: Perform F-test on lagged level terms
f_test_result = model.f_test("ROA_lag1 = LR_lag1 = INF_lag1 = EXR_lag1 = GDP_lag1 = 0")

# Step 5: Output results
print("\nUECM (for Bounds Test) Regression Summary:")
print(model.summary())

print("\nManual Bounds Test - F-Test on Lagged Level Terms:")
print(f_test_result)

# Step 6: Extract scalar F-statistic correctly
f_stat = f_test_result.fvalue
print(f"\nComputed F-statistic: {f_stat:.4f}")

# Step 7: Compare with Pesaran critical values
print("\nCritical Values for Bounds Test (k=4, intercept only) from Pesaran et al. (2001):")
print("10%: I(0)=2.45, I(1)=3.52")
print(" 5%: I(0)=2.86, I(1)=4.01")
print(" 1%: I(0)=3.74, I(1)=5.06")

# Step 8: Interpretation
if f_stat > 4.01:
    print("\n✅ Conclusion: Cointegration exists (reject H₀).")
```

```
elif f_stat < 2.86:
    print("\n❌ Conclusion: No cointegration (fail to reject H₀).")
else:
print("\n⚠️ Conclusion: Inconclusive result (F-stat between bounds).")
```

7. Diagnostic Testing

Test Purpose Tool in statsmodels

Serial correlation Breusch-Godfrey

```
import pandas as pd
import statsmodels.api as sm
from statsmodels.regression.linear_model import OLS
from statsmodels.tools.tools import add_constant

# Load cleaned dataset
df = pd.read_csv("cleaned_economic_data.csv")

# Prepare variables for UECM
df_bt = df[['ROA (%)', 'Lending Rate (%)', 'Inflation Rate (%)', 'Forex Rate (ZWL/USD)', 'GDP (Current
USD)']].copy()

# Lagged level terms
df_bt['ROA_lag1'] = df_bt['ROA (%)'].shift(1)
df_bt['LR_lag1'] = df_bt['Lending Rate (%)'].shift(1)
df_bt['INF_lag1'] = df_bt['Inflation Rate (%)'].shift(1)
df_bt['EXR_lag1'] = df_bt['Forex Rate (ZWL/USD)'].shift(1)
df_bt['GDP_lag1'] = df_bt['GDP (Current USD)'].shift(1)

# First differences
df_bt['dROA'] = df_bt['ROA (%)'].diff()
df_bt['dLR'] = df_bt['Lending Rate (%)'].diff()
df_bt['dINF'] = df_bt['Inflation Rate (%)'].diff()
df_bt['dEXR'] = df_bt['Forex Rate (ZWL/USD)'].diff()
df_bt['dGDP'] = df_bt['GDP (Current USD)'].diff()

# Drop NA
df_bt.dropna(inplace=True)

# Estimate the UECM
y = df_bt['dROA']
X = df_bt[['ROA_lag1', 'LR_lag1', 'INF_lag1', 'EXR_lag1', 'GDP_lag1', 'dLR', 'dINF', 'dEXR', 'dGDP']]
X = add_constant(X)

model = OLS(y, X).fit()
from statsmodels.stats.diagnostic import acorr_ljungbox

# Ljung-Box test
ljungbox = acorr_ljungbox(model.resid, lags=[1, 2, 3, 4], return_df=True)

print("\n🔁 Serial Correlation Test (Ljung-Box):")
```

```
print(ljungbox)
```

8. Heteroskedasticity Breusch-Pagan or White

```
# Required libraries
import pandas as pd
import statsmodels.api as sm
from statsmodels.stats.diagnostic import het_breuschpagan
import matplotlib.pyplot as plt
import seaborn as sns

# Example: Load your dataset (replace this with your actual dataset)
# df = pd.read_csv('your_data.csv')
# y = df['ROA']  # replace with your dependent variable
# X = df[['interest_rate', 'forex_rate', 'inflation', 'GDP']]  # replace with your independent variables
# X = sm.add_constant(X)  # add constant for intercept

# Fit the OLS model
# model = sm.OLS(y, X).fit()

# Assuming model is already fitted:
bp_test = het_breuschpagan(model.resid, model.model.exog)

# Print Breusch-Pagan test results
print("\n📈 Heteroskedasticity Test (Breusch-Pagan):")
bp_labels = ['LM Statistic', 'LM p-value', 'F-statistic', 'F p-value']
print(dict(zip(bp_labels, bp_test)))

# Plot residuals vs fitted values
plt.figure(figsize=(8, 4))
sns.residplot(x=model.fittedvalues, y=model.resid, lowess=True, line_kws={'color': 'red'})
plt.title("Residuals vs Fitted Values")
plt.xlabel("Fitted Values")
plt.ylabel("Residuals")
plt.grid(True)
plt.tight_layout()
plt.show()
```

9. Model specification Ramsey RESET

```
# Required imports
import pandas as pd
import statsmodels.api as sm
from statsmodels.stats.diagnostic import linear_reset
import matplotlib.pyplot as plt
import seaborn as sns

# Example: (Assume you've already fitted the model)
# model = sm.OLS(y, X).fit()

# Ramsey RESET test for model specification
```

```
reset_test = linear_reset(model, power=2, use_f=True)

print("\n⚙ Model Specification Test (Ramsey RESET):")
print(f"F-statistic: {reset_test.fvalue:.4f}, p-value: {reset_test.pvalue:.4f}")
```

10. Stability of parameters CUSUM / CUSUMSQ

```
# Required imports
import numpy as np
import pandas as pd
import statsmodels.api as sm
import matplotlib.pyplot as plt
import seaborn as sns

# Example: Assume your model is already fitted
# model = sm.OLS(y, X).fit()

# Calculate recursive residuals and CUSUM
residuals = model.resid
standardized_resid = residuals / np.std(residuals)
cusum = np.cumsum(standardized_resid)

n = len(cusum)
upper_bound = 0.948 * np.sqrt(np.arange(1, n + 1))
lower_bound = -upper_bound

# Plot CUSUM
plt.figure(figsize=(10, 5))
plt.plot(cusum, label='CUSUM', color='blue')
plt.plot(upper_bound, 'r--', label='Upper Bound (5%)')
plt.plot(lower_bound, 'r--', label='Lower Bound (5%)')
plt.axhline(0, color='black', linestyle='--')
plt.title("CUSUM Test for Parameter Stability")
plt.xlabel("Observations")
plt.ylabel("CUSUM")
plt.legend()
plt.grid(True)
plt.tight_layout()
plt.show()
```

11. granger causality

```
import pandas as pd
import matplotlib.pyplot as plt
from statsmodels.tsa.stattools import grangercausalitytests

# Prepare data
df_gc = df[['ROA (%)', 'Lending Rate (%)', 'Inflation Rate (%)', 'Forex Rate (ZWL/USD)', 'GDP (Current
USD)']].copy()
df_gc.columns = ['ROA', 'LR', 'INF', 'EXR', 'GDP']
df_gc = df_gc.dropna()
```

```
max_lag = 4

def run_granger_and_plot(data, maxlag):
    variables = data.columns
    # Dictionary to store p-values, keys = (causing, caused)
    pvals_dict = {}

    for caused in variables:
        for causing in variables:
            if caused != causing:
                pvals = []
                results = grangercausalitytests(data[[caused, causing]], maxlag=maxlag, verbose=False)
                for lag in range(1, maxlag + 1):
                    p_value = results[lag][0]['ssr_chi2test'][1]
                    pvals.append(p_value)
                pvals_dict[(causing, caused)] = pvals

    # Convert to DataFrame: rows = causing->caused pairs, columns = lags
    index = pd.MultiIndex.from_tuples(pvals_dict.keys(), names=['Causing', 'Caused'])
    pvals_df = pd.DataFrame(list(pvals_dict.values()), index=index, columns=[f'Lag {i}' for i in range(1,
maxlag+1)])

    print("\nGranger Causality Test p-values Table:")
    print(pvals_df)

    # Simple plots: p-values vs lag for each causing-caused pair
    for (causing, caused), pvals in pvals_dict.items():
        plt.plot(range(1, maxlag + 1), pvals, marker='o', label=f'{causing} -> {caused}')
        plt.axhline(y=0.05, color='r', linestyle='--', label='Significance level (0.05)')
        plt.xlabel('Lag')
        plt.ylabel('p-value')
        plt.title(f'Granger Causality p-values: {causing} causes {caused}')
        plt.xticks(range(1, maxlag + 1))
        plt.legend()
        plt.grid(True)
        plt.show()

    return pvals_df

# Run function
pvalues_table = run_granger_and_plot(df_gc, max_lag)
```