College of Business and Economics

Determinants of Banks Liquidity and Its Impact on Profitability on Selected Banks in Ethiopia.

A Thesis Report Submitted to the Department of Economics in Partial Fulfilment of the Requirements for a Degree of Master of Science in Financial Economics.

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December, 2024

Addis Ababa, Ethiopia.

Declaration

I, Eyob Gezahegn, thus confirm that I have independently conducted a research study entitled" Determinants of Banks Liquidity and Its Impact on Profitability on Selected Banks in Ethiopia" in partial fulfillment of the requirements for the Master of Science (M.Sc.) degree in Financial Economics.

I assert that this study is my original work and has not been submitted for any degree or diploma at this or any other institution. All referenced materials used in this research have been duly acknowledged.

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Acknowledgment

First and foremost, I would like to express my deepest gratitude to the almighty God for guiding me through this research journey and granting me the health and perseverance needed to complete it.

I am profoundly grateful to my advisor, whose insightful comments and unwavering support have been invaluable. His encouragement allowed me the freedom to explore and develop my research at my own pace.

Lastly, I wish to acknowledge all the individuals who have supported me, directly or indirectly, throughout this process. Your assistance and encouragement have been instrumental in helping me reach this milestone.

Abstract

The "Determinants of Banks Liquidity and Its Impact on Profitability in Selected Banks in Ethiopia" are reviewed in this paper, which covers the period from 2002 to 2022. The study uses both fixed effect and random effect panel data regression models to assess the factors influencing key financial ratios, such as the Loan to Deposit Ratio (LDR) and Liquid Asset to Total Asset Ratio (LATA), using a comprehensive dataset obtained from audited financial statements of sampled banks. Descriptive statistics indicate conservative lending practices and strong liquidity management among these banks, with notable variability observed across different financial metrics. The correlation analysis reveals there is moderately positive association between liquidity (measured by LATA) and profitability (measured by Return on Assets, ROA), suggesting that higher liquidity corresponds with increased profitability. Conversely, there is a significant positive correlation between LDR and Net Interest Margin (NIM), suggesting that effective asset-liability management enhances profitability. Panel unit root tests ensure the variables' stationarity post-differencing, thereby guaranteeing reliable regression outcomes. Model diagnostics, including tests for multicollinearity, normality, heteroscedasticity, and autocorrelation, validate the robustness of the regression models. The results underscore the importance of capital adequacy and effective asset-liability management in enhancing bank performance. This research contributes to the existing studies by providing nuanced insights into the financial trends with in the Ethiopian banking industry and offers practical implications for policymakers and banking professionals.

Table of Contents

List of Tables

List of Acronyms

AADR: Average annual deposit rate
AALR: Average annual lending rate
AIB: Awash International Bank
BIS: Bank for International Settlement
BB: Berhan Bank
BLUE: Best linear unbiased estimator
BUIB: Buna International Bank
BOA: Bank of Abyssinia
CAP: Capital adequacy
CBE: Commercial Bank of Ethiopia
Coop: Cooperative Bank of Oromia
CBRC: China Banking Regulatory Commission
CI: Condition Index
CLRM: Classical Linear Regression Model
DB: Dashen Bank
DBE: Development Bank of Ethiopia
FEM: Fixed Effect Model
GDP: Gross domestic Product
INF: general inflation rate
IRM: Interest rate margin
LG: Loan growth
LIB: Lion International Bank
LOLR: Lender of last resort
MoFED: Ministry of Finance and Economic Development
NBE: National Bank of Ethiopia
NIB: Nib International Bank
NPL: Non-performing loans
OIB: Oromiya International Bank
OLS: Ordinary Least Square
REM: Random Effect Model
ROA: Return on Assets
STIR: Short-term interest rate
UB: United Bank
VIF: Variance inflation factor
WB: Wogagen Bank
ZB: Zemmen Bank

Chapter One

1. Introduction

1.1 Background of the Study

The banking industry forms the backbone of the financial sector, playing a critical role in economic stability and development, particularly in emerging economies. Through financial intermediation and monetary policy transmission, banks support economic growth by channeling funds from savers to investors. A robust and sound banking sector enhances a nation's economic health and vitality, while instability or corruption in the sector can lead to severe economic consequences. This balance between liquidity and profitability is crucial for ensuring the resilience of financial institutions and the broader economy.

In Ethiopia, the banking sector is a vital component of the national economy. Proclamation 592 of 2008 emphasizes the sector's role in mobilizing resources for economic development. However, Ethiopian banks face unique challenges, including balancing regulatory liquidity requirements with the need to generate profits. This dynamic is particularly important as the sector continues to expand, with 25 banks operating by June 2022, according to the National Bank of Ethiopia (NBE).

Profitability and liquidity are crucial for effective financial intermediation, since the two variables reflecting the health of the banking sector. Bank for International Settlements (BIS, 2008) defines liquidity as the ability of a bank to increase assets and meet obligations without incurring losses. Proper liquidity management is essential for banks, as emphasized by the Basel Committee (2009), noting that a commercial bank's capacity to remain operational depends on its liquidity levels.

The global financial crisis highlighted the importance of liquidity for the functioning of both the banking sector and the financial market (Vodova, 2013). Profitability, calculated as the difference between operational expenses and income, is crucial for long-term business survival (Nuhiu et al., 2017). Therefore, the bank's activities must be conducted in a way that is consistent with generating profits to preserve the bank's viability and to give shareholders monetary gains or increases in the market price per share.

Maximum safety, or to put it simply, liquidity, can only be obtained if banks hold a large amount of cash or other liquid assets in comparison to the deposits they have received. However, if they do this, the banks will not make any money. Therefore, if the bank chooses the highest level of safety, it will have to forgo its goal of profitability, which is to pay dividends in accordance with

shareholder demands. Conversely, Conversely, prioritizing investments for higher returns can strain liquidity, especially during economic downturns. For Ethiopian banks, managing this trade-off is particularly challenging due to the dynamic regulatory environment and economic uncertainties. Poor liquidity management can lead to insolvency or diminished profitability, harming shareholder value and potentially destabilizing the broader financial system.

1.1.1 The Banking Industry of Ethiopia

Ethiopia's financial sector includes banks, insurance companies, and microfinance institutions. Modern banking began with the establishment of the Bank of Abyssinia in 1905 under Emperor Menelik II. This institution marked Ethiopia’s entry into international finance, with shares traded in major global cities like Addis Ababa, New York, and London (NBE, 2010).

The banking sector evolved significantly under Emperor Haile Selassie, who restructured the Bank of Abyssinia into the state-owned Bank of Ethiopia in 1931. After the Italian occupation (1936-1941), Ethiopia established the State Bank of Ethiopia in 1943, which operated both commercial and central banking functions. By 1963, the National Bank of Ethiopia and the Commercial Bank of Ethiopia were formed as distinct entities.

During the Derg regime (1974-1991), the command economy led to the nationalization and consolidation of private banks into a single state-owned entity. However, the liberalization of the banking sector began in 1991, fostering competition and growth. The Licensing and Supervision of Banking Business Proclamation No. 84/1994 introduced minimum capital requirements and capital adequacy standards, setting the stage for a more robust financial system.

As of June 2022, Ethiopia had 25 banks, 18 insurance companies, and 43 microfinance institutions (NBE, 2021/2022). The banking sector has expanded rapidly, with banks adding 1,600 new branches, increasing the total to 8,944. Private banks account for 76.1% of this network, reflecting their growing dominance. Despite this progress, significant challenges remain in balancing liquidity and profitability to ensure sustainable growth.

1.2 Statement of the Problem

Liquidity and profitability are fundamental aspects of banking operations, crucial for ensuring financial stability and long-term success. Globally, banks face the challenge of balancing these two elements, as effective liquidity management supports operational resilience, while profitability ensures sustainable growth.

After the financial crisis of 2007, liquidity risk has emerged as a major global concern for financial institutions. The global financial crisis has shown the importance of maintaining a level of liquidity high enough to cope with adverse situations.

In the Ethiopian banking sector, this balance is particularly challenging due to regulatory requirements, economic volatility, and the sector's evolving nature. Proclamation 592 of 2008 underscores the importance of liquidity management, but the impact of these practices on profitability remains unclear. This complexity is heightened by the absence of a secondary market and limited investment options, making liquidity management even more critical. This brings up an important query: what variables define the ideal level of liquidity for a bank?

Previous studies have examined various factors influencing liquidity and profitability, but their findings are often inconsistent and context-specific. For instance, research by Berhanu (2015) and Nigist (2015) has highlighted bank-specific factors such as capital adequacy, bank size, and non-performing loans. These studies identify key internal determinants of liquidity but do not provide conclusive insights into their impact on profitability. Similarly, Zelalem (2020) investigated macroeconomic factors like GDP growth and inflation, emphasizing their influence on liquidity. However, the complex interplay between these macroeconomic variables and profitability in Ethiopian banks remains underexplored.

The core issue facing Ethiopian banks is the challenge of balancing liquidity and profitability. Maintaining high liquidity ensures operational stability but often limits profitability, as excess liquid assets generate lower returns. Conversely, prioritizing profitability through aggressive lending can strain liquidity, increasing the risk of insolvency, especially during economic downturns. Despite the critical importance of this balance, the specific relationship between liquidity and profitability in Ethiopian banks has not been clearly articulated in the existing literature.

Despite the inconsistent finding in previously mentioned for comparable studies, the debate concerning the correlation between banks' profitability and liquidity, whether it is positive or negative remains unsettled in the literature, which promote further investigation, especially in the context of Ethiopia. To the researcher's knowledge, apart from Berhanu (2015) and Zelalem (2020), majority of earlier research have concentrated on the variables that independently affect profitability or liquidity. This study fills this gap by examining the variables influencing bank liquidity and its relationship to banks' profitability in a single analysis.

To this end, the research will address the following question

1- What are the bank-specific determinant variables that affect liquidity in Ethiopian commercial banks?
2- What macroeconomic factors impact commercial bank's liquidity in Ethiopia?
3- How does commercial banks' liquidity affect their profitability?

1.3 Objective of the Study

1.3.1 General Objective

The primary goal of the research is to determine the internal and external variables affecting liquidity of commercial banks and assess how this liquidity has an impact on profitability.

1.3.2 Specific Objectives

The study's specific goal is to accomplish three things:

1. To find bank-specific drivers of Ethiopian commercial banks liquidity.
2. To determine the macroeconomic factors that affect liquidity of commercial banks in Ethiopia.
3. To examine how liquidity influences bank profitability.

1.4 Scope of the Study

The scope of this paper is limited to examining the variables affecting Ethiopian commercial banks' liquidity and how this liquidity impact on their profitability. Although there are two officially state-owned and twenty-three privately held commercial banks in Ethiopia, the analysis focuses on seven banks with over two decades of operational experience, using financial data from 2002 to 2022. The study considers both bank-specific and macroeconomic variables were considered to provide a comprehensive assessment.

1.5. Significance of the Study

This paper seeks to integrate macroeconomic indicators with bank/industry-specific factors to analyze their substantial influence on commercial banks' liquidity and its subsequent effect on profitability. By elucidating this relationship, the research seeks to empower bankers with a deeper understanding, enabling them to effectively navigate the delicate balance between liquidity and profitability to achieve strategic business objectives and optimize the performance of banks. Ultimately, the insights garnered from this study not only benefit financial industry but also the broader economy and society at large.

1.5 Limitation of the study

1- The findings of this study may not be fully generalizable to newer or smaller banks due to differences in operational scale and maturity.

2- While key bank-specific and macroeconomic variables were analyzed, other influential factors, such as political instability, economic fluctuations, technological advancements, and customer behavior were not examined.

3- The study relies on historical financial data, which may not fully reflect recent market dynamics or emerging trends.

1.6. Organization of the study

There are four chapters in this study report. Chapter 1 provides an overview of the entire study. A thorough analysis of relevant literature is covered in Chapter 2. Chapter 3 describes the study methodology in depth. Chapter 4 covers data presentation, analysis, and interpretation. Additionally, this chapter offers a pertinent conclusion and suggestions in light of the data.

Chapter Two

2. Review of Related Literature

2.1 Theoretical Framework

Numerous studies have looked the factors that affect banks' profitability across different nations. Majority of these researches focus on either a single nation or a group of countries and consider both internal factors (such as bank-specific attributes) and external factors (like industry-specific and economic environment conditions). Numerous explanatory factors were proposed for both groups, based on the nature and goals of each study.

Liquidity refers to a bank's capacity to satisfy customer needs and offer loans and overdrafts. It also encompasses the cash and cash equivalents that banks held, such as treasury bills and commercial paper.

Liquidity risk often results from banks' essential role in converting short-term deposits into long-term loans. According to the Basel Committee's joint forum (2006), banks encounter two main types of liquidity risk: funding liquidity risk and market liquidity risk. Funding liquidity risk refers to the possibility that a bank may struggle to meet both expected and unexpected cash flow and collateral demands in a timely manner, without compromising its financial stability or ongoing operations. On the other hand, market liquidity risk pertains to the possibility that a bank might be unable to rapidly offset or liquidate a position at the prevailing market price due to insufficient market depth or disruptions. An asset that is presently regarded as liquid in the market may not have always been, and it might not consistently remain liquid in the future. The level of market liquidity can be influenced by factors such as market concentration and information asymmetry.

The interaction between funding liquidity risk and market liquidity risk is particularly strong during periods of crisis (Brunnermeier, 2009). A bank holding highly liquid assets in the market will typically have sufficient funding liquidity as long as it remains financially sound. However, even a financially sound bank can struggle to meet its short-term obligations if there are shifts in market liquidity. For instance, in the event that a sizable amount of a bank's assets abruptly loses market liquidity, the bank could find it difficult to fulfil its immediate obligations, which could result in financial hardship. This scenario reflects the challenges faced by numerous financial institutions in 2007 when previously active market for mortgage-backed securities collapsed.

This situation underscores the crucial role that liquidity plays in market operations and the banking sector, emphasizing the connections between funding and market liquidity risks.

According to the study conducted by Kashyap et al. (2002) underscore the critical role of banks' ability to provide liquidity, emphasizing that synergies should exist between their deposit-taking and lending activities. These synergies show how deposits and loan obligations are safeguarded by holding liquid assets as collateral to meet withdrawal demands. The relationship between systemic banking crises and lack of liquidity is thoroughly examined by Diamond & Rajan (2005). They proposed that if one bank fails, the quantity of readily available liquidity might potentially lower to the point that it may have a domino effect on other banks.

2.1.1 Measurements of Liquidity Risk

Liquidity risk defined as the possibility that a financial entity may face difficulties to fulfill its obligations promptly at a reasonable cost. Essentially, it signifies the chance that the entity may encounter funding difficulties within a specific timeframe. The financial crisis (2007-2009) underscores the critical importance of managing liquidity risk. Bank regulators now require that institutions create and routinely test formal contingency financing strategies. Factors such as the number of depositors, average account size, depositor location, and particular maturity and rate characteristics of each account are only a few of the variables that affect the liquidity risk related to a bank's deposit base. To address this risk, banks maintain reserves of highly liquid assets including cash and government securities to ensure they can meet their depositors' demands within the required timeframe.

Frameworks for managing liquidity risk are being strengthened on a national and international level. The Basel Committee on Banking Supervision (BCBS) leads these initiatives, introducing the Basel III framework, which sets both short-term and long-term liquidity standards aimed at enhancing the resilience of banks to liquidity risks (BCBS, 2010; BCBS, 2013). The Liquidity Coverage Ratio (LCR) mandates that financial institutions maintain sufficient high-quality liquid assets to cover net cash outflows over a 30-day stress period. In contrast, the Net Stable Funding Ratio (NSFR) focuses on promoting stable, long-term funding structures. Additionally, BCBS (2013) mandates detailed disclosures by banks regarding their compliance with these liquidity requirements. Moreover, The European Union formed the European Systemic Risk Board (ESRB), which began operations in January 2011, in reaction to the 2008 financial crisis. Its principal objective is to detect and manage risks that may endanger financial stability and have

an effect on the actual economy. The ESRB can offer warnings and recommendations to address systemic risks to financial stability within the EU, addressing both the EU as a whole and specific Member States (ESRB, 2013).

Liquidity concerns may be attributed to three primary factors. The first involves the liabilities side of the balance sheet, where the number of deposits withdrawn or the renewal of rolled-over interbank loans are highly unpredictable, particularly in cases where the bank is suspected in engaging in suspicious behavior. The second is on the asset side of the balance sheet, where the amount of future loan requests that the bank may receive are unpredictable. The third is off- balance sheet activity, such as credit lines and other commitments, derivative market positions (Rochet, 2008).

Therefore, there are three methods that banks may employ to protect themselves from liquidity crises. First, to lower the likelihood of liquidity issues jeopardizing the stability of the bank, banks maintain a reserve of liquid assets on the asset side of the balance sheet, such as cash, balances with other banks, government-issued debt instruments, and reverse repo deals. The second method is focused on the liabilities side of the balance sheet. Banks can borrow from other banks on the interbank market if they need liquidity; nevertheless, this strategy is closely associated with market liquidity risk. The third approach also addresses the liabilities side, where the central bank often acts as a lender of last resort (LOLR) to provide emergency liquidity support to specific illiquid institutions and ensure overall liquidity in the system during a widespread liquidity shortfall (Aspachs et al., 2005).

Therefore, measures of banks' liquidity positions aid in determining their actual liquidity risk exposures and in implementing the necessary liquidity risk management strategies, which are essential for the bank's proper and profitable operation.

There are two fundamentally conventional ways of calculating liquidity risk: the liquidity gap/flow approach and the liquidity ratios/stock approach. The liquidity gap/flow method measures the difference between assets and liabilities in both current and future periods. When assets exceed liabilities, there is a surplus; however, when liabilities exceed assets, a deficit occurs, which needs to be covered. This method helps to determine the necessary reserves by comparing the fluctuations in the bank's inflows and outflows over a specific period. Essentially, the flow approach views liquid reserves as a buffer, allowing the bank to measure its liquidity

risk by analyzing fluctuations in inflows and outflows to estimate the required reserve amount for a given period.

The second method for assessing liquidity risk is the liquidity ratio/stock technique, which uses ratios to identify trends in liquidity and is centered on both the asset and liability sides of the balance sheet. These ratios show that banks should take steps to ensure that suitable and affordable funding is readily available. Keeping a portfolio of readily liquid assets, such as government securities, cash reserves, or the minimum required reserves, holding sizeable amounts of stable liabilities, particularly deposits from retail customers, or keeping credit lines open with other financial institutions are some examples of these actions (Moore,2009).

Each method for assessing liquidity risk has its own limitations. The liquidity gap or flow approach requires more data and lacks a standardized method for predicting inflows and outflows. On the other hand, the liquidity ratio or stock approach, while simpler to calculate and interpret using publicly available data from banks' balance sheets, may not fully capture liquidity risk. Despite this drawback, the stock approach is more commonly used in both practical applications and academic research due to its standardized methods. According to Crosse and Hempel (1980), commonly used stock ratios include liquid assets to deposits, loan-to-deposit ratio, and liquid assets to total assets ratio. A higher loan-to-deposit ratio indicates lower liquidity, but both ratios have limitations. The loan-to-deposit ratio overlooks other assets convertible into cash, while the liquid assets ratio overlooks fund flows from repayments and changes in liabilities. However, these ratios generally exhibit parallel trends. For this study's objectives, the liquidity ratio or stock approach will be utilized over the flow or liquidity gap approach.

2.1.2 Measurement of Profitability

The profitability of banks holds significant importance for various stakeholders including creditors, owners, employees, and management. Key metrics commonly employed to assess bank profitability include Return on Asset (ROA), Return on Equity (ROE), and Net Interest Margin (NIM).

A bank's return on assets (ROA) is determined by dividing its net income or profit after tax to its total assets, indicating how well the bank uses its assets to generate profits. Alternatively, dividing net income by average total assets can be used to calculate it. Researchers who have used the ratio of net income to total assets (ROA) assessment include Ramlall (2009), Flamini et

al. (2009), Gul et al. (2011), Khrawish et al. (2011), and Soyemi et al. (2013). Conversely, scholars like Srairi (2009) and Sufian (2011) have opted for the net income to average total assets ratio.

ROE, representing a measure of bank's profitability in relation to its shareholders' equity, can be calculated by dividing net income or profit after tax by total common stock equity. Similarly, it can also be calculated by dividing net income by the average amount of equity in common stock. Researchers such as Ali et al. (2011) and Aminu (2013) have utilized the net income to total common stock equity ratio for ROE evaluation, while Sufian (2011) has employed the net income to average total common stock equity ratio.

The Net Interest Margin (NIM), which is calculated by dividing net interest revenue by the total number of assets or by the average of all interest-earning assets, indicates a bank's capacity to generate interest from its interest-earning assets. Scholars like Gul et al. (2011) and Soyemi et al. (2013) have used the net interest income to total assets ratio to assess NIM.

2.1.3 Bank Liquidity and Profitability

As observed by Rauch et al. (2008) and Shen et al. (2010), profitability is a key factor in determining how improved financial stability will affect a bank's ability to undertake liquidity changes and its capacity to bear risk. According to Athanasoglou et al. (2005), a healthy and prosperous banking sector is more resilient to unfavorable shocks and contributes to overall financial system stability.

Loans and advances represent one of the most lucrative assets for banks, constituting a major portion of their operational revenue. However, they also expose banks to liquidity risks since they rely on customer deposits. While extending more loans and advances can boost a bank's interest income and profit margin, it can also negatively impact the bank's liquidity. As a result, banks must carefully manage the balance between liquidity and profitability.

Different research offers contrasting perspectives regarding the correlation between profitability and liquidity. According to Bourke (1989), banks with higher liquid assets levels give a positive impression in the funding markets, which lowers financing costs and boosts profitability. However, banks that maintain liquid assets incur opportunity costs, according to Molyneux and Thornton (1992) and Goddard et al. (2004), which may have a detrimental effect on their profitability. The disadvantages of higher liquidity for financial firms have been pointed out by Myers and Rajan (1998). They highlight that while it enhances to collect money more quickly, it

can also make it more difficult for management to commit to credible investment plans, which could make it harder for the business to get outside funding. Here, maintaining a balance between liquidity and profitability is crucial because they are mutually exclusive. This is how profitability and liquidity are compromised.

2.2 Empirical Evidence

Numerous investigations into the factors influencing the liquidity of commercial banks worldwide have been conducted, given the importance of liquidity as a key concern for banks. Due to the vast number of studies conducted, it is challenging to summarize all findings. Therefore, this research narrows down to studies closely related to the subject, categorizing them into global data, data on Africa, and data on Ethiopia.

2.2.1 Related Empirical Evidence on a Worldwide Basis

To determine the key variables impacting the liquidity of Czech commercial banks, Vodová (2011) conducted a study using panel data regression analysis. The research examined bank- specific and macroeconomic data from 2001 to 2009, considering four firm-specific and eight macroeconomic independent variables affecting bank liquidity. The variables included the share of nonperforming loans as a percentage of total loans, bank profitability, GDP growth, loan interest rates, interest rate margin, monetary policy interest rate/repo rate, unemployment rate, and a dummy variable for the 2009 financial crisis were expected to negatively affect liquidity. Factors like capital adequacy, inflation rate, and interbank/money market interest rate were expected to positively affect liquidity. Liquidity ratios, such as liquid assets to total assets, liquid assets to total deposits and borrowings, loans to total assets, loans to deposits, and short-term financing, were used to measure the dependent variable (commercial bank liquidity).

The study conducted by Bordeleau & Graham (2010) provided empirical data on the correlation between group of American and Canadian banks' profitability from 1997 to 2009. In summary, the results revealed that retaining specific liquid assets and profitability had a nonlinear relationship. Beyond a certain point, an increase in liquid assets can diminish profitability, although it may lower liquidity risk, which the markets rarely reward. However, this advantage can eventually be outweighed by the opportunity cost of retaining low-yielding liquid assets. The study also found that the relationship between liquid assets and profitability can be influenced by

a bank's business strategy and the difficulties in the funding markets. Experts suggest that banks could enhance earnings by focusing a more conventional approach that relies more on loans and deposits, while maintaining fewer liquid assets.

The study by Moore (2009 looked into how the financial crisis impacted commercial banks' liquidity in Latin America and the Caribbean, aiming to understand how crises affect bank liquidity, identify key influencing variables, and determine whether liquidity during crises aligns with economic fundamentals. The research found that Customer cash needs, measured by changes in the cash-to-deposit ratio, were found to negatively affect liquidity. Liquidity was also influenced by the loan-to-deposit ratio, macroeconomic conditions, and short-term interest rates as opportunity costs. The study utilized ordinary least squares regression to reveal that liquidity is significantly and negatively affected by the fluctuations of the cash-to-deposit ratio and money market interest rates. However, in many countries, liquidity was found to be inversely related to the business cycle, suggesting that banks tend to maintain higher reserves during economic downturns.

The impact of interest rates on banks' willingness to take on risk and their choice to retain liquidity across European countries was empirically investigated by Lucchetta (2007). It analyzed factors such as the interbank rate, which serves as an indicator of banks' incentives to maintain liquidity, the monetary policy interest rate, which assesses lending capabilities, the bank's behavior on the interbank market; the more liquid the bank is, the more it lends there-and the ratios of loans to total assets and loan loss provisions to net interest revenues, which serve as risk indicators. Liquid banks should curb their customers' risk-taking, and banks' size relies on the logarithm of its total assets. According to the study's findings, banks' ability to maintain liquidity and their choice to participate as lenders in the interbank market are both negatively impacted by the risk-free interest rate. Conversely, the interbank interest rate has a favorable impact on such choices. The smaller, riskier banks are typically the ones who lend in the interbank markets. The risk-free interest rate, meanwhile, is connected favorably with bank risk- taking and loan investment.

2.2.2 Empirical Evidence in Africa

Research conducted by Chagwiza (2014) on Zimbabwe's commercial banks' liquidity, analyzing data from January 2010 to December 2011. The study aimed to identify factors influencing bank liquidity through regression analysis. The findings indicated that bank liquidity in Zimbabwe

was positively correlated with specific firm-related factors, such as capital adequacy, total assets (TOA), GDP, and the bank rate. Conversely, macroeconomic variables such as the business cycle, inflation rate, and acceptance of different currencies have a negative effect on liquidity.

A study conducted by Lartey et al. (2013) examined how liquidity and profitability are related for banks listed on the Ghana Stock Exchange. The research, which used a time series analysis from 2005 to 2010, found a slight positive correlation between liquidity and profitability, although both had decreased during the study period.

In Nigeria, Fadare (2011) examined the primary factors influencing banking liquidity and the relationship between these factors and financial frictions in the economy. Using a linear least squares model with data from 1980 to 2009, the study identified the liquidity ratio and lagged loan-to-deposit ratio as significant predictors of banking sector liquidity. The research also highlighted that a decrease in the current loan-to-deposit ratio could be attributed to falling monetary policy rates, reduced production volatility, and decreased cash demand.

2.2.3 Related Empirical Studies in Ethiopia

Factors impacting the profitability of banking industries in Ethiopia were examined by (Abera, 2012), focusing on macroeconomic, industry-specific, and bank-specific elements across eight commercial banks from 2000 to 2011. The study used mixed methods, including interviews and documentary analysis. Findings showed a significant impact of liquidity on profitability, with a negative correlation observed.

Using data from eight commercial banks in Ethiopia between 2000 and 2011, Tseganesh (2012) identified factors that influence bank liquidity and examined the association between liquidity and financial performance. The study found that non-performing loans (NPL) and short-term interest rates (STIR) negatively impacted bank performance, leading to reduced loan provision and profitability. Additionally, the research highlighted that while non-performing loans and short-term interest rates increased liquid assets, they negatively affected the return on assets (ROA).

A stduy conducted by Semu (2010) to determine how limiting or cutting loan distribution might affect Ethiopian banks' performance. It also makes an effort to examine the causes of lending

restrictions or cuts by banks. The study used a quantitative methodology, namely, a survey design approach. The study's conclusions demonstrated that capital and deposits were positively correlated with banks' return on equity (ROE) performance. Relationships exist between new loans and liquidity and bank performance as assessed by return on assets (ROA) and return on equity (ROE). However, the association was shown to be statistically negligible. The performance of banks as measured by ROA has no statistically meaningful association with deposit or capital levels. According to the report, banks may need to utilize their cash to buy bonds and treasury bills when they have trouble lending. Banks also need to create noninterest earning services. Banks should use whatever extra capital they have on hand to diversify their lending offerings and prevent inefficiencies.

2.3 Summary and Knowledge Gap

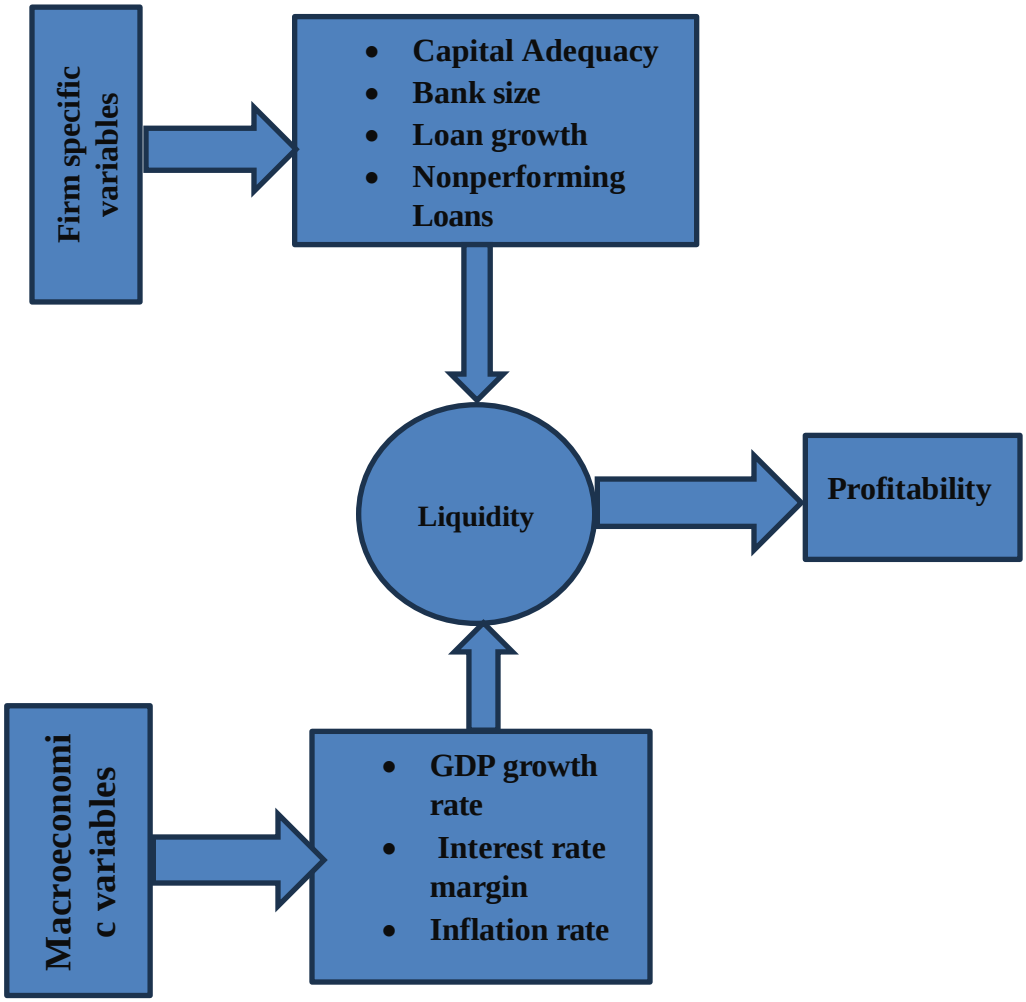
The literature review highlights that liquidity is vital for all businesses, especially within the banking sector, where it affects both the asset and liability sides of balance sheets. The studies also showed that a variety of variables, including bank-specific, macroeconomic, and regulatory issues, might affect a bank's liquidity. The impact of bank liquidity on financial performance and various bank-specific and macroeconomic factors affecting liquidity were central topics in this study.

Despite the theoretical consensus on bank liquidity, there is a notable gap in empirical literature concerning liquidity and its evaluation. The majority of empirical researches on bank liquidity was carried out aftermath of the U.S. subprime mortgage crisis. Although the fact that the global financial crisis once again highlighted the significance of liquidity for banking sector operations and financial market activities, there is a sizable vacuum in the empirical literature on liquidity and its evaluation. As per the aforementioned studies, both bank-specific factors (such as bank size, profitability, capital adequacy, and indicators reflecting the bank's risk position) and macroeconomic factors (including various interest rates and economic environment indicators) and central bank policies influence the liquidity status of commercial banks.

Furthermore, only a limited number of studies have examined liquidity as a potential predictor of bank profitability, with inconsistent findings. As far as the researcher is aware, limited empirical research has been done on the variables affecting bank liquidity and its impact on financial

performance in Ethiopia. Given the expansion of the banking sector and the lack of a functional secondary stock exchange, it is essential to inform the public about the key factors affecting bank liquidity and how they influence financial performance through empirical research. As a result, this study investigated various macroeconomic and bank-specific factors impacting banks' liquidity and its subsequent effect on financial performance. Additionally, majority of the research has been done separately, focusing either on the factors that affect profitability or liquidity. To bridge this gap, the study used a two-stage least squares (2SLS) estimate approach to look at the factors that influence bank liquidity risk and how it affects bank profitability within the confines of a single study framework.

Figure 1- Theoretical model on determinants of bank liquidity & its effect on profitability



Source - Developed based on literature

Chapter Three

3, Research Methodology

The objective of this chapter was to provide an overview of the study's selected research approach.

3.1. Data Source

To analyze factors influencing bank liquidity, the study employed unbalanced panel data for a subset of Ethiopian commercial banks. This involved collecting quantitative data from the published and audited financial statements of these banks between 2002 and 2022. The financial data were sourced from the National Bank of Ethiopia (NBE).

3.2 Population and Sampling Procedure

The target population for the research comprised the banking industry in Ethiopia. According to the NBE's June 2022 annual report, there were 25 operational commercial banks in Ethiopia.

Among the study population to choose a sample of commercial banks, the researcher used a non-probability sampling method, considering the population's characteristics and the study's objectives. In light of this, the researcher purposely selecting commercial banks based on two main criteria. Firstly, they have a long-standing presence and experience in the Ethiopian banking sector, with each institution operating for over two decades. Secondly, they have substantial customer bases and manage significant funds, high levels of capital adequacy, asset quality, earnings, and profitability indicating their strong market position. These banks included the Commercial Bank of Ethiopia (CBE), Dashen Bank S.C (DB), Awash International Bank S.C (AIB), Wegagen Bank S.C (WB), United Bank S.C (UB), Nib International Bank S.C (NIB), and Bank of Abyssinia S.C (BOA). Thus, the sample frame matrix is 21*7, which includes 147 observations.

Some of the banks were excluded because of the nonavailability of sufficient data during the study period. Development Bank of Ethiopia was also excluded due to its primary goal of fostering national development rather than financial gain.

3.3 Research Design

This study undertook an explanatory research design, which was deemed essential when the dependent variable was influenced by multiple independent variables (causal relationship) as

highlighted by Bhattacherjee (2012). In this context, liquidity could be influenced by various determining factors. This research used a combination of descriptive statistics and econometric techniques for data analysis. Descriptive statistics encompassed fundamental measures like mean, maximum, minimum, standard deviations, and others, facilitating a comprehensive understanding of the current condition and trends within the data. Using a sector sample of banks, econometric models were applied to further support this descriptive analysis by examining the causal relationships between the explanatory and dependent variables from 2002 to 2022. Furthermore, two important statistical tests were employed to ascertain the impact of banks' liquidity on their financial performance, the Westerlund test for cointegration and the Granger non-causality test, which was conducted by Dumitrescu & Hurlin (2012). The link between liquidity and profitability was being explored by taking Log of ROA as a profitability indicator.

3.4 Description of Variables and Hypothesis

3.4.1 Dependent Variable

Bank Liquidity: - is defined as the ability of a bank to satisfy customer need and offer advances in the form of loans and overdrafts. The liquidity status is quantified through numerical data using liquidity risk assessment techniques.

Loans to Deposits and Short-term Financing (L)

loan to deposit and short-term financing ratio measures the relationship between illiquid assets and volatile liabilities. It indicates the percentage of the bank's erratic money that are invested in risky loans. Examples of volatile financing include deposits, interbank borrowing, certificates of deposit, and short-term borrowing from the central bank. Therefore, A higher ratio suggests lower liquidity for the bank. This ratio helps to assess the reliability of the outcomes from L1.

$$L1 = \frac{loans}{deposit + short\ term\ financing}$$

Liquid Assets to Total Assets Ratio (L2)

The ratio of liquid assets to total assets can provide insights into a bank's ability to withstand liquidity shocks. given that market liquidity is constant across all banks in the sample, a higher percentage of liquid assets generally improves a bank's ability to endure such shocks. Nonetheless, a high ratio value might also be seen as ineffectual, as liquid assets generate lower returns, which means the bank loses out on significant opportunity costs. Therefore, it's crucial to strike an optimal balance between profitability and liquidity. Liquid assets of banks include cash on hand, deposits in other banks, and short-term government securities are recognized as collateral by the NBE, as stated in the NBE establishment proclamation (No. 591, pages. 4168).

$$L2 = \frac{liqudid\ assets}{total\ assets}$$

Bank Financial Performance: As per Rausch et al. (2008) and Shen et al. (2010), profitability takes into consideration the effect that improved financial soundness has on banks' ability to take on risk and execute liquidity transformation. Popa et al. (2009) state that returns on assets (ROA), return on equity (ROE), net banking income, and the efficiency ratio are common indicators of bank success. The research used ROA, which gauges banks' overall financial performance, as one of these metrics.

$$ROA = \frac{net\ income\ After\ tax}{total\ asssets}$$

3.4.2 Independent Variable

Capital Adequacy

Due to the highly uncertain environment in which banks operate, they are exposed to various risks and potential losses. Capital is crucial for maintaining the stability and safety of both individual banks and the overall banking system, serving as a buffer to protect depositors' funds from unexpected losses (Moh'd & Obeidat, 2013).

There are two opposing perspectives in the theoretical literature regarding the relationship between bank capital and liquidity generation. According to the first perspective, bank capital can hinder liquidity creation through two primary mechanisms: the financial fragility structure and the crowding-out hypothesis. According to Diamond and Rajan (2001), lower capital ratios associated with financial instability tend to promote liquidity creation, whereas higher capital ratios may deter depositors and thus reducing liquidity generation (Gorton & Winton, 2017). The financial fragility structure works as follows: Banks receive funds from depositors and subsequently loan these funds to borrowers. Through close monitoring of borrowers, the bank gathers confidential information that offers a competitive advantage in evaluating the profitability of individual borrowers. This informational advantage allows banks to extract higher returns from depositors by requiring a larger share of loan revenues. If depositors resist paying this higher price, the bank may cease its monitoring and loan collection activities. To address depositors' reluctance to trust the bank, it must maintain a fragile financial structure with a high proportion of liquid deposits. This ensures depositors' trust, as they can withdraw their funds if the bank fails to meet its obligations. Consequently, financial instability encourages liquidity production by enabling banks to attract more deposits and issue additional loans.

On the other hand, higher capital tends to lessen financial fragility and strengthen the bank's negotiating position, which undermines the credibility of the bank's pledge to depositors. Therefore, increased capital tends to limit the production of liquidity. Furthermore, (Gorton & Winton, 2000) argue that higher capital ratios may also inhibit liquidity generation by crowding out deposits. Deposits serve as effective liquidity hedges for agents, as they can be withdrawn at par value and are insured to some extent. Bank capital, however, is illiquid and has a variable value depending on the bank's health and stock market conditions. Therefore, higher capital ratios cause funds to shift from liquid deposits to less liquid bank capital, decreasing the bank's capacity to generate new liquidity.

Conversely, the "risk absorption" concept posits that higher capital strengthens a bank's ability to produce liquidity, aligning with banks' risk-transformation role. Liquidity creation exposes the bank to greater risk, as losses rise with the volume of illiquid assets (Allen & Gale, 2004). Selling illiquid

assets to meet liquidity demands becomes riskier as more liquidity is provided. Bank capital allows institutions to assume more risk, enhancing their capacity to generate liquidity (Repullo, 2004). According to this second viewpoint, a higher capital ratio improves the bank's ability to provide liquidity.

H1: Capital adequacy has a positive and significant impact on a bank's liquidity

Bank size

According to the "too big to fail" argument huge banks would benefit from an implicit guarantee since it would reduce their funding costs and enable them to invest in riskier assets (Iannotta et.al., 2007).

As a result, massive banks' reputations that are "too big to fail" may encourage risk-taking and moral hazard. Large banks may not be as motivated to retain liquid assets if they believe they are "too big to fail." In the event of a liquidity shortfall, they rely on Lender of Last Resort liquidity support. As a result, large banks are more inclined to engage in larger levels of liquidity generation, which exposes them to losses from having to sell illiquid assets to meet client liquidity needs. In light of this, there may be a positive relationship between bank size and illiquidity. However, despite having little liquidity, tiny banks do have a tendency to be centered on conventional intermediation and transformation operations ((Rochet, 2008); (Berger & Bouwman, 2009)).

H2: Bank size has a positive and significant impact on a bank's liquidity

Loan growth

As stated in the Comptroller's Handbook (1998), lending is the principal business activity for most commercial banks. Typically, the loan portfolio is the largest asset and the main source of revenue, making it a significant risk to the bank's stability and safety. Given that loans are illiquid assets, an increase in loans results in a higher proportion of illiquid assets in the bank's portfolio. Pilbeam (2005) notes that the demand for loans, which drives loan growth, significantly affects the liquidity maintained by banks. Banks tend to hold more liquid assets, such as short-term loans, when loan demand is low because short-term loans are generally more profitable. Conversely, when loan demand is high, banks hold fewer liquid assets. Therefore, an increase in loans and advances negatively impacts the liquidity of banks.

H3: Loan growth has a negative and significant impact on banks' liquidity

Nonperforming Loans

A loan that has a nonperforming loan (NPL) is one for which the borrower is not making the required contractual payments for an extended period of time, both in terms of principal and interest (Nazir & Afza, 2009). When the amount projected to be repaid is less than the contracted value recorded on the bank's balance sheet, NPLs become impaired. Loan loss provisions (LLPs) are created when this occurs. LLPs are deductible items in accounting. This accounting adjustment represents the difference between the amount that bank borrowers have committed to repaying the bank and the bank's most recent forecast of the amount they will actually receive.

As a result, the number of NPLs reflects the quality of a bank's assets. The ratio of nonperforming loans to total gross loans is determined by dividing the total value of the loan portfolio (including nonperforming loans before deducting specific loan loss provisions) by the value of nonperforming loans. The reported gross value of the loan should match the amount identified as nonperforming. This ratio is used to measure nonperforming loans (Bloem & Gorter, 2001).

H4: Nonperforming loans have a negative and significant impact on banks' liquidity

Gross domestic product (GDP)

The theory of bank liquidity and financial fragility, which explains the inherent instability of the capitalist system as an endogenous market process, depends on the relationship between banks' liquidity preferences and the economic cycle (Minsky, 2016). During economic booms, marked by high confidence in profitability, investment levels increase. In these periods, economic units tend to reduce their preference for liquid assets, favoring riskier but higher-yielding capital assets. They are more likely to hold less liquid capital assets and incur short-term debt with higher interest rates (Painceira, 2010). According to the "loanable fund theory of interest," which is supported by Pilbeam (2005) and the aforementioned reasoning, the supply of loans (i.e., illiquid assets for banks) rises when the economy is in a boom or emerging from a recession.

According to (Aspachs et.al., 2005), banks tend to accumulate liquidity during recessions when lending opportunities tend to be less favorable and deplete it during economic booms when lending possibilities may have improved. Thus, it is reasonable to assume that faster economic development

will cause banks to deplete their liquidity reserves and encourage them to increase lending.

H5: Real GDP has a negative and significant impact on banks' liquidity

Inflation rate

The welfare impacts of adjusting the inflation goal are important to central banks expanding corpus of theoretical research also explains the mechanisms by which even anticipated increases in inflation hinder the financial sector's ability to deploy resources efficiently. Most contemporary monetary theories agree that inflation increases the opportunity cost of keeping liquidity, which affects how resources that are needed for transactions requiring liquidity are allocated.

According to Boyd and Bruce Champ (2006), a potential way inflation could impede economic growth through the banking industry is by limiting the total quantity of credit that is available to businesses.

The story generally unfolds like this. A rise in inflation may cause a decline in the real rate of return on assets. While borrowing becomes easier, saving is discouraged due to the lower real rates of return. As a result, the market may see an influx of lower-quality borrowers who are more likely to default on their loans. Banks might respond to this situation by credit rationing, driven by the combined effects of reduced real returns on loans and the increased risk posed by new borrowers. This credit rationing by financial intermediaries leads to lower economic investment. The economy's current and future productivity would decline with less investment. Additionally, when inflation rises, banks and other economic actors will hold more liquid or short-term assets. Consequently, there is a positive relationship between the increase in the inflation rate and bank liquidity.

H6: Inflation has a positive and significant impact on a bank's liquidity

Interest rate margin

The interest rate that borrowers must pay to liquidity holders in order to relinquish their assets is known as their interest rate margin. According to the liquidity preference theory, lenders need a high interest rate, which includes the interest rate margin or liquidity premium, in order to lend money. The basic premise of this idea is that fund lenders prefer short-term lending, while most borrowers want long-term borrowing. Thus, borrowers are prepared to pay interest rate margins or liquidity premiums in order to convince lenders to grant huge loans (Pilbeam 2005). The magnitude of the

liquidity premium/interest rate margin increases with each day till maturity. Since they got a higher premium, lenders thereby forfeit their liquid assets.

According to Keynes (1964), the interest rate, serving as the reward for giving up liquidity, reflects the reluctance of money holders to lose their liquid control. He explains that the interest rate balances the desire to hold wealth in cash form with the available amount of cash. Higher interest rate margins and increased liquidity premiums compel banks to extend more loans while

holding fewer liquid assets. As per Brock and Suarez (2000), the interest rate margin is defined as the gap between the total cost a borrower pays to a bank and the net return a depositor earns. This results in a negative correlation between the interest rate margin and the liquidity of banks.

H7: The interest rate on loans (liquidity premium paid by borrowers) has a negative and significant impact on a bank's liquidity.

3.5. Econometric Model Specification

The study employed a fixed effect model (FEM) to achieve the research goal. By controlling for individual bank characteristics and adding dummy variables to capture within-bank variations over time, fixed effects models improved the accuracy of evaluating the impact of determinants on liquidity. This technique eliminated the effect of those time-invariant characteristics and allowed us to evaluate the net effect of the predictors on the outcome variable.

Thus, the general regression model is as follows:

$$Yit = \alpha + \beta xit + uit$$

where t is the time-series dimension and subscript i stands for the cross-section. The left-hand variable $Y_{i\,t}$ is the dependent variable, α is the intercept term, β is a k×1 vector of parameters to be estimated on the explanatory variables, and Xit is a 1 × k vector of observations on the explanatory variables, t = 1, . . ., T; i = 1, . . ., N.

As a result, the following general model includes every variable needed to test the study's hypotheses:

$$logLIQi,t = \alpha + \beta 1logNPLi,t + \beta 2logCARi,t + \beta 3SIZEi,t + \beta 4LGi,t + \beta 5GDPt + \beta 6INFt + \beta 7logIRMt + ui,t \ldots\ldots\ldots\ldots\ldots (1)$$

Regression is more effective than correlation. According to Brooks (2019), In contrast to correlation, a change in x can affect a change in y in a regression scenario if x has a significant impact on y. To determine how banks' liquidity affected their financial performance, two crucial statistical tests: the Westerlund test for cointegration and the Dumitrescu & Hurlin (2012) Granger non-causality test will be used. The Westerlund test allows us to explore the potential long-term relationships between the variables under consideration, indicating whether they move together over time. On the other hand, the Dumitrescu & Hurlin test aids in discerning the direction of causality between variables, helping us understand the dynamic interactions within the model. Together, these tests provide a comprehensive framework for analyzing the relationships and causal links within the dataset, enriching the depth of analysis and enhancing the robustness of our findings.

$$logROAi,t = \alpha + \sum_{it}^{n} LQit + ui,t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

where

LIQ i,t is the liquidity ratio of the i^{th} bank in year t

NPLi,t is the nonperforming loan of the i^{th} bank in year t.

The proxy was the share of nonperforming loans from the total loan portfolio of a bank.

$$NPL = \frac{non\ perforingloans}{total\ loans}$$

CAPi,t is the capital adequacy of the i^{th} bank in year t.

The proxy was the ratio of total bank capital to total assets.

$$CAP = \frac{equity}{total\ assets}$$

SIZEi, t is the size of the i^{th} bank in year t.

The proxy was a natural logarithm of the bank's total assets

$$size = \ln total\ assets$$

LGi,t is the loan growth of the i[th] bank in year t.

The proxy was the percentage change in loans. L is total loans and advances to customers.

$$LG = \frac{Lt - (t-1)}{t-1}$$

GDPt is the real domestic product growth of Ethiopia in year t. The proxy was the growth rate of real GDP.

INFt is the overall inflation rate in Ethiopia in year t. IRMt is the interest rate margin in year t.

The proxy was the difference between the average annual lending and deposit interest rate. Uit: is

a random error term

ROAit is the return on total assets of bank i in year t

SigfaLQ: significant factors affecting bank liquidity

Table 1. Summary of explanatory variables and their expected effect on the dependent variables.

Variable		Measure (proxies)	Notation	Expected effect
Dependent Variables	Liquid assets to total assets ratio		L1	
	Loans to deposits and short-term financing		L2	
Independent Variables	Capital adequacy Ratio	Equity/ Total Assets	CAP	Positive
	Bank size	Natural Logarithm of Bank's Total Asset	Size	Positive
	Loan growth	the loan growth of the bank	LG	Negative
	Nonperforming loans	the percentage of nonperforming loans on total volume of loans	NPL	Negative
	Gross domestic product	the real domestic product growth of Ethiopia	GDP	Negative
	Inflation rate	the overall inflation rate in Ethiopia	INF	Positive
	Interest rate margin	the difference between interest rate on annual average loans/Lending rate and interest rate on deposits/Deposit rate)	IRM	Negative

3.5 Reliability, Validity and Diagnostic Tests

To ensure the reliability of the data, audited financial statements from seven Ethiopian commercial banks over the period 2002 to 2022 were used. These consistent sources ensured that the data accurately represented the banks' financial performance. Validity was addressed by aligning the selected variables such as loan growth, capital adequacy, and non-performing loans with established financial theories and previous empirical studies.

Diagnostic Tests

Several diagnostic tests were conducted to ensure the robustness of the regression models. Some of these included:

- Multicollinearity**:** Assessed using the Variance Inflation Factor (VIF), with results indicating no multicollinearity among independent variables.
- Heteroscedasticity**:** Tested using the Breusch-Pagan test, confirming homoscedasticity in the residuals.
- Autocorrelation**:** Checked using the Durbin-Watson statistic, showing no significant autocorrelation.

CHAPTER FOUR

4. RESULTS AND DISCUSSION

This chapter included a comprehensive explanation of the important correlation and regression findings in addition to the presentation of the data that had been collected. The analysis included classical linear regression model (CLRM) tests and diagnostic assessments to ensure the robustness of the findings. Correlation analyses among the study variables and descriptive statistics of both dependent and independent variables were carefully examined. Both fixed and random effect regression models were used to analyze the data, and the outcomes of both models were thoroughly outlined. Finally, a detailed discussion of the results was conducted, incorporating the study's findings and relevant empirical literature to provide a comprehensive interpretation.

4.1 Descriptive Analysis

This part covers a thorough overview of the variables under research by presenting the descriptive statistics of the independent and dependent variables All of the variables' findings were included, with the number of observations, mean, median, standard deviation, minimum, and maximum values, all summarized in a table format.

Table 2 Descriptive statistics of the data

	observations	Mean	Median	Maximum	Minimum	Std.Dev.
L1 (LDR)	101	63.68792	62.50152	96.70037	29.68698	15.10783
L2 (LATA)	147	28.61235	26.70021	59.40661	8.231504	13.94509
ROA	147	2.661689	2.74221	4.684208	0.2	0.863711
ROE	147	24.89484	22.95077	77.70858	1.4	12.36193
CAP	147	0.117892	0.118277	0.280255	0.037171	0.037287
Size	147	9.53515	9.52278	13.96183	5.749393	1.704754

NPL	126	0.007747	0.004425	0.077494	-0.00147	0.011137
LG	147	0.277177	0.252386	1.050436	-0.17426	0.193198
GDP	147	0.095039	0.095039	0.135724	-0.81545	0.187397
INF	147	15.91004	10.81986	55.24131	-1.2219	13.07244
IRM	147	5.146187	4.901534	9.329667	0.949587	1.727034

Source: Audited financial statements of sampled commercial banks and own computation.

Table 2 displayed the descriptive statistics of all the unbalanced panel data of all the variables from 2002 to 2022.

The typical value of the loan-to-deposit ratio (L1), for the bank was 63.687%. Typically, an optimal loan-to-deposit ratio (LDR) for the banking sector rangs between 80% and 90%. A bank with LDR of 100% would indicate that it has loaned out one Birr for every Birr in deposits, suggesting minimal reserves available for anticipated or unforeseen events. Consequently, the observed average LDR of 63.687% among Ethiopian banks suggested conservative lending practices. This implied that for every 100 Birr in deposits, the banks extended only 63.687 Birr as loans and advances, maintaining a substantial buffer to accommodate unexpected losses or potential bank runs.

The Liquid Asset to Total Asset ratio (L2) averaged 28.61% over the analyzed period. This indicated that, on average, Ethiopian banks kept more than one-fourth of their assets in liquid forms, capable of being converted to cash within a year to address liquidity needs. The standard deviation of this ratio was 13.94%, with values ranging from 8.23% to 59.41%, pointing to a significant variability in liquidity positions among the banks during the period under review. This variation underscored the differing strategies and risk appetites of the banks concerning liquidity management.

The analysis of the tested seven banks in Ethiopia unveiled a mean Profit from Resources (ROA) of approximately 2.66%, as illustrated in Table 2. This metric suggested that a speculation of one Birr in the absolute resources of these banks yielded an average return of ETB 2.66. The standard

deviation of ROA across the banks stood at 0.86%, with values ranging from 0.2% to 4.68%. This spread highlighted a significant variation in the ROA figures observed over the designated period, indicating diverse performance levels among the banks.

In contrast, the Return on Equity (ROE) for these banks averaged 24.89%, which implies that, on average, the banks generated 24.89 Birr for every 1000 Birr of shareholders' equity invested. The standard deviation of ROE was 12.36%, with a range from 1.4% to 77.7%, reflecting substantial variability in profitability among the banks over the examined timeframe.

Of the variables unique to each bank, there was a notable variance in the banks' sizes. The average size was 9.54, with a standard deviation of 1.7, and the values ranges from 5.75 to 13.96. The largest bank was the Commercial Bank of Ethiopia (CBE), which was more than twice the size of the smallest privately owned commercial banks. This highlights CBE's dominant position in the Ethiopian banking sector.

Capital adequacy, a crucial variable, had an average value of 11.6%, exceeding the international standard of 8% (Reporter, March 13, 2010). The maximum and minimum capital adequacy values were 29.4% and 3.7%, respectively. The standard deviation was 4.8%, indicating that most Ethiopian banks maintain capital adequacy ratios close to the average.

4.2. Regression Analysis: Results and Discussions

4.2.1. Correlation Analysis

According to Gujarati (2004), correlation analysis is used to assess how strongly variables are related to one another or how much they are linearly associated. The correlation coefficients in a Pearson correlation matrix can range from -1 to +1. A coefficient of +1 denotes an ideal positive relationship, while a coefficient of -1 indicates an ideal negative relationship. A coefficient of 0 connotes no direct connection between the factors.

Table 3 Correlation matrix of dependent and independent variables

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1) Log of LATA (L2)	1.000									
(2) Log of LD (L1)	-0.128	1.000								
(3) Log of ROA	0.369	0.030	1.000							
(4) Log of NIM	-0.354	0.624	-0.038	1.000						
(5) Bank size	-0.767	-0.341	-0.330	-0.044	1.000					
(6) Log of NPL	-0.018	0.014	-0.364	-0.141	0.142	1.000				
(7) Log of CAR	0.278	0.567	0.338	0.516	-0.618	-0.344	1.000			
(8) GDPGR	0.098	0.018	0.158	0.372	-0.189	-0.236	0.377	1.000		
(9) Inflation	0.038	0.280	-0.109	0.223	-0.039	0.195	0.148	0.090	1.000	
(10) LG	-0.467	0.493	0.080	0.409	0.153	-0.138	0.201	0.187	0.079	1.000

(Source: own computation based on data)

The correlation matrix provided offered several insights into the relationships between various financial and economic variables. There was a strong negative correlation between the logarithm of liquid assets to total assets (Log of LATA or L2) and bank size (-0.767), suggesting that larger banks tended to hold a smaller proportion of liquid assets relative to their total assets. This may have indicated a higher risk tolerance or more efficient liquidity management in larger banks. Additionally, a moderate positive correlation between Log of LATA and return on assets (Log of ROA) (0.369) implied that banks with a higher ratio of liquid assets to total assets tended to achieve higher profitability. Conversely, there was a moderate negative correlation between Log of LATA and net interest margin (Log NIM) (-0.354), indicating that higher liquidity ratios might be associated with lower margins.

The strong positive correlation between the logarithm of loan to deposits (Log of LD or L1) and Log NIM (0.624) suggested that banks with higher loan-to-deposit ratios tended to have higher net interest margins, possibly due to more effective asset-liability management. Similarly, the strong positive correlation between Log of LD and the capital adequacy ratio (Log of CAR) (0.567) indicated that higher loan was associated with higher capital buffers.

4.2.2. Panel Unit Root Tests

To prevent potential inaccuracies in regression outcomes due to non-stationary variables, the study was carried out panel unit root tests to assess stationarity and the existence of unit roots in the panel data. Utilizing the Fisher type test for panel unit root is recommended for unbalanced

panel data and the analysis aimed to confirm data stationarity at either the level or after differencing. The study employed ADF-Fisher panel unit root tests for unbalanced panel data, assuming independence among individual unit root processes. This method utilized chi-square test statistics and a lag of 1 to address higher-order autoregressive components. The findings showed that after differencing the data once, some variables became stationary, highlighting the importance of this step in ensuring the reliability of regression analyses.

Table 4 Panel unit root test results

Variables	**ADF test statistic (Inverse chi-squared value) variables at level form**	**ADF test statistic (Inverse chi-squared value) variables first difference from**
Loan to total deposit		56.47***
Liquid asset to total asset		38.11***
CAR	31.46***	
BSIZE	39.51***	
NPL		83.80***
LG	28.76**	
GDPGR	49.30***	
INF	54.90***	
NIM		84.64***

***, **, * indicate significant at 1%, 5% and 10% level respectively.

The ADF test results indicated that all the variables listed were non-stationary in their level forms but exhibited stationarity after taking their first differences. This implied that any analysis involving these variables should use their differenced forms to ensure reliability and accuracy.

4.3. Regression Model Tests

In order to properly evaluate hypotheses and guarantee that the regression produced reliable results, tests for appropriateness, assumptions, and regression model fitness were required. As a result, the Hausman test and helpful regression diagnostic tests, such as tests for autocorrelation, heteroskedasticity, multicollinearity, normality, and model specification, have been performed on the study.

4.3.1. Hausman Test for Model Selection

As mentioned in his book, Brooks (2008), explains that financial research primarily uses two panel estimator approaches: fixed effects and random effects models. The fixed effects model is favored by the alternative hypothesis, while the random effects model is suggested to be

appropriate by the null hypothesis, which was tested using the Hausman test. To determine which model—random effects or fixed effects—should be utilized, a Hausman test was performed. Random effects are preferred if the p-value is greater than 0.05, indicating that the test was statistically significant. However, if the p-value is below 0.05, then fixed effect is selected based on the data (Gujarati 2004).

Hausman test results for model 1 loan to deposit ratio (L1 as dependent) and model 2 liquid asset to total asset (L2 as dependent

	Coef.
Chi-square test value	139.102
P-value	0

Hausman (1978) specification test

	Coef.
Chi-square test value	2.392
P-value	.935

Hausman (1978) specification test

(Source**:** own computation based on data)

Based on the above result,

for model 1 We accept the alternative hypothesis (H1: Fixed effect model is acceptable) and reject the null hypothesis (H0: Random effect model is suitable).

According to Model 2, the fixed effect model is not as appropriate as the random effects model. It suggests that there is no relation between the individual effects (or entity-specific effects) and the explanatory factors, meaning that accurate and reliable estimates can be obtained using the random effects model.

4.3.2 Testing Assumptions of Regression Model

Multicollinearity Test

Multicollinearity is the problem that occurs when there is a close straight connection between the explanatory factors, which results in inaccurate regression estimations. In essence, it implied that one independent variable's effect on the model was already accounted for by other variables, rendering it redundant. This phenomenon occurred when strong linear relationships existed among one or more explanatory variables.

The researcher in this study used the correlation coefficient values and variance inflation factor (VIF) shown in Table 3 to evaluate multicollinearity among the explanatory factors. Typically, researchers became concerned about multicollinearity when the correlation coefficient exceeds

0.80. However, the results in Table 3. indicated that no multicollinearity was present, as the

correlation between variables did not approach this threshold. Furthermore, the computed VIF values corroborated the absence of multicollinearity across the variables.

Adhering to the conventional VIF threshold of 5, where values exceeding 5 indicated multicollinearity, the findings in the table below confirm that there was no indication of multicollinearity among the model's variables. The VIF values remain well below the critical threshold, affirming the robustness of the regression model and the explanatory variables' independence

Table 5. The Variance inflation factor results in the explanatory variables

Variable	VIF	1/VIF
Log of CAR	3.050	0.328
Bank size	2.100	0.475
Log NIM	1.880	0.531
LG	1.290	0.776
Log of NPL	1.270	0.786
GDPGR	1.260	0.794
Inflation	1.130	0.882
Mean VIF	1.71	

(Source: own computation based on the collected data)

The skewness/kurtosis test was utilized in this investigation to determine whether the distribution of the error term was normal. This test evaluated whether the residuals deviated significantly from the expected normal distribution. We were unable to reject the null hypothesis based on the skewness/kurtosis test results, indicating that there was neither skewness nor kurtosis that was statistically significant in the residuals. The validity of the regression model is supported by the implication that the residuals are roughly normally distributed.

Table 6 Test for normality assumption results

The skewness/kurtosis test of residuals: for model 1 (LDR as dependent) and model 2 (LATA as dependent)					
P-value (Skewness)		P-value (Kurtosis)		P-value (joint)	
Model 1 (LDR)	Model 2 (LATA)	Model 1 (LDR)	Model 2 (LATA)	Model 1	Model 2
0.883	0.2471	0.938	0.7914	0.9862	0.4879

Source: own computation based on the collected data

The table's results show that, for both models, we were unable to reject the null hypothesis that there was no skewness or kurtosis. This supported the robustness and validity of the results by demonstrating that the error components in each model are normally distributed, which satisfies a fundamental premise of the regression analysis.

Test for Heteroskedasticity

A basic tenet of the classical linear regression model is homoscedasticity, which states that the disturbance term's probability distribution is constant for every observation. This means the variance of each $u\,i$ is the same for all observations. Heteroscedasticity is the state that results from difference in variance between the disturbance terms. To detect heteroscedasticity, the Breusch-Pagan-Godfrey test is employed to ensure that the assumption of homoscedasticity holds true. For the test statistic to be considered valid, the p-values must exceed the 0.05 significance level.

In the table below (table 7), Since the p-values for both models are above 0.05, we are unable to reject the null hypothesis of homoscedasticity. This supports the assumption of constant variance for the disturbance term in both regression models by showing that there is no clear indication of heteroscedasticity in either Model 1 or Model 2.

Table 7. The results of the Heteroskedasticity Test.

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity for model 1 (LDR as dependent) and model 2 (LATA as dependent)

Test statistic-Chi squared value		Calculated Chi2 statistic p-value	
Model 1 (LDR)	Model 2 (LATA)	Model 1 (LDR)	Model 2 (LATA)
1.82	0.05	0.1774	0.8157

Source: Own computation based on the collected data

Test for Autocorrelation

The last premise of the Regression Model that is investigated in this work is the absence of autocorrelation, which implies that the covariance between the error terms across time (or cross-sectionally, depending on the data type) is zero. In simple term, it is assumed that there is no correlation between the errors. According to Brooks (2008), errors that show correlation are referred to as "autocorrelation" or "serial correlation."

To provide a more robust confirmation of the absence of autocorrelation, the Breusch-Godfrey (BG) test was conducted. The BG test is capable of evaluating autocorrelation across multiple lags, in contrast to the Durbin-Watson test, which is limited to testing for first-order autocorrelation. The combined results from these tests provide a comprehensive assessment of autocorrelation in the models, ensuring the reliability of the regression estimates by confirming that the errors are indeed uncorrelated.

Breusch-Godfrey LM test for autocorrelation for model 1 (LDR)

Number of gaps in the sample	chi2	df	Prob>Chi2
12	19.396	1	0.000
H0: no serial correlation			

Source: Own computation based on the collected data

The Breusch-Godfrey test's p-value is 0.000, which is much lower than the 0.05 significance limit. This suggests compelling evidence that challenges the null hypothesis that there is no autocorrelation. As a result, the null hypothesis is rejected, indicating that autocorrelation exists

within the model.

Correction of Model 1 (LDR) Autocorrelation

To address the autocorrelation issue, the researcher utilized the 'prais' command instead of standard regression and appended the 'corc' command at the end of the variable list. To test the null hypothesis of no autocorrelation in the residuals against the hypothesis of positive autocorrelation at the 5% significance level. The researcher needs to consider the Durbin-Watson critical values. Given that there are seven regressors, the relevant critical values are found in the column labeled k =7. According to the Durbin-Watson table, the lower bound (d) is 1.530 and the upper bound ($d\ U$) is 1.722.

For the original Durbin-Watson statistic:

The observed value is 0.752590. Since this is lower than the lower bound of 1.530, the null hypothesis of no autocorrelation was rejected, suggesting positive first-order autocorrelation.

For the transformed Durbin-Watson statistic:

The observed value is 1.693637. Since 1.693637 is between the lower bound ($d\ L$ =1.530) and the upper bound ($d\ U$ =1.722), the null hypothesis was not rejected. This indicates that the transformation has mitigated the autocorrelation issue. Thus, the revised Durbin-Watson statistic after applying the 'prais' command and 'corc' method falls within the acceptable range, suggesting that the residuals are no longer significantly autocorrelated.

Log of Loan to total deposit	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Inflation	0	0	1.39	.171	0	.001	
LG	.18	.03	6.00	0	.12	.24	***
GDPGR	-.295	.168	-1.76	.084	-.63	.041	*
Log of CAR	.204	.082	2.49	.015	.04	.367	**
Log of NPL	.003	.009	0.37	.713	-.015	.021	
Bank size	-.001	.01	-0.11	.911	-.021	.019	
Log NIM	.338	.072	4.68	0	.194	.482	***
Constant	2.401	.124	19.35	0	2.153	2.649	***

Mean dependent var	1.803	SD dependent var	0.101
R-squared	0.576	Number of obs	70
F-test	12.027	Prob > F	0.000
Akaike crit. (AIC)	-242.772	Bayesian crit. (BIC)	-224.784

*** p<.01, ** p<.05, * p<.1

Durbin-Watson statistic (original) 0.752590
Durbin-Watson statistic (transformed) 1.693637

Breusch-Godfrey LM test for autocorrelation for model 2

Number of gaps in the sample	chi2	df	Prob>Chi2
11	40.296	1	0.000
H0: no serial correlation			

Source: Own computation based on the collected data

As the p-value is below the commonly used significance level of 0.05, the null hypothesis that there is no serial correlation is rejected. This indicates that the model's residuals include strong evidence of serial correlation. Serial correlation means that the residuals are correlated over time, which violates a fundamental assumption of regression models. Hypothesis tests may become faulty as a result of ineffective estimations and inaccurate standard errors.

Correction for model 2 autocorrelation

Table 8. Prais-Winsten AR (1) regression

Log of Loan to total deposit	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Inflation	0	0	1.39	.171	0	.001	
LG	.18	.03	6.00	0	.12	.24	***
GDPGR	-.295	.168	-1.76	.084	-.63	.041	*
Log of CAR	.204	.082	2.49	.015	.04	.367	**
Log of NPL	.003	.009	0.37	.713	-.015	.021	
Bank size	-.001	.01	-0.11	.911	-.021	.019	
Log NIM	.338	.072	4.68	0	.194	.482	***
Constant	2.401	.124	19.35	0	2.153	2.649	***

Mean dependent var	1.803	SD dependent var	0.101
R-squared	0.576	Number of obs	70
F-test	12.027	Prob > F	0.000
Akaike crit. (AIC)	-242.772	Bayesian crit. (BIC)	-224.784

*** *p<.01*, ** *p<.05*, * *p<.1*

Durbin-Watson statistic (original) 0.752590

Durbin-Watson statistic (transformed) 1.693637

For the transformed Durbin-Watson statistic:

The observed value is 1.693637. Given the Durbin-Watson statistic table and the number of observations (70) and predictors (7), the lower bound (d) is approximately 1.44 and the upper bound

($d\ U$) is approximately 1.73. Since 1.693637 is between the lower bound (1.44) and the upper bound (1.73), the null hypothesis was not rejected. This indicates that the transformation has mitigated the autocorrelation issue. Thus, the revised Durbin-Watson statistic after applying the Prais-Winsten AR (1) regression falls within the acceptable range, suggesting that the residuals are no longer significantly autocorrelated.

Test for cross-sectional dependence

To address the issue of cross-sectional dependence in the panel data, The Frees' test of cross-sectional independence was applied for model 1(fixed effect), while Friedman's test of cross-sectional independence was used for model 2 (random effect). The null hypothesis of the Pesaran test posits that there is no correlation between residuals across cross-sections.

Table 9. Friedman's test of cross-sectional independence

Friedman's test for cross-sectional dependence: (LATA) as dependent	
Test statistic- value	Calculated p-value
11.320	0.0790

Given that the p-value (0.0790) is above the significance level of 0.05, we fail to reject the null hypothesis of cross-sectional independence. This suggests that model 2 does not appear to include any meaningful evidence of cross-sectional dependence.

Test for Omitted Variables

To find out if the regression model has bias from omitted variables, the Ramsey RESET test was used. This diagnostic test assesses whether the model's specification is adequate by checking for omitted variables through the inclusion of powers of the fitted values. The null hypothesis for this test asserts that the model includes all necessary variables.

Ho: model has no omitted variables

Ramsey RESET test using powers of the fitted values for model 1 (LD) and for model 2 (LATA)			
Test statistic- value		Calculated p-value	
Model 1	Model 2	Model 1	Model 2

0.81	0.92	0.4931	0.641

Both models had p-values exceeding standard significance thresholds (e.g., 0.05 or 0.10), indicating insufficient evidence to reject the null hypothesis. This suggests that there are no significant specification errors in either model.

4.4 Model Estimation

In this section, the findings of the fixed and random effect regression models are presented. The results delineate the influence of each explanatory variable on the dependent variable, quantified by the estimated beta coefficients. These coefficients indicate whether the effects are positive or negative and quantify the impact of each variable on the dependent variable.

The statistical significance of each variable was assessed through p-values, which indicate the confidence level at which the null hypothesis (that the variable has no effect) can be rejected. Variables with lower p-values are considered significant predictors of the dependent variable.

Furthermore, the R-squared values provided insights on the models' capacity for explanation. They show how much of the variance in the dependent variable can be explained by the independent variables in the regression model. Higher R-squared values denote a better fit, indicating that the model more effectively captures the variations in the dependent variable. These metrics collectively offer a comprehensive evaluation of the models' performance and the relationships between the variables.

The study's fixed effect and random effect regression models, which were used to determine the statistically significant determinants of commercial banks' liquidity, as indicated by L1 and L2, respectively, are shown in the table below.

$$LIQi,t = \alpha + \beta 1 NPLi,t + \beta 2 CAPi,t + \beta 3 SIZEi,t + \beta 4 LGi,t + \beta 5 GDPt + \beta 6 INFt + \beta 7 IRMt + ui,t$$

Liquidity measured by loans to deposits and short-term financing ratio (L1)

Log L1 = $\alpha + \beta 1 logNPLi,t + \beta 2 logCAPi,t + \beta 3 logSIZEi,t + \beta 4 logLGi,t + \beta 5 GDPGR + \beta 6 logINFt + \beta 7 logIRMt + ui,t$ model 1

Table 10. Fixed effect estimation result for model 1

Log of Loan to total deposit	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Log of CAR	-.024	.093	-0.25	.8	-.21	.162	
LG	.183	.04	4.56	0	.103	.263	***
Inflation	.001	0	1.94	.056	0	.002	*
GDPGR	-.589	.111	-5.32	0	-.81	-.368	***
Log of NPL	.02	.01	1.97	.053	0	.04	*
Bank size	-.033	.01	-3.39	.001	-.053	-.014	***
Log NIM	.45	.088	5.13	0	.275	.625	***
Constant	2.724	.222	12.29	0	2.282	3.166	***

Mean dependent var	1.802	SD dependent var	0.102
R-squared	0.537	Number of obs	83
F-test	11.592	Prob > F	0.000
Akaike crit. (AIC)	-259.034	Bayesian crit. (BIC)	-239.683

***, **, * indicate significant at 1%, 5% and 10% level respectively

The table above displays the findings of the regression analysis that was conducted to identify the important variables that influence the liquidity of commercial banks, as indicated by L1. The mean liquidity level (L1) across the sample is 1.802, with a standard deviation of 0.102, indicating low variability around the mean. The R-squared value of 0.537 suggests that 53.7% of the variation in liquidity levels is explained by the model, demonstrating moderate explanatory power. Model diagnostics reveal an F-test value of 11.592 with a p-value less than 0.000, confirming the model's high significance and rejecting the null hypothesis that all coefficients are zero. The Akaike Information Criterion (AIC) of -259.034 and the Bayesian Information Criterion (BIC) of -239.683 provide measures for model comparison, with lower values suggesting a better fit.

The statistical significance of the variables is indicated by the significance levels, with *** p<.01, ** p<.05, and * p<.1, marking variables that were significant predictors of liquidity at varying levels of confidence. This comprehensive analysis underscored the model's reliability and highlights the critical determinants of bank liquidity.

Liquidity measured by liquid assets to total assets ratio (L2)

$$L2= \alpha + \beta 1 logNPLi,t + \beta 2 logCAPi,t + \beta 3 logSIZEi,t + \beta 4 logLGi,t + \beta 5 GDPGR + \beta 6 logINFt + \beta 7 logIRMt + ui,t \quad \text{model 2}$$

Table 11. Random effect estimation result for model 2

Log of Liquid Assets to total asset	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Log of CAR	.139	.102	1.35	.176	-.062	.34	
LG	-.367	.057	-6.49	0	-.479	-.256	***
Inflation	.002	.001	2.31	.021	0	.004	**
GDPGR	.156	.054	2.88	.004	.05	.262	***
Log of NPL	-.004	.017	-0.22	.825	-.037	.03	
Bank size	-.103	.008	-13.15	0	-.118	-.088	***
Log NIM	-.472	.088	-5.34	0	-.645	-.298	***
Constant	1.938	.131	14.82	0	1.682	2.194	***

Mean dependent var	1.387	SD dependent var	0.236
Overall r-squared	0.792	Number of obs	126
Chi-square	450.535	Prob > chi2	0.000
R-squared within	0.781	R-squared between	0.944

***, **, * indicate significant at 1%, 5% and 10% level respectively

The table above presents the results of the random effect regression models used to find major factors of commercial banks' liquidity, as measured by L2. The average liquidity level (L2) throughout the sample is 1.387, with a standard deviation of 0.236, showing substantial fluctuation around the mean. The model's overall R-squared scored of 0.792 indicated that it accounts for 79.2% of the variability in liquidity levels, indicating excellent explanatory power. The model diagnostics show a Chi-square value of 450.535 with a p-value less than 0.000, indicating that it is highly significant and rejecting the null hypothesis that all coefficients are zero. The R-squared score of 0.781 indicates that 78.1% of the variability in liquidity within individual banks over time is captured by the model. The between R-squared value of 0.944 shows that 94.4% of the variability in liquidity between different banks is explained by the model, reflecting its robustness.

Test for cointegration

Statistic	Value		p-value	
Variance ratio	Model 1	Model 2	Model 1	Model 2
	-1.5728	-2.3464	0.0479	0.0095

Westerlund test for cointegration of model 1

The results of the Westerlund test for cointegration indicated that there is a long-run equilibrium relationship between the variables "Log ROA" and "Log of Liquid Assets to Total Assets" across the panels. Despite potential short-term deviations, these variables tend to move together in the long term. This finding is crucial for econometric modeling and forecasting, as it validates the presence of cointegration among the panels in the dataset, ensuring that the model captures the long-run dynamics of the variables.

Causality test between ROA, LDR and LATA

Table 12. Dumitrescu & Hurlin (2012) Granger non-causality test results

	log(lt) for Model 1 (LTD)			log(lt) for Model 2 (LATA)		
	Z-bar	Z-bar tilde	p-value	Z-bar	Z-bar tilde	p-value
LOgROA	8.8822	6.1150	0.0000	6.5150	4.4001	0.0000

H0: loglt does not Granger-cause Log ROA

H1: loglt does Granger-cause Log ROA for at least one panel (Crossid).

Model 1 (LTD): The significant Z-bar (8.8822) and Z-bar tilde (6.1150) values indicated that changes in log liquidity (LTD) Granger-cause changes in log return on assets (LogROA). This implies that liquidity, as measured by the loan-to-deposit ratio, has predictive power over the profitability of banks.

Model 2 (LATA): Similarly, the significant Z-bar (6.5150) and Z-bar tilde (4.4001) values suggest that liquidity, as measured by liquid assets to total assets, also Granger-causes profitability. This confirms the robustness of the relationship across different liquidity measures.

4.5. Discussions of the results

The related literature that was presented in Chapter 2 of this study served as the basis for the discussions of regression results in this part. Two financial ratios were examined in the regression analyses: the log of the Loan to Total Deposit ratio (L1) and the log of Liquid Assets to Total Assets ratio (L2). The results were based on different sets of predictors, with significance levels indicated by *** (1%), ** (5%), and * (10%). As a result, the link between dependent and independent variables was addressed using the findings of this investigation, and

then it was compared to the theoretical literature and other researchers' findings as presented in the study's empirical evaluation.

Capital adequacy and liquidity

Liquidity is assessed using loans to deposits and short-term financing ratio (L1)

The analysis of capital adequacy, operationalized through the equity-to-total-assets ratio, revealed a negative and statistically insignificant effect on bank liquidity, as measured by the L1 liquidity ratio. The regression results indicated a p-value of 0.8 and a negative coefficient of - 0.024, which contradicts the initial hypothesis (H1) posited in this study. Instead, these findings align with the financial fragility and crowding out of deposits hypothesis, which suggests that higher capital requirements may lead to reduced deposit inflows as depositors may perceive the bank as overly conservative, potentially leading to lower returns on their deposits. Consequently, banks might experience reduced liquidity as they rely less. On the other hand, a higher CAR typically signifies a stronger capital base, providing a cushion against financial distress. The positive coefficient 0.139 of L2 suggests that an increase in CAR is linked to a rise in the log of liquid assets to total assets. This supports the idea that banks with higher CARs tend to hold more liquid assets as part of their risk mitigation strategy. By maintaining a higher capital buffer, these banks can better absorb losses, which might lead to a preference for holding more liquid assets to meet unexpected withdrawals or financial obligations swiftly. Although the relationship is not statistically significant (p-value: 0.176), it hints at the potential role of CAR in liquidity management. Banks with higher CARs might adopt more conservative liquidity management practices, ensuring they have adequate liquid assets to maintain financial stability.

Bank size and liquidity

To determine how bank size affected the liquidity of Ethiopian commercial banks, the natural logarithm of total assets was employed as a stand-in for bank size. The regression results from both fixed effect (coefficient: -0.033 and p-value: 0.001) and random effect (coefficient: -0.103 and p-value: 0) models were found to be inconsistent with the initial hypothesis (H2), which predicted a positive and significant impact of bank size on liquidity. Instead, the negative coefficients observed in both models indicate an inverse relationship between bank size and liquidity positions, as measured by L1 and L2 ratios.

The coefficient of -0.103 indicates that for each unit increase in bank size, the liquid assets to total assets ratio decreases by approximately 0.103 units, when other factors are constant. This result is consistent with Vento and Ganga (2009), who argue that larger banks benefit from lower funding costs, allowing them to invest in riskier assets because of implicit guarantees. This "too big to fail" status can lead to moral hazard and excessive risk-taking. As a result, large banks might see themselves as less exposed to liquidity risks, thereby reducing their incentive to maintain high levels of liquid assets.

Therefore, a noteworthy inverse correlation between bank size and liquidity implies that larger Ethiopian commercial banks often possess a lower proportion of liquid assets in respect to their overall assets, defying the idea that larger banks would improve their liquidity positions. Their perceived capacity to handle the risks that come with their scale is probably what motivates them to act in this way, which could lower their incentive to maintain liquid assets.

Loan growth and liquidity

In the fixed effect regression analysis (Model 1), the yearly growth rate of net loans and advances, a stand-in for loan growth, showed a positive coefficient of 0.183. This coefficient suggests that, contrary to the hypothesis's predicted negative association, an increase in loan growth is linked to an increase in liquidity (L1). Furthermore, it was shown that the positive effect of loan growth on bank liquidity was statistically significant, as indicated by a p-value of 0. This result of statistical significance emphasizes the strength of the observed effect.

Since loans are often considered illiquid assets due to their inherent nature of being less readily convertible into cash. In this model, it was found that loan growth significantly and negatively impacts the liquidity of commercial banks (L2). Specifically, the coefficient (-0.367) associated with loan growth suggests that for every 1% increase in loan growth, there is an approximate 0.367 unit decrease in the ratio of liquid assets to total assets in the bank's portfolio, while holding all other factors remain constant. This result underscores the tangible effect that loans, as illiquid assets, have on the overall liquidity position of banks, reinforcing the idea that rapid loan growth can diminish liquidity within the banking sector.

Nonperforming loan and liquidity

In the regression results, the fixed effect model output reveals a significant positive association between non-performing loans (NPLs) and the natural logarithm of the Loan to total Deposit ratio (L1) at a 10% significance level, with a coefficient of 0.02 and a p-value of 0.053. This indicates that as NPLs increase, the L1 ratio also increases, suggesting a direct effect. This result contrasts with typical expectations (H4) regarding non-performing loans, which are generally viewed as detrimental to bank liquidity. Instead, the analysis suggests a prudent policy approach by banks, where higher portfolio quality diminishes the incentive to reduce lending. This improvement in liquidity might be attributed to better internal risk management practices. Specifically, holding all other independent variables constant, a 1% change in non-performing loans (credit risk) is associated with a corresponding 2% adjustment in the liquidity position, as measured by L1. This result aligns with Vodová's (2011) study, which found a link between liquidity ratios and non-performing loans.

Contrary to the results of Model 1, which suggested a positive and significant relationship, this model indicates a slight negative association between non-performing loans (NPLs) and the liquidity ratio L2. However, the lack of statistical significance is clear from a p-value of 0.825 and a negative coefficient of -0.004. This outcome contradicts the hypothesis (H2) posited in this study, which anticipated NPLs would have a major detrimental effect on liquidity. The insignificance of the relationship between NPLs and liquidity coincides with Vodová's (2012) research on Slovak commercial banks, which concluded that NPLs did not impact their liquidity in a statistically significant way. The study's coefficient of -0.004 indicates that, under the assumption that all other variables stay constant, a 1% rise in NPLs would result in a 0.4% decline in Ethiopian commercial banks' liquidity ratio (L2) throughout the sampling period. This result implies that NPLs have no discernible effect on Ethiopian commercial banks' liquidity positions during the time period and sample under study. Thus, the empirical data in this study does not support the notion that there is a strong negative link between NPLs and liquidity. This could imply that Ethiopian commercial banks have mechanisms or practices in place that mitigate the possible negative impact of NPLs on their liquidity, or that the overall influence of NPLs on liquidity is overshadowed by other factors not captured in the model.

Real GDP growth rate and liquidity

The research found that the Gross Domestic Product (GDP) has a major effect on the liquidity of Ethiopian commercial banks. The annual real GDP growth rate, used as a proxy for GDP, was determined to be statistically significant at the 1% level, with a p-value of 0. The study's hypothesis (H5) is supported by the negative coefficient of -0.589, indicating a strong inverse link between bank liquidity (L1) and GDP growth. More precisely, a one-unit increase in the annual real GDP growth rate in Ethiopian corresponds to a 5.89-unit fall in the liquidity ratio of commercial banks, ceteris paribus. This finding supports the notion that higher economic growth, as measured by real GDP, correlates with reduced liquidity within banks, likely due to increased lending and investment activities spurred by economic expansion. The study's conclusions are in line with those of Vodová (2011) and Aspachs et al. (2005), who similarly observed a negative correlation between bank liquidity and GDP growth. This alignment with existing literature underscores the reliability and validity of the study's conclusions regarding how macroeconomic conditions affect bank liquidity in Ethiopia.

As per the findings in model 2 of the study, real GDP growth rate has a positive and statistically significant impact on the liquidity of commercial banks (L2), with a coefficient of 0.156. The initial hypothesis of the study suggested a negative and significant correlation between real GDP growth and bank liquidity, which is at odds with the current finding. The positive coefficient shows a clear correlation between real GDP growth and liquidity. In other words, if all other factors remain unchanged, there is a corresponding 0.156 unit rise in the L2 ratio for every 1% increase in the real GDP growth rate. The study's findings support those of Moore (2010), indicating a positive relationship in the Ethiopian banking sector. The positive coefficient suggests that during cyclical downturns, the expected transaction demand for money by banks decreases, leading to increased liquidity. This observation supports the theory that during expansionary times, richer households and businesses tend to rely more on internal finance, which lowers their debt levels and lessens their reliance on external credit. Conversely, during recessions, individuals and companies might seek more bank credit to mitigate the effects of declining income and profits, which in turn reduces bank liquidity, as noted by Calza et al. (2001).

Inflation rate and liquidity

Based on the L1 and L2 ratios, banks' liquidity was positively impacted by inflation. The L1 ratio had a coefficient of 0.001 and a p-value of 0.056, indicating significance at the 10% level.

At a 5% significance level, the coefficient for the L2 ratio was 0.002 with a p-value of 0. 021. The statistically significant positive influence of inflation on the L1 and L2 ratio supports hypothesis (H6), which is grounded on the theory of information asymmetry. Based on this theory, economic entities such as commercial banks steer clear of making long-term investments in situations where there is a possibility of actual investment value diminishing. This exacerbates credit market rationing and prompts banks to hold risk-free or liquid assets.

The coefficient for both L1 and L2 indicates that for each percentage point increase or decrease in the general inflation rate, the proportion of liquid assets held by commercial banks increases or decreases by accordingly. This finding suggests that during periods of inflation, banks adjust their portfolios to maintain liquidity by reducing long-term or capital investments in favor of more liquid assets.

Interest rate margin and liquidity

The study's final macroeconomic variable was interest rate margin, with net interest margin serving as a proxy. The results indicated that the interest rate margin, or the premium paid by borrowers, has a notable and statistically significant effect on banks' liquidity as measured by L1, with a coefficient of 0.45 and a p-value of 0, significant at the 1% level. This finding in contrast with Hypothesis 7, which is rooted in the liquidity preference theory. This outcome is in line with the findings reported in the studies conducted by Vodová (2011) and Bunda and Desquilbet (2008). It is a little surprise that the interest rate margin has a beneficial effect because it implies that banks are not encouraged to lend more money by larger margins. Rather, they encourage banks to keep more liquid assets on hand. Despite the lack of concrete empirical proof, this phenomenon aligns with the issues surrounding credit crunch and credit rationing. A credit crunch happens when the availability of credit is restricted below levels what is normally seen with market interest rates, impacting the profitability of investment ventures. The L2 regression model indicates a strong, statistically significant negative correlation between the interest rate margin and the liquidity of commercial banks, as measured by the L2 ratio (coefficient: -0.472, p-value: 0, significant at the 1% level). This suggests that as the net interest margin (NIM) increases, the liquidity of the bank’s decreases.

How does liquidity influence bank profitability

The outcomes of this research align with Shah et al.'s (2018) conclusions, indicating a notable influence of the loan-to-deposit ratio (LTD) on bank profitability, as measured by return on assets

(ROA). A higher LTD indicates lower liquidity, while a lower ratio suggests the opposite. This alignment underscores the validity of the study's conclusions regarding the importance of LTD in determining bank liquidity. Although a larger variance in LTD can boost profitability, an excessive increase in the ratio could heighten liquidity risks, ultimately leading to a decline in future performance.

The study's results align with the findings of Bordeleau & Graham (2010) and Rasul (2013), emphasizing the importance of the liquidity-to-total-assets ratio (LATA) in shaping bank profitability (ROA). Liquid assets, such as cash equivalents, reserves at central banks, and loans to other credit institutions, play a critical role in ensuring operational safety, reducing bankruptcy risks, and enhancing profitability. Given that banks use short-term deposits to issue long-term loans, maintaining sufficient liquidity is crucial for stability and profit generation. This reinforces the study’s conclusion that moderate liquidity levels are essential for reducing external liquidity costs and improving financial performance.

However, some scholars, including Eljelly (2004), Olagunju et al. (2011), and Nimer et al. (2013), argue that excessive liquidity can harm profitability by diverting business opportunities away from banks. Too many liquid assets may limit the bank's ability to generate higher returns, thereby reducing profits. Considering this, from Dumitrescu & Hurlin (2012) Granger non- causality test results we can conclude that both LTD and LATA are positively related to ROA. The finding underscores the significant predictive impact of liquidity management practices on bank profitability. Essentially, it suggests that monitoring and managing liquidity effectively can serve as a leading indicator for forecasting financial performance, particularly in terms of ROA.

CHAPTER FIVE

5. Summary, Conclusion and Recommendations

5.1 Summary

The primary objective of this research endeavor was to identify the determinants of liquidity in Ethiopian commercial banks and evaluate its impact on profitability. To achieve this aim, panel data encompassing seven commercial banks in Ethiopia from 2002 to 2022 was rigorously analyzed using a spectrum of statistical methodologies to yield a comprehensive understanding of the dataset. The analytical framework incorporated descriptive statistics, correlation analyses, and regression models, all supported by diagnostic assessments to ensure the credibility and precision of the conclusions drawn regarding two liquidity ratios and financial performance. The analysis was based on both fixed and random effect model.

The descriptive analysis unveiled that the Loan-to-Deposit Ratio (LDR) exhibited an average of 63.69%, indicative of conservative lending practices prevalent among Ethiopian banks. Conversely, the Liquid Asset to Total Asset (LATA) ratio averaged at 28.61%, showcasing notable variability in liquidity positions across the banks. Noteworthy disparities were observed in performance metrics, with Return on Assets (ROA) averaging at 2.66% and Return on Equity (ROE) at 24.89%, underscoring diverse performance levels within the banking sector. Furthermore, a substantial variance in the sizes of banks was noted, with the Commercial Bank of Ethiopia notably surpassing privately owned banks in scale.

Capital adequacy ratios were reported to exceed international standards, signaling robust capital positions among the banks. The correlation analysis unearthed intricate relationships between various financial and economic variables, elucidating significant associations such as the inverse correlation between LATA and bank size, and the positive correlation between LDR and net interest margin (NIM). Panel unit root tests confirmed the stationarity of variables post- differencing, ensuring the reliability of the regression outcomes.

The Hausman test indicated the suitability of the fixed effect model for LDR, while the random effect model was deemed appropriate for LATA. Diagnostic evaluations encompassing multicollinearity, normality, heteroscedasticity, and autocorrelation further validated the resilience and efficacy of the regression models employed in this comprehensive study.

5.2 Conclusion

This study thoroughly examines the determinants of liquidity in Ethiopian commercial banks and assesses how these factors impact profitability. The findings indicate that factors such as capital adequacy, bank size, and macroeconomic conditions significantly influence liquidity, which in turn affects profitability. These insights underscore the importance of effective liquidity management in maintaining financial stability and enhancing bank performance.

To optimize outcomes, banks should adopt balanced strategies that address both liquidity needs and profitability goals. Policymakers can use these findings to refine regulations that support sustainable banking practices. Future research could further explore the role of technological advancements and customer behavior in shaping liquidity dynamics.

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5.3 Recommendations

In-depth Analysis of Capital Adequacy: - Conduct further research to explore why capital adequacy does not significantly impact liquidity in the expected manner. This could involve looking at other mediating factors or different contexts within the banking sector.

Adaptive Strategies for Economic Changes: - Develop adaptive strategies that allow banks to respond dynamically to changes in the macroeconomic environment, ensuring robust liquidity management under varying economic conditions. This could involve using advanced econometric models to forecast the impact of liquidity changes on profitability and adjust strategies accordingly.

Long-term Financial Planning: - Policymakers should consider the long-term equilibrium relationships revealed by the cointegration tests when formulating financial regulations. Policies that support stable liquidity levels can lead to sustained profitability and overall financial stability.

Finally, it is highly recommended that banks and financial researchers continue to refine their models to capture the complex dynamics between financial indicators. Incorporating more variables and using advanced econometric techniques can provide deeper insights and more accurate predictions.

5.4 Future Study Implications

Future research could build upon this study in several important ways to deepen the understanding of liquidity and profitability dynamics in the Ethiopian banking sector and beyond:

- Expand the Scope and Sample Size: - Include more banks, especially newer or smaller institutions, to provide a more comprehensive view of the sector. This would help determine whether the findings apply to banks with different operational scales and market positions.
- Examine Additional Variables**:** - Investigate other factors such as political stability, technological advancements, and customer behavior. These factors could offer deeper insights into the broader influences on bank liquidity and profitability.
- Comparative Studies Across Regions**: -** Conduct comparative studies involving banks from other developing or emerging economies. This would help identify unique challenges and best practices that could be adapted to the Ethiopian context.
- Customer-Centric Studies: - Investigate how customer behaviors, preferences, and trust

influence banks' liquidity strategies. Customer dynamics play a crucial role in deposit stability and withdrawal patterns, impacting liquidity.

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Appendix

Table A1: Summary of Explanatory Variables and Their Expected Effects on Dependent Variables

Variable	**Measure/Proxy**	**Expected Effect on Dependent Variable**
Capital Adequacy Ratio	Total Equity / Total Assets	Positive
Bank Size	Natural Logarithm of Bank's Total Asset	Positive
Loan Growth	Percentage Change in Loans	Negative
Nonperforming Loans	% of Nonperforming Loans / Total Loans	Negative
Gross Domestic Product (GDP)	Real GDP Growth	Negative
Inflation Rate	Overall Inflation Rate	Positive
Interest Rate Margin	Difference between Lending and Deposit Rates	Negative

Source: Developed based on the literature

Table A2: Descriptive Statistics of the Variables

Variable	Observations	Mean	Median	Max	Min	Std. Dev.
Liquid Assets to Total Assets (L2)	147	28.61%	26.70%	59.41%	8.23%	13.94%
Loan to Deposits Ratio (L1)	101	63.69%	62.50%	96.70%	29.69%	15.10%
Return on Assets (ROA)	147	2.66%	2.74%	4.68%	0.20%	0.86%
Capital Adequacy Ratio (CAR)	147	11.79%	11.83%	28.03%	3.71%	3.72%
Bank Size (Natural Logarithm of Total Assets)	147	9.54	9.52	13.96	5.75	1.70
Nonperforming Loans (NPL)	126	0.78%	0.44%	7.75%	-0.14%	1.11%
Loan Growth (LG)	147	27.72%	25.24%	105.04%	-17.42%	19.32%
GDP Growth Rate (GDPGR)	147	9.50%	9.50%	13.57%	-8.15%	18.74%
Inflation Rate (INF)	147	15.91%	10.82%	55.24%	-1.22%	13.07%
Interest Rate Margin (IRM)	147	5.15%	4.90%	9.33%	0.95%	1.73%

Source: Own computation based on data

Table A3: Regression Model Assumptions Testing

Test	Description	Results
1. Normality test	Test if residuals are normally distributed	P > 0.05 (Residuals follow a normal distribution).
2. Heteroscedasticity test	Checks if variance of errors is normal	P > 0.05 (No heteroscedasticity)
3. Multicollinearity test (VIF)	Checks for high correlation between variables	Mean VIF = 1.71 (No concern)
4. Autocorrelation test	Test for serial correlation in residuals	No significant autocorrelation
5. Hausman test for model selection	Compares Fixed vs Random effect models	Model1 - Fixed effect and Model2 - Random effect

Table A4: Correlation Matrix of Key Variables

Variables	**L2 (Liquid Assets/Total Assets)**	**L1 (Loan/Deposits)**	**ROA (Return on Assets)**	**NIM (Net Interest Margin)**	**Size (Bank Size)**	**NPL (Nonperforming Loans)**	**CAR (Capital Adequacy)**	**GDPGR (Real GDP)**	**INF (Inflation Rate)**	**LG (Loan Growth)**
L2	1.000	-0.128	0.369	-0.354	-0.767	-0.018	0.278	0.098	0.038	-0.467
L1	-0.128	1.000	0.030	0.624	-0.341	0.014	0.567	0.018	0.280	0.493
ROA	0.369	0.030	1.000	-0.038	-0.330	-0.364	0.338	0.158	-0.109	0.080
NIM	-0.354	0.624	-0.038	1.000	-0.044	-0.141	0.516	0.372	0.223	0.409
Size	-0.767	-0.341	-0.330	-0.044	1.000	0.142	-0.618	-0.189	-0.039	0.153
NPL	-0.018	0.014	-0.364	-0.141	0.142	1.000	-0.344	-0.236	0.195	-0.138
CAR	0.278	0.567	0.338	0.516	-0.618	-0.344	1.000	0.377	0.148	0.201
GDPGR	0.098	0.018	0.158	0.372	-	-0.236	0.377	1.000	0.090	0.187

Variables	L2 (Liquid Assets/Total Assets)	L1 (Loan/Deposits)	ROA (Return on Assets)	NIM (Net Interest Margin)	Size (Bank Size)	NPL (Nonperforming Loans)	CAR (Capital Adequacy)	GDPGR (Real GDP)	INF (Inflation Rate)	LG (Loan Growth)
					0.189					
INF	0.038	0.280	-0.109	0.223	-0.039	0.195	0.148	0.090	1.000	0.079
LG	-0.467	0.493	0.080	0.409	0.153	-0.138	0.201	0.187	0.079	1.000

Table B-1

Models with an intercept (from Savin and White)

Durbin-Watson Statistic: 1 Per Cent Significance Points of dL and dU

k'*=1

*k' is the number of regressors excluding the intercept

	k'=2		**k'=3**		**k'=4**		**k'=5**		**k'=6**		**k'=7**		**k'=8**		**k'=9**		**k'=10**	
n	dL	dU	dL	dU	dL	dU	dL	dU	dL	dU	dL	dU	dL	dU	dL	dU	dL	dU
6	0.390	1.142	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
7	0.435	1.036	0.294	1.676	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
8	0.497	1.003	0.345	1.489	0.229	2.102	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
9	0.554	0.998	0.408	1.389	0.279	1.875	0.183	2.433	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
10	0.604	1.001	0.466	1.333	0.340	1.733	0.230	2.193	0.150	2.690	-----	-----	-----	-----	-----	-----	-----	-----
11	0.653	1.010	0.519	1.297	0.396	1.640	0.286	2.030	0.193	2.453	0.124	2.892	-----	-----	-----	-----	-----	-----
12	0.697	1.023	0.569	1.274	0.449	1.575	0.339	1.913	0.244	2.280	0.164	2.665	0.105	3.053	-----	-----	-----	-----
13	0.738	1.038	0.616	1.261	0.499	1.526	0.391	1.826	0.294	2.150	0.211	2.490	0.140	2.838	0.090	3.182	-----	-----
14	0.776	1.054	0.660	1.254	0.547	1.490	0.441	1.757	0.343	2.049	0.257	2.354	0.183	2.667	0.122	2.981	0.078	3.287
15	0.811	1.070	0.700	1.252	0.591	1.465	0.487	1.705	0.390	1.967	0.303	2.244	0.226	2.530	0.161	2.817	0.107	3.101
16	0.844	1.086	0.738	1.253	0.633	1.447	0.532	1.664	0.437	1.901	0.349	2.153	0.269	2.416	0.200	2.681	0.142	2.944
17	0.873	1.102	0.773	1.255	0.672	1.432	0.574	1.631	0.481	1.847	0.393	2.078	0.313	2.319	0.241	2.566	0.179	2.811
18	0.902	1.118	0.805	1.259	0.708	1.422	0.614	1.604	0.522	1.803	0.435	2.015	0.355	2.238	0.282	2.467	0.216	2.697
19	0.928	1.133	0.835	1.264	0.742	1.416	0.650	1.583	0.561	1.767	0.476	1.963	0.396	2.169	0.322	2.381	0.255	2.597
20	0.952	1.147	0.862	1.270	0.774	1.410	0.684	1.567	0.598	1.736	0.515	1.918	0.436	2.110	0.362	2.308	0.294	2.510
21	0.975	1.161	0.889	1.276	0.803	1.408	0.718	1.554	0.634	1.712	0.552	1.881	0.474	2.059	0.400	2.244	0.331	2.434
22	0.997	1.174	0.915	1.284	0.832	1.407	0.748	1.543	0.666	1.691	0.587	1.849	0.510	2.015	0.437	2.188	0.368	2.367
23	1.017	1.186	0.938	1.290	0.858	1.407	0.777	1.535	0.699	1.674	0.620	1.821	0.545	1.977	0.473	2.140	0.404	2.308
24	1.037	1.199	0.959	1.298	0.881	1.407	0.805	1.527	0.728	1.659	0.652	1.797	0.578	1.944	0.507	2.097	0.439	2.255
25	1.055	1.210	0.981	1.305	0.906	1.408	0.832	1.521	0.756	1.645	0.682	1.776	0.610	1.915	0.540	2.059	0.473	2.209
26	1.072	1.222	1.000	1.311	0.928	1.410	0.855	1.517	0.782	1.635	0.711	1.759	0.640	1.889	0.572	2.026	0.505	2.168
27	1.088	1.232	1.019	1.318	0.948	1.413	0.878	1.514	0.808	1.625	0.738	1.743	0.669	1.867	0.602	1.997	0.536	2.131
28	1.104	1.244	1.036	1.325	0.969	1.414	0.901	1.512	0.832	1.618	0.764	1.729	0.696	1.847	0.630	1.970	0.566	2.098
29	1.119	1.254	1.053	1.332	0.988	1.418	0.921	1.511	0.855	1.611	0.788	1.718	0.723	1.830	0.658	1.947	0.595	2.068
30	1.134	1.264	1.070	1.339	1.006	1.421	0.941	1.510	0.877	1.606	0.812	1.707	0.748	1.814	0.684	1.925	0.622	2.041
31	1.147	1.274	1.085	1.345	1.022	1.425	0.960	1.509	0.897	1.601	0.834	1.698	0.772	1.800	0.710	1.906	0.649	2.017
32	1.160	1.283	1.100	1.351	1.039	1.428	0.978	1.509	0.917	1.597	0.856	1.690	0.794	1.788	0.734	1.889	0.674	1.995
33	1.171	1.291	1.114	1.358	1.055	1.432	0.995	1.510	0.935	1.594	0.876	1.683	0.816	1.776	0.757	1.874	0.698	1.975
34	1.184	1.298	1.128	1.364	1.070	1.436	1.012	1.511	0.954	1.591	0.896	1.677	0.837	1.766	0.779	1.860	0.722	1.957
35	1.195	1.307	1.141	1.370	1.085	1.439	1.028	1.512	0.971	1.589	0.914	1.671	0.857	1.757	0.800	1.847	0.744	1.940
36	1.205	1.315	1.153	1.376	1.098	1.442	1.043	1.513	0.987	1.587	0.932	1.666	0.877	1.749	0.821	1.836	0.766	1.925
37	1.217	1.322	1.164	1.383	1.112	1.446	1.058	1.514	1.004	1.585	0.950	1.662	0.895	1.742	0.841	1.825	0.787	1.911
38	1.227	1.330	1.176	1.388	1.124	1.449	1.072	1.515	1.019	1.584	0.966	1.658	0.913	1.735	0.860	1.816	0.807	1.899
39	1.237	1.337	1.187	1.392	1.137	1.452	1.085	1.517	1.033	1.583	0.982	1.655	0.930	1.729	0.878	1.807	0.826	1.887
40	1.246	1.344	1.197	1.398	1.149	1.456	1.098	1.518	1.047	1.583	0.997	1.652	0.946	1.724	0.895	1.799	0.844	1.876

45 1.288 1.376 1.245 1.424 1.201 1.474 1.156 1.528 1.111 1.583 1.065 1.643 1.019 1.704 0.974 1.768 0.927 1.834 0.881 1.902
50 1.324 1.403 1.285 1.445 1.245 1.491 1.206 1.537 1.164 1.587 1.123 1.639 1.081 1.692 1.039 1.748 0.997 1.805 0.955 1.864
55 1.356 1.428 1.320 1.466 1.284 1.505 1.246 1.548 1.209 1.592 1.172 1.638 1.134 1.685 1.095 1.734 1.057 1.785 1.018 1.837
60 1.382 1.449 1.351 1.484 1.317 1.520 1.283 1.559 1.248 1.598 1.214 1.639 1.179 1.682 1.144 1.726 1.108 1.771 1.072 1.817
65 1.407 1.467 1.377 1.500 1.346 1.534 1.314 1.568 1.283 1.604 1.251 1.642 1.218 1.680 1.186 1.720 1.153 1.761 1.120 1.802
70 1.429 1.485 1.400 1.514 1.372 1.546 1.343 1.577 1.313 1.611 1.283 1.645 1.253 1.680 1.223 1.716 1.192 1.754 1.162 1.792
75 1.448 1.501 1.422 1.529 1.395 1.557 1.368 1.586 1.340 1.617 1.313 1.649 1.284 1.682 1.256 1.714 1.227 1.748 1.199 1.783
80 1.465 1.514 1.440 1.541 1.416 1.568 1.390 1.595 1.364 1.624 1.338 1.653 1.312 1.683 1.285 1.714 1.259 1.745 1.232 1.777
85 1.481 1.529 1.458 1.553 1.434 1.577 1.411 1.603 1.386 1.630 1.362 1.657 1.337 1.685 1.312 1.714 1.287 1.743 1.262 1.773
90 1.496 1.541 1.474 1.563 1.452 1.587 1.429 1.611 1.406 1.636 1.383 1.661 1.360 1.687 1.336 1.714 1.312 1.741 1.288 1.769
95 1.510 1.552 1.489 1.573 1.468 1.596 1.446 1.618 1.425 1.641 1.403 1.666 1.381 1.690 1.358 1.715 1.336 1.741 1.313 1.767
100 1.522 1.562 1.502 1.582 1.482 1.604 1.461 1.625 1.441 1.647 1.421 1.670 1.400 1.693 1.378 1.717 1.357 1.741 1.335 1.765
150 1.611 1.637 1.598 1.651 1.584 1.665 1.571 1.679 1.557 1.693 1.543 1.708 1.530 1.722 1.515 1.737 1.501 1.752 1.486 1.767
200 1.664 1.684 1.653 1.693 1.643 1.704 1.633 1.715 1.623 1.725 1.613 1.735 1.603 1.746 1.592 1.757 1.582 1.768 1.571 1.779

k'*=11

*k' is the number of regressors excluding the intercept

k'=12 k'=13 k'=14 k'=15 k'=16 k'=17 k'=18 k'=19 k'=20

n dL dU dL dU dL dU dL dU dL dU dL dU dL dU dL dU dL dU dL dU
16 0.060 3.446 ----- ----- ----- ----- ----- ----- ----- ----- ----- ----- ----- ----- ----- ----- ----- ----- ----- -----
17 0.084 3.286 0.053 3.506 ----- ----- ----- ----- ----- ----- ----- ----- ----- ----- ----- ----- ----- ----- ----- -----
18 0.113 3.146 0.075 3.358 0.047 3.557 ----- ----- ----- ----- ----- ----- ----- ----- ----- ----- ----- ----- ----- -----
19 0.145 3.023 0.102 3.227 0.067 3.420 0.043 3.601 ----- ----- ----- ----- ----- ----- ----- ----- ----- ----- ----- -----
20 0.178 2.914 0.131 3.109 0.092 3.297 0.061 3.474 0.038 3.639 ----- ----- ----- ----- ----- ----- ----- ----- ----- -----
21 0.212 2.817 0.162 3.004 0.119 3.185 0.084 3.358 0.055 3.521 0.035 3.671 ----- ----- ----- ----- ----- ----- ----- -----
22 0.246 2.729 0.194 2.909 0.148 3.084 0.109 3.252 0.077 3.412 0.050 3.562 0.032 3.700 ----- ----- ----- ----- ----- -----
23 0.281 2.651 0.227 2.822 0.178 2.991 0.136 3.155 0.100 3.311 0.070 3.459 0.046 3.597 0.029 3.725 ----- ----- ----- -----
24 0.315 2.580 0.260 2.744 0.209 2.906 0.165 3.065 0.125 3.218 0.092 3.363 0.065 3.501 0.043 3.629 0.027 3.747 ----- -----
25 0.348 2.517 0.292 2.674 0.240 2.829 0.194 2.982 0.152 3.131 0.116 3.274 0.085 3.410 0.060 3.538 0.039 3.657 0.025 3.766
26 0.381 2.460 0.324 2.610 0.272 2.758 0.224 2.906 0.180 3.050 0.141 3.191 0.107 3.325 0.079 3.452 0.055 3.572 0.036 3.682
27 0.413 2.409 0.356 2.552 0.303 2.694 0.253 2.836 0.208 2.976 0.167 3.113 0.131 3.245 0.100 3.371 0.073 3.490 0.051 3.602
28 0.444 2.363 0.387 2.499 0.333 2.635 0.283 2.772 0.237 2.907 0.194 3.040 0.156 3.169 0.122 3.294 0.093 3.412 0.068 3.524
29 0.474 2.321 0.417 2.451 0.363 2.582 0.313 2.713 0.266 2.843 0.222 2.972 0.182 3.098 0.146 3.220 0.114 3.338 0.087 3.450
30 0.503 2.283 0.447 2.407 0.393 2.533 0.342 2.659 0.294 2.785 0.249 2.909 0.208 3.032 0.171 3.152 0.137 3.267 0.107 3.379
31 0.531 2.248 0.475 2.367 0.422 2.487 0.371 2.609 0.322 2.730 0.277 2.851 0.234 2.970 0.193 3.087 0.160 3.201 0.128 3.311
32 0.558 2.216 0.503 2.330 0.450 2.446 0.399 2.563 0.350 2.680 0.304 2.797 0.261 2.912 0.221 3.026 0.184 3.137 0.151 3.246
33 0.585 2.187 0.530 2.296 0.477 2.408 0.426 2.520 0.377 2.633 0.331 2.746 0.287 2.858 0.246 2.969 0.209 3.078 0.174 3.184
34 0.610 2.160 0.556 2.266 0.503 2.373 0.452 2.481 0.404 2.590 0.357 2.699 0.313 2.808 0.272 2.915 0.233 3.022 0.197 3.126
35 0.634 2.136 0.581 2.237 0.529 2.340 0.478 2.444 0.430 2.550 0.383 2.655 0.339 2.761 0.297 2.865 0.257 2.969 0.221 3.071
36 0.658 2.113 0.605 2.210 0.554 2.310 0.504 2.410 0.455 2.512 0.409 2.614 0.364 2.717 0.322 2.818 0.282 2.919 0.244 3.019
37 0.680 2.092 0.628 2.186 0.578 2.282 0.528 2.379 0.480 2.477 0.434 2.576 0.389 2.675 0.347 2.774 0.306 2.872 0.268 2.969
38 0.702 2.073 0.651 2.164 0.601 2.256 0.552 2.350 0.504 2.445 0.458 2.540 0.414 2.637 0.371 2.733 0.330 2.828 0.291 2.923
39 0.723 2.055 0.673 2.143 0.623 2.232 0.575 2.323 0.528 2.414 0.482 2.507 0.438 2.600 0.395 2.694 0.354 2.787 0.315 2.879
40 0.744 2.039 0.694 2.123 0.645 2.210 0.597 2.297 0.551 2.386 0.505 2.476 0.461 2.566 0.418 2.657 0.377 2.748 0.338 2.838
45 0.835 1.972 0.790 2.044 0.744 2.118 0.700 2.193 0.655 2.269 0.612 2.346 0.570 2.424 0.528 2.503 0.488 2.582 0.448 2.661
50 0.913 1.925 0.871 1.987 0.829 2.051 0.787 2.116 0.746 2.182 0.705 2.250 0.665 2.318 0.625 2.387 0.586 2.456 0.548 2.526
55 0.979 1.891 0.940 1.945 0.902 2.002 0.863 2.059 0.825 2.117 0.786 2.176 0.748 2.237 0.711 2.298 0.674 2.359 0.637 2.421
60 1.037 1.865 1.001 1.914 0.965 1.964 0.929 2.015 0.893 2.067 0.857 2.120 0.822 2.173 0.786 2.227 0.751 2.283 0.716 2.338
65 1.087 1.845 1.053 1.889 1.020 1.934 0.986 1.980 0.953 2.027 0.919 2.075 0.886 2.123 0.852 2.172 0.819 2.221 0.789 2.272
70 1.131 1.831 1.099 1.870 1.068 1.911 1.037 1.953 1.005 1.995 0.974 2.038 0.943 2.082 0.911 2.127 0.880 2.172 0.849 2.217
75 1.170 1.819 1.141 1.856 1.111 1.893 1.082 1.931 1.052 1.970 1.023 2.009 0.993 2.049 0.964 2.090 0.934 2.131 0.905 2.172
80 1.205 1.810 1.177 1.844 1.150 1.878 1.122 1.913 1.094 1.949 1.066 1.984 1.039 2.022 1.011 2.059 0.983 2.097 0.955 2.135
85 1.236 1.803 1.210 1.834 1.184 1.866 1.158 1.898 1.132 1.931 1.106 1.965 1.080 1.999 1.053 2.033 1.027 2.068 1.000 2.104
90 1.264 1.798 1.240 1.827 1.215 1.856 1.191 1.886 1.166 1.917 1.141 1.948 1.116 1.979 1.091 2.012 1.066 2.044 1.041 2.077
95 1.290 1.793 1.267 1.821 1.244 1.848 1.221 1.876 1.197 1.905 1.174 1.943 1.150 1.963 1.126 1.993 1.102 2.023 1.079 2.054
100 1.314 1.790 1.292 1.816 1.270 1.841 1.248 1.868 1.225 1.895 1.203 1.922 1.181 1.949 1.158 1.977 1.136 2.006 1.113 2.034
150 1.473 1.783 1.458 1.799 1.444 1.814 1.429 1.830 1.414 1.847 1.400 1.863 1.385 1.880 1.370 1.897 1.355 1.913 1.340 1.931
200 1.561 1.791 1.550 1.801 1.539 1.813 1.528 1.824 1.518 1.836 1.507 1.847 1.495 1.860 1.484 1.871 1.474 1.883 1.462 1.896

Table B-2
Models with no intercept (from Farebrother): Positive serial correlation
Durbin-Watson One Per Cent Minimal Bound

N	K=0	K=1	K=2	K=3	K=4	K=5	K=6	K=7	K=8	K=9	K=10	K=11	K=12	K=13	K=14	K=15	K=16	K=17	K=18	K=19	K=20	K=21
2	0.001	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
3	0.034	0.000	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
4	0.127	0.022	0.000	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
5	0.233	0.089	0.014	0.000	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
6	0.322	0.175	0.065	0.010	0.000	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
7	0.398	0.253	0.135	0.049	0.008	0.000	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
8	0.469	0.324	0.202	0.106	0.038	0.006	0.000	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
9	0.534	0.394	0.268	0.164	0.086	0.031	0.005	0.000	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
10	0.591	0.457	0.333	0.223	0.136	0.070	0.025	0.004	0.000	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
11	0.643	0.515	0.394	0.284	0.189	0.114	0.059	0.021	0.003	0.000	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
12	0.691	0.568	0.451	0.341	0.244	0.161	0.097	0.050	0.018	0.003	0.000	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
13	0.733	0.617	0.503	0.396	0.298	0.212	0.139	0.083	0.043	0.015	0.002	0.000	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
14	0.773	0.662	0.552	0.448	0.350	0.262	0.185	0.121	0.072	0.037	0.013	0.002	0.000	-----	-----	-----	-----	-----	-----	-----	-----	-----
15	0.809	0.703	0.598	0.496	0.400	0.311	0.232	0.163	0.107	0.063	0.032	0.011	0.002	0.000	-----	-----	-----	-----	-----	-----	-----	-----
16	0.842	0.741	0.640	0.541	0.447	0.358	0.278	0.206	0.145	0.094	0.056	0.028	0.010	0.002	0.000	-----	-----	-----	-----	-----	-----	-----
17	0.873	0.776	0.679	0.583	0.491	0.404	0.323	0.249	0.184	0.129	0.084	0.050	0.025	0.009	0.001	0.000	-----	-----	-----	-----	-----	-----
18	0.901	0.808	0.715	0.623	0.533	0.447	0.366	0.292	0.225	0.166	0.116	0.075	0.044	0.023	0.008	0.001	0.000	-----	-----	-----	-----	-----
19	0.928	0.839	0.749	0.660	0.572	0.488	0.408	0.333	0.265	0.204	0.150	0.105	0.068	0.040	0.020	0.007	0.001	0.000	-----	-----	-----	-----
20	0.952	0.867	0.780	0.694	0.609	0.527	0.448	0.374	0.304	0.241	0.185	0.136	0.095	0.062	0.036	0.018	0.006	0.001	0.000	-----	-----	-----
21	0.976	0.893	0.810	0.727	0.644	0.564	0.486	0.413	0.343	0.279	0.221	0.169	0.124	0.087	0.056	0.033	0.017	0.006	0.001	0.000	-----	-----
22	0.997	0.918	0.838	0.757	0.677	0.599	0.523	0.450	0.381	0.316	0.257	0.203	0.155	0.114	0.079	0.051	0.030	0.015	0.005	0.001	0.000	-----
23	1.018	0.942	0.864	0.786	0.709	0.632	0.558	0.486	0.417	0.352	0.292	0.237	0.187	0.143	0.104	0.073	0.047	0.027	0.014	0.005	0.001	0.000
24	1.037	0.964	0.889	0.813	0.738	0.664	0.591	0.520	0.452	0.387	0.327	0.270	0.219	0.172	0.131	0.096	0.067	0.043	0.025	0.013	0.004	0.001
25	1.056	0.984	0.912	0.839	0.766	0.693	0.622	0.553	0.486	0.421	0.361	0.304	0.251	0.203	0.160	0.122	0.089	0.062	0.040	0.023	0.012	0.004
26	1.073	1.004	0.934	0.863	0.792	0.722	0.652	0.584	0.518	0.454	0.394	0.336	0.283	0.233	0.189	0.148	0.113	0.083	0.057	0.037	0.022	0.011
27	1.089	1.023	0.955	0.886	0.817	0.749	0.681	0.614	0.549	0.486	0.426	0.368	0.314	0.264	0.218	0.176	0.138	0.105	0.077	0.053	0.034	0.020
28	1.105	1.040	0.974	0.908	0.841	0.774	0.708	0.643	0.579	0.517	0.457	0.400	0.345	0.294	0.247	0.204	0.164	0.129	0.098	0.071	0.050	0.032
29	1.120	1.057	0.993	0.929	0.864	0.798	0.734	0.670	0.607	0.546	0.487	0.430	0.376	0.324	0.276	0.232	0.191	0.154	0.120	0.091	0.067	0.046
30	1.134	1.073	1.011	0.948	0.885	0.822	0.759	0.696	0.635	0.574	0.516	0.460	0.405	0.354	0.305	0.260	0.217	0.179	0.144	0.113	0.086	0.062
31	1.147	1.088	1.028	0.967	0.905	0.844	0.782	0.721	0.661	0.602	0.544	0.488	0.434	0.383	0.334	0.288	0.244	0.205	0.168	0.135	0.106	0.080
32	1.160	1.103	1.044	0.985	0.925	0.865	0.805	0.745	0.686	0.628	0.571	0.516	0.462	0.411	0.362	0.315	0.271	0.230	0.193	0.158	0.127	0.100
33	1.173	1.117	1.060	1.002	0.944	0.885	0.826	0.768	0.710	0.653	0.597	0.542	0.489	0.438	0.389	0.342	0.298	0.256	0.218	0.182	0.149	0.120
34	1.185	1.130	1.075	1.018	0.961	0.904	0.847	0.790	0.733	0.677	0.622	0.568	0.516	0.465	0.416	0.369	0.324	0.282	0.243	0.206	0.172	0.141
35	1.196	1.143	1.089	1.034	0.978	0.923	0.867	0.811	0.755	0.700	0.646	0.593	0.541	0.491	0.442	0.395	0.350	0.308	0.268	0.230	0.195	0.163
36	1.207	1.155	1.102	1.049	0.995	0.940	0.886	0.831	0.777	0.723	0.669	0.617	0.566	0.516	0.467	0.421	0.376	0.333	0.292	0.254	0.218	0.185
37	1.217	1.167	1.116	1.063	1.010	0.957	0.904	0.850	0.797	0.744	0.692	0.640	0.590	0.540	0.492	0.446	0.401	0.358	0.317	0.278	0.241	0.207
38	1.228	1.178	1.128	1.077	1.026	0.974	0.921	0.869	0.817	0.765	0.713	0.663	0.613	0.564	0.516	0.470	0.425	0.382	0.341	0.302	0.265	0.230
39	1.237	1.189	1.140	1.090	1.040	0.989	0.938	0.887	0.836	0.785	0.734	0.684	0.635	0.587	0.540	0.494	0.449	0.406	0.365	0.325	0.288	0.252
40	1.247	1.200	1.152	1.103	1.054	1.004	0.954	0.904	0.854	0.804	0.754	0.705	0.657	0.609	0.562	0.517	0.473	0.430	0.388	0.349	0.311	0.275
45	1.289	1.247	1.204	1.160	1.116	1.071	1.026	0.981	0.936	0.890	0.845	0.800	0.755	0.710	0.666	0.623	0.581	0.539	0.499	0.459	0.421	0.384
50	1.325	1.287	1.248	1.208	1.168	1.128	1.087	1.046	1.004	0.963	0.921	0.880	0.838	0.797	0.756	0.715	0.675	0.636	0.597	0.559	0.521	0.485
55	1.356	1.321	1.286	1.250	1.213	1.176	1.139	1.101	1.063	1.025	0.987	0.948	0.910	0.872	0.833	0.796	0.758	0.721	0.684	0.647	0.611	0.576
60	1.383	1.351	1.319	1.285	1.252	1.218	1.183	1.149	1.114	1.078	1.043	1.008	0.972	0.936	0.901	0.865	0.830	0.795	0.760	0.725	0.691	0.657
65	1.408	1.378	1.348	1.317	1.286	1.254	1.222	1.190	1.158	1.125	1.092	1.059	1.026	0.993	0.960	0.927	0.894	0.861	0.828	0.795	0.762	0.730
70	1.429	1.401	1.373	1.345	1.316	1.286	1.257	1.227	1.197	1.166	1.136	1.105	1.074	1.043	1.012	0.981	0.950	0.919	0.888	0.857	0.826	0.795
75	1.448	1.423	1.396	1.369	1.342	1.315	1.287	1.260	1.231	1.203	1.174	1.146	1.117	1.088	1.058	1.029	1.000	0.971	0.941	0.912	0.883	0.854
80	1.466	1.442	1.417	1.392	1.367	1.341	1.315	1.289	1.262	1.236	1.209	1.182	1.155	1.127	1.100	1.072	1.045	1.017	0.989	0.962	0.934	0.907
85	1.482	1.459	1.436	1.412	1.388	1.364	1.340	1.315	1.290	1.265	1.240	1.214	1.189	1.163	1.137	1.111	1.085	1.059	1.033	1.006	0.980	0.954
90	1.497	1.475	1.453	1.431	1.408	1.385	1.362	1.339	1.315	1.292	1.268	1.244	1.220	1.195	1.171	1.146	1.121	1.097	1.072	1.047	1.022	0.997
95	1.510	1.490	1.469	1.448	1.426	1.405	1.383	1.361	1.338	1.316	1.293	1.271	1.248	1.225	1.201	1.178	1.155	1.131	1.108	1.084	1.060	1.037
100	1.523	1.503	1.483	1.463	1.443	1.422	1.402	1.381	1.359	1.338	1.317	1.295	1.273	1.251	1.229	1.207	1.185	1.162	1.140	1.118	1.095	1.072
150	1.611	1.598	1.585	1.571	1.558	1.544	1.530	1.516	1.502	1.488	1.474	1.460	1.445	1.431	1.416	1.402	1.387	1.372	1.357	1.342	1.327	1.312
200	1.664	1.654	1.644	1.634	1.624	1.613	1.603	1.593	1.582	1.572	1.561	1.551	1.540	1.529	1.519	1.508	1.497	1.486	1.475	1.434	1.453	