Banks' Liquidity Shocks: A Study of South African Banks

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Declaration

I, Mwambela Tembo declare that all work submitted in this dissertation is my own except where otherwise properly acknowledged. This work was done under the supervision of Dr. Euphemia I. Godspower-Akpomiemie. This thesis is submitted in partial fulfilment of requirements for the degree of Master of Management in Finance and Investment with the University of Witwatersrand.

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Abstract

After the 2007-2008 global financial crisis focus on bank liquidity and liquidity risk rose significantly. Regulators through the Basel III accords introduced two liquidity measures, Liquidity Coverage Ratio (LCR) and Net Stable Funding Ratio (NSFR) to regulate liquidity risk. Studies have found conflicting results on the robustness of these measures and the impact of liquidity regulation on bank performance. This study quantifies the optimal liquidity ratio a bank must hold to withstand liquidity shocks and maximize shareholder value. Furthermore, examines the use of the difference between the optimal liquidity ratio and the actual liquidity ratio as a measure of liquidity risk. The study used time series data of South African banks from 2006 to 2021.

For this study, polynomial equations were developed to map the Return on Average Equity (ROAE), a proxy for shareholder value to the liquidity ratio which is used as a measure of a bank's ability to withstand liquidity shocks. The optimal liquidity was found by maximizing the ROAE. This study found that due to the unique operational and capital structure each bank has a different optimal liquidity ratio. The study also found the difference between the optimal liquidity and the actual liquidity is a robust measure of liquidity risk. Based on these findings we suggest that regulators should develop liquidity regulation that encourages maximizing shareholder value or bank performance. We also propose regulators should develop liquidity measures that consider a banks internal assessment of its counterparties and exposures.

Keywords: Liquidity Risk, Bank Regulation, Liquidity Ratio, South Africa

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Chapter 1: Introduction

1.1 Context of the study

The South African banking sector is well regulated and is guided by the Basel accords in line with other members of the Bank for International Settlements (BIS). The BIS within its structure has the Basel Committee on Banking Supervision (BCBS) which sets the primary global standards for the prudential regulation of banks (BCBS, n.d.). The BCBS as part of the Basel III accords proposes that liquidity risk be managed using the Liquidity Coverage Ratio (LCR) and the Net Stable Funding Ratio (NSFR) which require banks to hold more capital (BIS, 2010). The BCBS dictates that the LCR >= 100% while the NSFR > 100% (BIS, 2010). The objective of these reforms is to ensure banks can withstand shocks arising from financial and economic stress (BIS, 2010).

According to Diamond and Dybvig (1983), capital regulation restricts banks from their core function of liquidity creation, therefore it is not an effective preventive tool against liquidity risk. The risk absorption hypothesis according to Bhattacharya and Thakor (1993) disagrees with Diamond and Dybvig (1983) and argues that the more capital banks hold, the more risk they can absorb.

Several theoretical and empirical studies have been conducted to support the opposing theories of Diamond and Dybvig (1983) and Bhattacharya and Thakor (1993). However, Horváth et al. (2012) found that the LCR and NSFR capital requirements lead to a reduction of liquidity creation for smaller banks. They further found that greater liquidity creation reduces a banks solvency. This reverse causality between tighter capital regulation and how liquidity creation leads to solvency implies there is existence of an optimal level of liquidity creation (Horváth et al., 2012).

Based on Horváth et al. (2012) optimal level of liquidity hypothesis, there must exist an optimal liquidity ratio a bank can hold to be able to absorb liquidity risk and create liquidity. Zhang et al. (2020) developed an option-pricing approach model to calculate the optimal liquidity ratio a bank must hold to absorb liquidity risk and maximize equity using data from Chinese banks. The aim of this study was to quantify the optimal liquidity banks must hold to absorb risk and maximize shareholder value of South African banks. Furthermore, a trend analysis was performed to measure the impact of 2007 to 2008 Global Financial Crisis and the 2020 Covid-19 global health pandemic on the liquidity risk of South African banks.

1.2 Theoretical background of the study

Diamond and Dybvig (1983) state the role of a bank is to transform illiquid assets such as loans and mortgages into liquid demand deposits. The liquidity mismatch between the bank's assets and its liabilities creates a significant risk for the bank as withdrawals from depositors may come at an inconvenient time and force a sale of assets at a significant discount to meet demands from depositors.

According to Acharya (2006), banks are concerned with liquidity risk from the funding side, because it shows the bank's ability to raise funds easily and quickly, to cover its immediate obligations, either from internal or external sources of financing. The two main sources of liquidity risk are idiosyncratic, which are specific to the institution, and systematic liquidity shocks like those observed during recessions (e.g., The Great Depression) or oil price shocks (like that in the mid-1970s). This ability to raise funds by banks internally or externally to respond to the liquidity shocks is highly dependent on the bank's capital structure.

As the role of banks in the economy has grown, and the products offered have evolved and become more complex, so has the banks' capital structure. The capital structure has made banks more susceptible to liquidity risk. There are multiple definitions of liquidity risk but most literature agree that it is the risk that a company does not have the ability to meet short-term financial obligations without incurring significant losses (Acharya, 2006; Adesina, 2019; Chen et al., 2021; Diamond and Rajan, 2001). During the 2007-2008 Global Financial Crisis, some of the most notable bank failures due to the inability to meet financial obligations caused by liquidity shocks were Lehman Brothers in the USA and Northern Rock in the UK (Shin, 2009).

Bank failures or liquidity shocks did not first occur during the Global Financial Crisis but have occurred on several occasions in the last century. The 1974 notable failure of Bankhaus Herstatt in West Germany led to the establishment of the Basel Committee on Banking Supervision, which over the years has published the accords on capital adequacy known as Basel I, Basel II, and Basel III (BIS, n.d.). Basel III was introduced in response to the 2007-2008 Global Financial Crisis, its notable reforms include the introduction of liquidity requirements the Liquidity Coverage Ratio (LCR) and the Net Stable Funding Ratio (NSFR) (BCBS, 2010).

The Basel III accords use LCR and NSFR as measures of liquidity risk however, there are alternative proposals on how liquidity risk can be measured. For example, Soula (2017) uses a risk factor model to develop an individual measure of the banks' exposure to systematic risk. Musakwa (2013) proposes using a survival model incorporated with the standard framework to measure funding liquidity risk, while an option-pricing approach is developed by An et al. (2020).

Since 1994, the South African banking sector has witnessed bank failures for various reasons including liquidity risk, capital requirements and bank regulation. According to Thulare (2019) of all the failed banks since 1994, eight of them faced either liquidity problems or inadequate capital. The most recent of these failures were African Bank and VBS Mutual Bank which both faced liquidity problems and were later placed under curatorship with the latter liquidated.

This study focused on banks' ability to withstand liquidity shocks, focusing on South Africa's six listed retail banks. These banks have been designated Systemically Important Financial Institutions (SIFI) by the Governor of the South African Reserve Bank (SARB) because their failure would lead to instability in South Africa's financial sector (SARB, 2019). It is therefore important to measure, given the importance of these banks to South Africa's banking sector and economy, their ability to withstand liquidity shocks.

The SIFI banks are listed entities and according to Bhanu et al. (2018) shareholder value is the most important goal for an organization in a competitive business environment to maintain long term relationships with investors. Zhang et al. (2020) in their methodology quantify the optimal liquidity a bank must hold to withstand liquidity shocks and maximize shareholder value.

This study aimed at quantifying the optimal liquidity that maximized the Return on Average Equity (ROAE) by fitting and maximizing a polynomial relationship between the ROAE and the liquidity ratio of the SIFI banks.

1.3 Problem Statement

According to Clark (2015) banks play a key role in economic growth and implementing economic policy, for example when the government wants to encourage home ownership by lowering interest rates it is through the banks that these loans are issued. South Africa has a well-regulated banking system, and despite this has experienced bank failures due to liquidity issues post the Global Financial Crisis (Thulare, 2019). The failure of banks designated SIFI would not only have severe consequences in the banking sector but on other parts of the economy (SARB, 2019). Tabak et al. (2016) found that stronger bank supervision is positively related to banking stability and SIFI banks are more stable in a highly supervised bank environment.

LCR and NSFR are liquidity measures that were introduced as part of Basel III, according to Hong et al. (2014) these measures have limited effects on bank failures. Hong et al. (2014) further found that there is a negative relationship between NSFR and bank failure while LCR had an insignificant effect. Given the need for a highly supervised environment for SIFI according to Tabak et al. (2016) and the effect of LCR and NSFR on bank failures, Hong et al. (2014), alternative measures of liquidity risk could be considered or developed.

Quantifying the optimal liquidity that a SIFI bank must hold to withstand liquidity shocks and maximize shareholder value is not only important from a regulators point of view but market investors also. Even though LCR and NSFR are guidelines for measuring and managing liquidity risk they are not able to identify and analyze the occurrence of a stress scenario and the way in which relevant variables change under such a scenario (Zhang et al., 2020). By determining the optimal liquidity and using it to find the difference from the actual liquidity the bank holds, a robust measure of liquidity risk could be developed. South Africa's SIFI banks are listed and based on the findings from a study by Cheng et al. (2020) liquidity risk has an impact on the profitability of listed banks, and so the banks liquidity gap can also play a role in explaining the banks expected shareholder value.

The banks in this study have SIFI, if these institutions were to fail it would disrupt the financial sector due to their nature and interconnectedness amongst other sectors of the economy and therefore lead to financial instability. Being able to identify which banks have a liquidity shortfall will allow regulators to intervene and provide support to prevent the dangers associated with a possible bank failure. The ability to identify potentially at-risk banks due to a lack of liquidity can maintain confidence in the financial system.

1.4 Research Objectives

Given the significance of measuring the liquidity risk of banks, the objective of this paper is to:

1. Empirically determine the optimal liquidity ratio of the SIFI banks,
2. Determine the liquidity risk of the banks by measuring the deviation of the actual liquidity ratio from the optimal liquidity ratio,

3. Based on the liquidity risk measure, determine which banks can withstand a liquidity shock.

1.5 Research Questions

Based on the objectives, the study aims to answer the following questions:

1. What is the optimal liquidity ratio of the banks?
2. What is the deviation between the actual liquidity ratio and the optimal liquidity ratio calculated?
3. Are the SIFI banks holding adequate liquidity to withstand liquidity shocks and maximize shareholder value?

1.6 Hypotheses

Diamond and Dybvig (1983, 1986) in their studies conclude that capital regulation restricts banks from creating liquidity, which is their core function, and is not an effective method of managing risk. Bhattacharya and Thakor (1993) however has an opposing view and finds that capital regulation allows banks to absorb more risk. Horváth et al. (2012) found that capital regulation does restrict liquidity creation in the banking sector, but greater liquidity creation does lead to insolvency, thus this relationship suggests there must exist an optimal level of liquidity creation.

The optimal liquidity creation hypothesis indicates the existence of an optimal liquidity expressed as a ratio bank must hold that will allow them to maintain the optimal level to absorb liquidity risk and maximize the return on equity.

To achieve the research objectives the following hypothesis was formulated:

Hypothesis 1: Does the liquidity gap play a role in expected shareholder value.

H_0 : The liquidity gap plays a role in expected shareholder value.

H_1 : The liquidity gap does not play a role in expected shareholder value.

1.7 Significance of the study

Banks are financial institutions that have assets in the form of short-term and long-term loans and liabilities in the form of short-term deposits. This mismatch exposes banks to various risks including liquidity risk. Since 1994 the South African banking sector has witnessed several bank failures due to liquidity issues with African Bank and VBS the most recent. To promote a more resilient banking sector the Basel III accords introduced LCR and NSFR to strengthen liquidity regulations (BCBS, 2010). Due to the role and significance of 6 South African banks the SARB declared them SIFI. This study aims to quantify the optimal liquidity of the SIFI banks and furthermore introduce a robust alternative liquidity risk measure using a model based approach that can be theoretically justified, unlike most proxies such as the liquid asset ratio the funding gap.

I expect the findings of this research to contribute to literature on robust liquidity risk measures used by managers, regulators, and other agents in the banking sector. The results will also contribute to discussions on the stability and regulation of SIFI banks in South Africa. Furthermore, this study will add to discussions of theories on the significance of liquidity in banks shareholder value.

1.8 Limitations of the Study

This study was focused on South African banks designated as SIFI and may not apply universally to all banks within South Africa and in other countries. Even though Basel III accords apply to all members of the BIS globally the findings of this study may be unique to South Africa. For example, factors such as the regulatory structure may not be the same because South Africa has a twin peaks model which may not be the case in other countries. Therefore, the results presented must be read with this in mind as the research only looks at SIFI banks.

1.9 Paper Outline

Section one of this study above details the introduction, background of the study and the problem statement. This section further presents the research objects, significance of the study and ends with the limitations of the study. Section two gives an overview of banking, liquidity risk, liquidity risk management and its regulation. The section further discusses different liquidity risk measures used in other studies and by regulators. The third section discusses the methodology applied in this study and section for presents the data analysis and findings. Section five concludes the study and discusses recommendations and suggestions for future studies.

Chapter 2: Literature Review

2.1 Introduction

This chapter gives a summary of literature that is the theoretical foundation of this study. The first section gives a brief overview of banking and introduces liquidity risk and the role it plays in the banking sector globally and in South Africa. The following section discusses literature on liquidity risk regulation. Furthermore, various liquidity measures used in different studies and by regulators are discussed in the third section. The fourth and final sections give a summary of the literature discussed and how the literature supports the need for this study.

2.2 Overview of Banking and Liquidity Risk

According to Diamond and Dybvig (1986) banks convert illiquid assets into liquid demand deposits. Deposits from customers are distributed to other agents in the economy who need liquidity in the form of loans. As banks have transformed their operations from traditional liquidity creation, their funding has shifted from asset-based to a liability-based funding approach (Claasen & van Rooyen, 2012). Zonke (2013) also found that South African SIFI banks depend largely on wholesale funding because it is cheaper. Banks have started to issue debt instruments as additional source of funding to meet immediate liquidity needs of their customers. This shift in the funding approach has made banks more susceptible to liquidity risk.

Liquidity risk is defined as the inability of firms to meet short-term financial obligations without incurring significant losses. According to Fernando and Herring (2001), a liquidity shock is an unanticipated demand for liquidity and comes in two forms, idiosyncratic and systemic. Idiosyncratic liquidity shocks are independently distributed across the banks within while systemic liquidity shocks are identically distributed and affect all banks within the sector. Liquidity shocks bring to light a bank's liquidity risk. Diamond and Dybvig (1983, 1986) and Diamond and Rajan (2001) state the biggest liquidity shock a bank can experience is a bank run, but Thulare (2019) adds that liquidity shocks can also be caused by underperforming assets and high-risk loans. Thulare (2019) analyzed nine South African banks that failed between 1994 and 2018 and found that eight of them failed due to some form of liquidity risk.

Okeahalam (1998) identified four core banks in South Africa and based on the regulator showing bias towards them suggests that they were treated as 'too-big-to-fail'. Given their potential systemic impact on the financial system, six South African banks were designated as systemically important financial institutions (SIFIs) (SARB, 2019). Tabak et al. (2016) found that stronger banking supervision has a positive relation with banking stability and SIFI banks are more stable under high supervision.

2.3 Overview of Liquidity Risk Management and Regulation

Literature from various authors on banking all agree that banks and the financial sector must be regulated however there is a debate on how this should be done. Diamond and Dybvig (1983) develop a theoretical model which starts with analyzing an economy with a single bank and as more banks are introduced the model concludes liquidity risk can best be managed by deposit insurance scheme. A further theoretical study by Diamond and Dybvig (1986) suggest that the proposed regulation of increasing capital requirements prevents banks from performing their core function of liquidity creation. Diamond and Rajan (2001) from the results of their theoretical model support theories that capital requirements restrict the ability of banks to create liquidity and add financial fragility of banks incentivizes them to create more liquidity.

A quantitative study conducted in South Africa by Jacobs et al. (2012) using DI returns submitted to the South African Reserve Bank (SARB) for 10 banks found that additional capital requirements would not be an effective mitigant against liquidity risk because liquidity risk differs amongst banks and a general capital charge for all banks would not be feasible. The study used information for the months of April 2006, July 2006, October 2006, January 2007, and April 2007. Liquidity measures for the 10 banks were calculated namely, loan-to-deposit ratio, the loan-to-liability ratio, the liquid-asset-to-liability ratio, the volatile liability dependency ratio, the total-deposit-to-total-liability ratio, the equity-to-total-asset ratio, the percentage composition of deposits and net liquid assets. The study also included a liquidity risk questionnaire of 11 questions sent to 8 experienced professionals from South Africa's major banks assessing regulators must require banks to hold capital for liquidity risk. The results of the quantitative study support theories from the works of Diamond and Dybvig (1983, 1986) and Diamond and Rajan (2001) stating additional capital requirements is not the best form manage liquidity risk. Most of the respondents of the survey did not agree that additional capital would be the best way to manage liquidity risk because it is not seen as an effective guard against liquidity risk, capital is expensive and restrictive.

Horváth et al. (2012) found similar results to Jacobs et al. (2012) in their study of 31 Czech banks using panel data from 2000 to 2010. Using a Granger-Causality framework to analyze balance sheet data they found that capital requirements limit liquidity creation, especially for smaller banks. However, they also found that liquidity creation causes a reduction in capital and thus may hamper bank solvency. They concluded that capital and liquidity creation have a negative bicausal relationship.

The BCBS introduced two minimum standards, Liquidity Coverage Ratio (LCR) to "promote short-term resilience of bank's liquidity risk profile" and the Net Stable Funding Ratio (NSFR) to "promote resilience over a longer-term horizon by creating incentives for banks to fund activities with more stable sources of funding on an ongoing basis" (BIS, 2010). These minimum standards require banks to hold more capital which is in opposition of theories by Diamond and Dybvig (1983, 1986) and Diamond and Rajan (2001) but in support of the risk absorption hypothesis.

An empirical study was conducted using data for almost all commercial banks in the United States by Berger and Bouwman (2009) with the goal of quantifying the amount of liquidity created by banks. One of the goals of the study was to use the liquidity measures developed to measure the effect of capital on liquidity creation. Using data between 1993 to 2003, the study found that for large banks holding more capital has a positive effect on liquidity and the ability to absorb liquidity risk and is negative for small banks.

Grundke and Kühn (2020) developed a bottom-up balance sheet simulation model to measure the impact of LCR and NSFR. The model considered credit risk, interest rate risk and liquidity risk including their interactions. 9 different German stylized banks were simulated, and their liquidity ratios analyzed. The study found that banks with higher liquidity ratios had lower liquidity related defaults. This study supports the risk absorption hypothesis that more capital leads to a greater ability to absorb risk.

The literature discussed in this section shows two opposing views on capital regulation, on one side in support of Bhattacharya and Thakor (1993) risk absorption hypothesis and the other side in support of Diamond and Dybvig (1983) that capital regulation is not the ideal method of managing risk in the financial sector as it restricts banks from performing their core function.

2.4 Liquidity Risk Measurement

This section empirically discusses literature that explores different measures used in previous studies to measure or act as a proxy for liquidity risk for banks and their limitations.

The standard funding liquidity risk measure framework compares the expected cumulative shortfalls over a particular time horizon against stock of available funding sources (Neu, 2007 as cited in Musakwa, 2013). Musakwa (2013) builds on this framework by introducing a survival model to assign cashflows to future time horizons which has been a topic of debate in the standard framework. This approach gives a better understanding to measuring funding liquidity risk and is applied on a South African bank in the study, but it does have limitations because it ignores potential correlations between survival times of different assets and liabilities. Furthermore, interactions between funding liquidity risk and other dimensions of liquidity risk such as systemic and market liquidity risk are ignored.

After the 2007-2008 the Basel III accords introduced LCR and NSFR as measures of liquidity (BCBS, 2010). Hong et al. (2014) conduct an empirical study on the LCR and NSFR as liquidity measures from 2001 to 2011 of U.S. commercial banks. The aim of the study was to examine the link between liquidity risk measures and bank failures. The study found that LCR and NSFR have limited effects on bank failures and that systematic risks have a greater impact on bank failures. The study highlighted the limitations of using LCR and NSFR as liquidity risk measures.

Soula (2017) conducted a study using data between 2005 to 2012 from 85 banks from 12 countries across Europe was used to develop a risk factor model to measure individual bank exposure to liquidity conditions. The measure was used to determine the sensitivity of volatility in bank stock returns to an aggregate risk factor. The author found that balance sheet indicators such as LCR and NSFR, only reflect the degrees of potential bank exposure to liquidity shocks but do not quantify liquidity risk or the sensitivity to liquidity risk. The study further found larger size and higher capitalized banks are insulated from aggregate liquidity risk.

Rudhani and Balaj (2019) aimed to study the impact of liquidity risk on the performance of 9 banks in Kosovo between 2010 and 2015 using a linear regression. The study used the Return on Assets (ROA) and Return on Equity (ROE) as bank performance measures. As proxies for liquidity risk three measures were used, the current or short-term assets divided by total assets, and the liquid assets over liquid liabilities. The final was the ratio between total loans over deposits and current liabilities. The authors found that there is a positive and significant relationship between liquidity risk and performance. The main limitations of this study are, firstly it assumes the relationship between liquidity risk and bank performance is linear and secondly it uses balance sheet indictors as proxies for liquidity risk.

Zhang et al. (2020) in their study aimed to propose a new approach at quantifying a banks liquidity needs. The study uses an option-pricing approach to develop a closed form equation for the value of equity taking account both bank run and insolvency risk. The approach also determines the optimal liquidity ratio derived by maximizing the value of bank equity. The study used quarterly data from 2006 to 2016 of 16 listed banks in China. The study found that the deviation of the liquidity asset ratio from the optimal liquidity ratio in a bank is a robust proxy for liquidity risk. The limitation of the study is only banks from China were used in the study and so the results may be limited to Chinese banks.

2.5 Gaps in Literature

Some previous studies focused on testing the robustness of the LCR and NSFR as measures of liquidity risk while others looked at the impact of liquidity regulation on bank performance. Previous studies have used balance sheet indicators to determine the impact of liquidity risk on bank performance despite studies highlighting the limitations in doing so. Therefore, this study to focuses on quantifying the optimal liquidity ratio banks must hold to withstand liquidity shocks and its impact on bank performance. The study believes that a stable banking sector that inspires confidence must not only be comprised of banks that can withstand shocks but maximize shareholder value.

2.6 Chapter Summary

This chapter provided a brief overview of liquidity risk in banking and its causes. The importance of managing liquidity risk and the importance of managing and unbiasedly monitoring SIFIs in South Africa. Opposing views on capital regulation are discussed, some studies recommend capital regulation while others argue that capital regulation restricts banks from performing their core function of liquidity creation. The chapter ends with analyzing different liquidity measures used as proxies for measures of liquidity risk and a discussion on whether LCR and NSFR can be used as adequate measures of liquidity risk. The literature in this section highlights the significance of quantifying the optimal liquidity banks must hold as this will serve as a middle ground for the opposing views on capital regulation and furthermore introduce a measure to replace the proxies for liquidity risk.

Chapter 3: Research Methodology

This chapter gives a summary of the steps that were taken to address the research questions. First the research design was discussed followed by the data collection and sampling approach. The subsequent section discussed the measuring instruments and data analysis methods. The weaknesses of the study conclude this chapter.

3.1 Research design

This research design is quantitative in nature because it made use of data analytics, and its results evaluated using mathematical and statistical methods to describe the observed population over a chosen period. According to Yilmaz (2013), a quantitative research method aims to explain an outcome or occurrence according to numerical data which is analyzed using mathematical based methods such as statistics (Lowhorn, 2007). The aim of this study was to quantify the optimal liquidity ratio for South African Banks by maximizing the polynomial relationship between the Return on Average Equity (ROAE) and the Liquidity Ratio. Previous studies by Rudhani and Balaj (2019) and Zeng and Fu (2017) which also aimed at developing relationships between risk and bank performance deployed quantitative research designs. This study adopted a quantitative research design.

3.2 Population and sample

The population of a study is the universe of events or data of interest to the researcher according to Taherdoost (2016). The author further defines a sample as a subset of the population that is representative of its characteristics.

This sampling technique where events or data have been included because the researcher believes they should be included is called judgmental sampling by Taherdoost (2016). Judgmental sampling was preferred for the proposed study because it gave the researcher discretion to select a sample that includes events of interest and allows the researcher to mitigate issues such as information inadequacy.

The population of this study is all registered South African banks, and the sample was the 6 banks designated as SIFI observed from 2006 to 2021. This period was chosen to analyze the liquidity risk measure during the global financial crisis and the Covid-19 global health pandemic.

3.3 Data collection

This study used time series data of the 6 banks from 2006 to 2021. The data was sourced from Bank-Focus, this is a database of banks and financial institutions worldwide. The information is sourced from a combination of annual reports, information providers and regulatory sources by Bureau van Dijk and is regarded a reliable source. To develop a best fit polynomial relationship between the shareholder value and liquidity, the study used the average Return on Average Equity (ROAE) and the ratio between liquid assets over total assets as a proxy for the liquidity risk measure.

Table 3.1: Average of ROAE and Liquidity Ratio

	Average ROAE	Average Liquidity Ratio
Bank A	0.24	0.27
Bank B	0.18	0.23
Bank C	0.24	0.30
Bank D	0.17	0.36
Bank E	0.12	0.33
Bank F	0.15	0.13

3.4 Measuring Instruments

To study the impact of liquidity risk on financial performance of banks', Balaj and Rudhani (2019) developed a linear regression model with liquidity ratios as the independent variables and the performance metrics as dependent variables. The authors used Return on Equity (ROE) and Return on Assets (ROA) as financial performance metrics. The ratio between liquid assets and total assets, the ratio between liquid assets and liquid liabilities, and the ratio between loans and deposits and current liabilities.

This study was carried out by developing a best fit curve to model the relationship between the ROAE and the ratio between the liquid assets and the total assets. The ratio between liquid assets and the total assets (L) is liquidity risk metric chosen because it measures the ability to absorb liquidity shocks. The best fit curve was chosen based on which curve had the highest Adjusted R-Squared value for each of the banks.

$$ROAE = \sum_{i=1}^{n} \beta_i L^i + C \qquad (3.1)$$

Where n is the nth degree of the polynomial that best fits the relationship between the dependent and the independent variable.

Table 3.2 explains the variables and their source.

Table 3.2: Variable definitions

Parameters	Description	Source
ROAE	Return on Average Equity	BankFocus
L^i	Liquidity Asset Ratio = Liquid Assets/ Total assets	BankFocus
β_i	Coefficient of the i^{th} variable	Best Fit Equation Result
C	Constant	Best Fit Equation Result

According to Fu and Zeng (2017), polynomial equations can be maximized with conditions to find the optimal solution. The optimal liquidity, L* was found by maximizing the value of ROAE in equation (3.1) using the Newton-Rhapson algorithm.

$$L^* = \max_{L \, \epsilon [L,U]} ROAE \qquad (3.2)$$

The liquidity gap, LG, the difference between the optimal liquidity, L*, and the liquidity ratio, L, was used to measure if banks in the sample are holding enough liquidity to absorb liquidity risk and to maximize ROAE.

$$LG_i = L^* - L_i \qquad (3.3)$$

3.5 Data analysis

Primary and secondary analyses were performed in this study. Primary analysis is defined as the original analysis of the data in the research study while secondary analysis is the reanalysis of data to answer research questions with better statistical techniques according to Glass (1976). Primary analysis was conducted by analyzing the data collected looking at trends over time and descriptive statistics.

Secondary analysis was conducted by generating descriptive statistics and trends over time of the difference between optimal liquidity ratio and the liquidity asset ratio. These statistics included and were not limited to the mean, standard deviation, minimum and maximum. These values were used to give summarized insights of the results of this study and assist in identifying any irregularities in the distribution of the results.

The optimal liquidity was found by maximizing equity using the Newton-Rhapson algorithm in equation (3.1). The R programing language was used to find the best fit curve and maximize the ROAE, the language is designed to handle large data sets, to be reproducible and has the in-built function maxNR. The function maxNR maximizes any function unconstrained based on the Newton-Rhapson method.

For a robustness check, we used regression analysis to further examine whether the liquidity gap (LG) has explanatory power towards shareholder value compared to our conventional liquidity ratio (see equation 3.4 and 3.5). The shareholder value is proxied by ROAE. Some control variables that could affect shareholder value based on previous studies were included in the model (see Table 3.3)(C. M. Chen & Lee, 2013; Cheng et al., 2020; Zhang et al., 2020). To prevent look ahead bias, the variables are lagged one period to align with when bank financials are released to predict the expected shareholder value.

$$ROAE_{i,t} = \beta_1 LG_{i,t-1} + \beta_2 Size_{i,t-1} + \beta_3 Tier1_{i,t-1} + \beta_4 CAR_{i,t-1} + \beta_5 IL_{i,t-1} + \beta_6 ROAA_{i,t-1} + C \quad (3.4)$$

$$ROAE_{i,t} = \beta_1 LR_{i,t-1} + \beta_2 Size_{i,t-1} + \beta_3 Tier1_{i,t-1} + \beta_4 CAR_{i,t-1} + \beta_5 IL_{i,t-1} + \beta_6 ROAA_{i,t-1} + C \quad (3.5)$$

Table 3.3: Variable Definitions for Equations 3.4 and 3.5

Variable	Variable Definition	Source
ROAE	Return on Average Equity	BankFocus
LG	Liquidity Gap	BankFocus
LR	Liquidity Ratio = Liquid Assets/ Total Assets	BankFocus
Size	Size of bank = Ln(Total Assets)	BankFocus
Tier1	Tier1 Capital	BankFocus
CAR	Capital Adequacy Ratio	BankFocus
IL	Impaired Loans/Total Loans	BankFocus
ROAA	Return on Average Assets	BankFocus
C	Intercept	Best Fit Equation Result
β_i	Coefficient of the ith variable	Best Fit Equation Result

3.6 Research Limitations

This study developed polynomial equations to map the relationship between the ROAE and the liquidity ratio. Therefore, the study experienced the limitations of polynomial models. These limitations include, polynomials may provide a good fit within the range, but they frequently deteriorate outside the range and each model has different limits for optimization. Furthermore, high degree polynomials have multiple oscillations between exact-fit values and so has poor interpolatory properties.

The liquidity ratio defined as the ratio between liquid assets and total assets was used as a proxy for a liquidity measure. No robustness tests were conducted nor was it compared against other measures to ensure that it was the best measure of liquidity for this type of study.

3.7 Summary

A descriptive quantitative research design was applied during this study. Secondary data of the 6 South African banks was used to develop a polynomial equation that was maximized to find the optimal liquidity ratio the banks must hold. The data was sourced from a credible public source and can be easily verified. The ROAE of the banks was maximized using the Newton-Rhapson method using R programming language.

Chapter 4: Results and Analysis

4.1 Introduction

This chapter presents and discusses the results of the methodology discussed in chapter 3. The analysis includes descriptive statistics of the ROAE and the liquidity ratio, results of the best fit models developed and the optimization results. A trend analysis of the liquidity gap was also carried out to analyze the liquidity risk over time.

4.2 Descriptive Statistics and Correlation Analysis

Table 4.1 shows the descriptive statistics of the ROAE by bank. The descriptive statistics gave us insight on how the ROAE differs for each of the banks and how it is distributed.

Table 4.1: Summary Statistics of ROAE by Bank

	ROAE					
	A	B	C	D	E	F
Average	13.69%	16.01%	11.76%	23.99%	22.99%	15.90%
Minimum	4.66%	5.53%	7.40%	16.07%	12.67%	6.83%
Maximum	19.59%	27.14%	16.45%	29.47%	34.95%	26.90%
Standard Deviation	3.51%	5.37%	2.73%	3.44%	5.47%	4.98%
Skewness	-0.92	0.74	0.12	-0.68	0.22	0.94
Kurtosis	1.99	1.13	-0.98	0.62	0.73	1.55

Table 4.1 shows that Bank D has the highest average, 23.99%, amongst all the banks with Bank C having the lowest average of 11.76%. The high average ROAE could be a result of a larger focus on consumer banking compared to sector peers who have more diversified banking operations. Low ROAE may be a result of offering more specialized banking services to consumer and corporate clients which reduces the target market. Bank E has the largest range with a minimum of 12.67% and a maximum of 34.95%resulting in the largest standard deviation of 5.47%. The large standard deviation in shareholder value could be a result of operating in multiple jurisdictions, the global financial crisis and the covid-19 global pandemic impacted countries differently and as a result the returns of banks that operate in multiple countries. The spread in the average ROAE indicates the significant difference in shareholder value over the period amongst the sample population.

Table 4.2: Summary statistics of the Liquidity Ratio by Bank

Liquidity Ratio						
	A	B	C	D	E	F
Average	12.64%	23.47%	32.28%	29.94%	23.71%	34.25%
Min	9.12%	8.90%	25.86%	20.36%	11.75%	28.93%
Max	15.80%	30.51%	36.16%	51.96%	39.61%	41.21%
Standard Deviation	2.30%	5.47%	2.93%	9.03%	8.84%	3.65%
Skewness	-0.11	-1.38	-0.74	1.35	0.75	0.03
Kurtosis	-1.27	2.05	-0.01	1.35	-0.64	-0.61

Table 4.2 shows the Average, Minimum, Maximum, Standard Deviation, Skewness and Kurtosis of the liquidity ratio by bank. Bank F has the highest average liquidity ratio at 34.25%, while Bank A has the lowest average at 12.64%. The significant difference in liquidity ratio could be a result of bank size, banks with multinational operations hold higher liquidity because of different regulatory requirements in the different jurisdictions they operate. Bank D has the largest range with a maximum liquidity ratio of 51.96% and a minimum of 20.36% as a result has the largest standard deviation at 9.03% which supports the large range found. This large standard deviation could be a result of a larger focus on consumer banking and exposure to one jurisdiction as a result is greatly impacted by systemic shocks that occurred during the sample period.

Table 4.3: Summary of Correlation between ROAE and Liquidity Ratio by Bank

Summary of Average ROAE, Liquidity Ratio and Pearson Correlation						
	A	B	C	D	E	F
ROAE	13.69%	16.01%	11.76%	23.99%	22.99%	15.90%
Liquidity Ratio	12.64%	23.47%	32.28%	29.94%	23.71%	34.25%
Correlation	8.90%	-37.70%	-47.20%	-23.60%	46.10%	62.00%

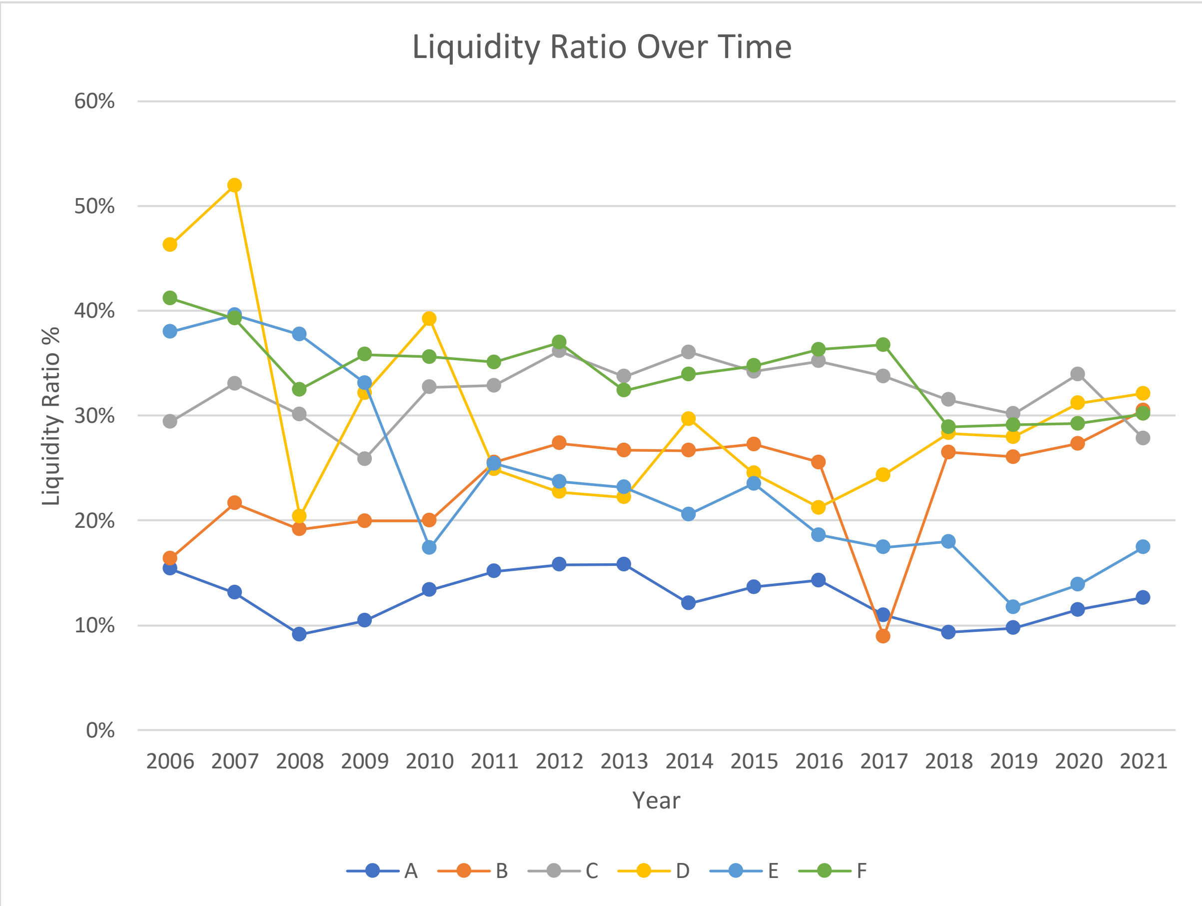
Table 4.3 shows the correlation between ROAE and liquidity ratio by bank. The results show that Bank A, Bank E and Bank F have a positive correlation between ROAE and liquidity ratio with Bank F with the highest positive correlation at 62%. The positive correlation could be caused by the large size of the bank, with banking operations diversified away from consumer banking and a conservative risk appetite. Banks B, C, and D are negatively correlated, with Bank C with the highest negative correlation at -47.7%. The negative correlation may be a result of the unique specialized banking services offered by the banks, as a result we can conclude banks with target

clients have a negative correlation between ROAE and the liquidity ratio. The spread in correlation indicates the unique relationship the liquidity ratio and ROAE exists for each bank.

4.3 Liquidity Ratio and ROAE Over Time

Figure 4.1 shows the liquidity ratio over time by bank. The figure shows how each bank responded to two systemic shock events, namely the 2007-2008 global financial crisis and the Covid-19 global pandemic of 2020.

Figure 4.1: Liquidity Ratio Over Time



During the 2007-2008 global financial crisis all the banks in the sample had a drop in their liquidity, Bank D had the biggest drop from 52% in 2007 to 20% in 2008. This could be a result of its higher risk appetite, focus on consumer banking operating mainly in South Africa made it more susceptible to systemic shocks. From 2008 to 2010 the Liquidity Ratio for all banks increases except for Bank E that continues its downwards trend. This may be a lagged effect of the global financial crisis in its operations outside South Africa affecting the overall group liquidity. During the sample period Bank D has the highest deviation, this could be due to higher risk appetite, not diversified operations and exposure only to South Africa and there do not have to adhere to other jurisdictions regulatory requirements. In 2017, Bank B had significant drop in liquidity which may have been caused by the change in ownership structure which required a large amount of capital. In 2020 the Prudential Authority revised regulation and set the LCR to 80% from 100% due to the Covid-19 global pandemic (Prudential Authority, 2021). However, despite the reduction in liquidity requirements all the banks in the sample increased their Liquidity Ratio in 2020 and 2021 except for Bank C whose liquidity was still higher than Bank A and Bank E. This increase in liquidity could have been because of the Covid-19 pandemic extending into 2021 and the banks staying conservative.

Figure 4.2: ROAE Over Time

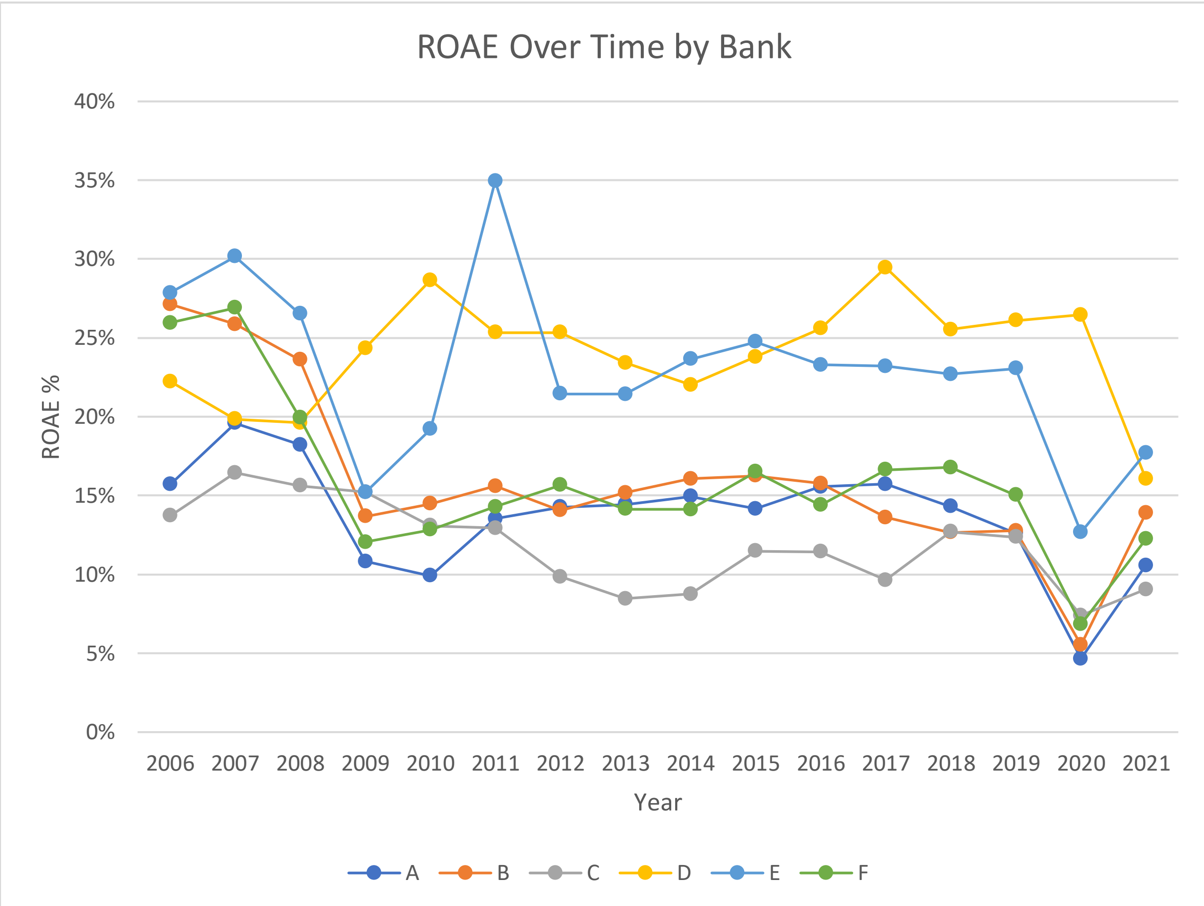


Figure 4.2 shows the ROAE during the sample period. For all banks the ROAE drops between 2007 and 2008 which is during the global financial crisis. According to Claasen and Van Rooyen (2012), the impact of the global financial crisis was mainly in the form of a slowdown in revenue which Figure 4.2 supports. All banks continued to see a decline in ROAE in 2009 except for Bank D which saw an increase, this could be due to no operations in other countries. The decline in

ROAE could be caused by slow economic recovery in all the other and changes in regulation. Between 2010 and 2019 the ROAE remained relatively stable except for Bank E which saw a sharp rise in 2011 and declined to previous levels in 2012, this may have been caused by a restructuring in the operations that led to a significant drop in bank size in 2011 and an increase to previous levels in 2012. All banks except Bank D saw a decline in ROAE during the 2020 Covid-19 global pandemic. The lockdown restrictions impacted multinationals the most as limited economic activity in most countries impacted ROAE. In 2021 all the banks saw an increase in ROAE except for Bank D which experienced a significant decline. Bank D mainly operates in South Africa and hence the drop in ROAE may have been lagged effects from 2020 while multinationals experienced the benefits of the increased economic activity in other countries and hence saw an increase in ROAE.

4.4 Best Fit Model and Optimal Liquidity Results

This section discusses the results of the best fit model for the relationship between the ROAE and the liquidity ratio for each bank. The best fit model is maximized as discussed in chapter 3 to find the optimal liquidity ratio.

4.4.1 Best Fit Models

Table 4.4 shows the Nth degree of the best fit polynomial model, the Adjusted-R^2 used to measure the accuracy of the polynomial equation, the p-value measures the statistical significance of the model. The lower and upper bounds is the range of the liquidity ratio that was used to maximise the ROAE.

Table 4.4: Best Fit Model Results

	Best Fit Models					
	A	B	C	D	E	F
N^{th} Degree	3	3	4	5	5	4
Adjusted R^2	0.05	0.31	0.32	0.16	0.35	0.49
P-Value	0.33	0.06	0.08	0.26	0.09	0.02
Lower Bound - L	0.00	0.00	0.25	0.00	0.00	0.25
Upper Bound - U	1.00	0.53	0.38	0.55	1.00	0.50

Bank A and Bank B had best fit polynomial to the 3rd degree, Bank C and Bank F to the 4th degree and Bank D and Bank F were fitted with polynomials to the 5th degree. Bank A has an Adjusted-R^2 of 0.05 and a P-Value of 0.33, making it statistically significant at confidence level of 50%. Bank A has the weakest fitting equation amongst the sampled banks.

Bank B, Bank C and Bank E have an Adjusted-R^2 ranging between 0.30 and 0.35 and statistically significant at a 10% alpha level. Bank D has an Adjusted -R^2 of 0.16 and a P-Value of 0.26 making statistically significant at 50%. Bank F has an Adjusted-R^2 of 0.49 making it the best fit model compared to the other banks with a P-Value of 0.02 and therefore is statistically significant at 5%.

4.4.2 Optimal Liquidity Results

The best fit models are maximized as per Equation (3.2) to find the optimal liquidity. The optimal liquidity is the liquidity ratio each bank should hold to maximize the ROAE.

Table 4.5: Optimal Liquidity Ratio and Maximised ROAE vs. Average Liquidity Ratio and Average ROAE

	Optimal Liquidity and Maximized ROAE					
	A	B	C	D	E	F
Opt LiqRat	14.74%	15.29%	31.20%	40.59%	42.35%	41.23%
Avg LiqRat	12.64%	23.47%	32.28%	29.94%	23.71%	34.25%
MaxROAE	15.46%	23.64%	13.11%	27.73%	35.79%	24.58%
Avg ROAE	13.69%	16.01%	11.76%	23.99%	22.99%	15.90%

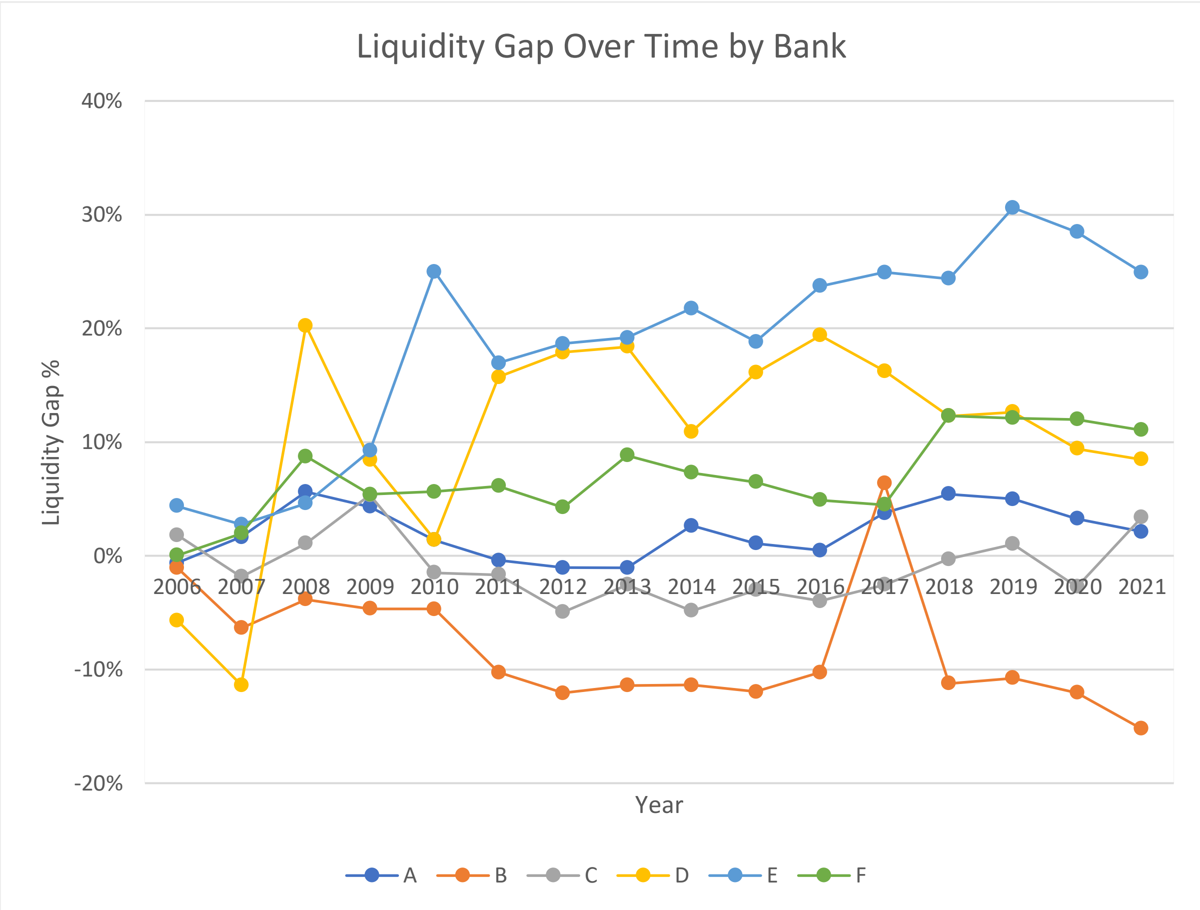
Table 4.5 shows the optimal liquidity ratio and the maximized ROAE compared against the average liquidity ratio and the average ROAE. The optimal liquidity ratio is higher than the average liquidity ratio for Bank A, Bank D, Bank E and Bank F. This could be because these banks have large consumer deposits and have a medium to high-risk appetite, and so must hold more liquid assets.

Bank B and Bank C have an average liquidity ratio greater than the optimal liquidity but an average ROAE lower than the MaxROAE, this indicates that the average ROAE can be increased if the banks lower their liquidity ratio. Bank B and Bank C hold relatively low consumer deposits with a low-risk appetite and so holding more liquidity will not maximize shareholder value.

4.5 Liquidity Gap Over Time

As a measure of liquidity risk the liquidity gap is the difference between the optimal liquidity found by the polynomial equations and the actual liquidity risk. A positive liquidity gap indicates a high deviation from the optimal liquidity of the bank. Figure 4.3 shows the liquidity gap over the sample period.

Figure 4.3: Liquidity Gap Over Time



During the 2007-2008 global financial crisis Bank D had the largest liquidity gap and was at highest risk. This could be because it only operates in South Africa and so does not need to adhere to regulation across multiple jurisdictions. Chen et al. (2021) found that banks that had lower capital ratios had greater liquidity risk during the global financial crisis and this is supported in Figure 4.3. Bank B during the sample period had a liquidity gap less than 0, had low liquidity risk except in 2017 when its liquidity gap was approximately 8%. This increase in liquidity risk was caused by a large capital expenditure as the bank restructured its ownership. Bank C on average has a negative liquidity risk, this could be because it offers specialized banking services and has a low-risk appetite. Bank A and Bank F have liquidity risk that is relatively stable except, both banks have a operate in multiple jurisdictions and over the sample period showed a consistent medium-risk appetite within the consumer segment of its operations.

Bank D and Bank E on average have the highest liquidity gap during the sample period indicating they have the highest liquidity risk. Bank Es liquidity increases during the sample period from 4% in 2006 to 25% in 2021, this may have been caused by a reduction of its short-term liabilities such as consumer deposits and so a reduction in liquid assets held to meet regulatory requirements. Bank D has the most changes in liquidity risk over the sample period, because it only operates in South Africa and targets high-risk consumers its liquidity risk over time is impacted by the economic environment and its impact on this segment of the population.

4.6 Hypothesis and Robustness Test

To examine whether the liquidity gap (LG) has explanatory power towards shareholder value compared to the conventional liquidity ratio a regression analysis was performed, using equations 3.4 and 3.5. The shareholder value is proxied by ROAE. Table 4.6 shows the results of the regression model 3.4.

Table 4.6: Regression Results with Liquidity Gap

Coefficient	Estimate	t-value	Pr(>|t|)
(Intercept)	0.15	0.98	0.33
LG	0.17	2.98	0.00
Size	0.00	0.07	0.95
Tier1	0.29	2.09	0.04
CAR	-0.50	-2.60	0.01
IL	-0.14	-0.68	0.50
ROAA	2.68	3.63	0.00
Adjusted R-squared: 0.43			

The results in Table 4.6 also show that Tier1, CAR and ROAA are statistically significant and contribute to the ROAE. Increasing Tier1 and ROAA has a positive impact on ROAE while reducing the CAR increases the ROAE. Bank size and IL which is a proxy for loan book performance have no statistical significance in determining the ROAE. The regression model has an Adjusted -R^2 of 43%, which means that the model predicts 43% of the ROAE.

Table 4.7 shows the results of the regression model 3.5. The results show that the Liquidity Ratio (LR) is not a significant variable in modelling the ROAE. The Tier1, CAR and ROAA are significant with the absolute value of the t-value greater than 2. Bank Size and IL are insignificant even with the addition of the of the LR variable.

Table 4.7: Regression Results with Liquidity Ratio

Coefficient	Estimate	t-value	Pr(>|t|)
(Intercept)	0.03	0.16	0.87
LiqRat	-0.01	-0.23	0.82
Size	0.01	1.00	0.32
Tier1	0.36	2.53	0.01
CAR	-0.63	-3.16	0.00
IL	-0.24	-1.14	0.26
ROAA	3.71	5.40	0.00
Adjusted R-squared: 0.37			

Comparing the results from Table 4.6 and Table 4.7, the liquidity gap (LG) is significant with a t-value greater than 2 and p-value significant at 1% and therefore plays a role in shareholder value. We do not reject the null hypothesis. Compared to a similar study by Zhang et al. (2020), LG is also significant at 1% for the different measures of expected equity value for Chinese banks. The liquidity ratio (LR) that has a t-value less than 2 and a p-value greater than alpha at 1%. This result differs from that found by Rudhani and Balaj (2019), who found that the LR is significant at an alpha of 1% in a linear regression model.

The coefficient of LG is positive, suggesting a positive relationship between LG and the ROAE. This indicates the larger deviation from the optimal liquidity the larger the expected shareholder value for South African banks, however this would increase their liquidity risk. Zhang et al. (2020) found that the LG had a negative coefficient meaning the expected equity value of Chinese banks reduces as the LG increases.

4.7 Summary

This chapter focused on quantifying the optimal liquidity that maximizes shareholder value and withstands liquidity shocks. As a proxy for shareholder value the ROAE was used, and polynomial equations were developed mapping the liquidity ratio to the ROAE. The polynomial equations were found to be statistically significant and maximized as per equation (3.2) to find the optimal liquidity ratio.

Furthermore, as a measure of liquidity risk the Liquidity Gap, LG, the difference between the optimal liquidity and the liquidity ratio was calculated. A robustness test was conducted by running a regression to measure the significance of the LG in determining the ROAE. The LG was found to be statistically significant.

4.8 Conclusion and Recommendations Conclusion of the Study

The study found that the optimal liquidity ratio that maximises ROAE and allows banks to withstand liquidity shocks can be quantified. Furthermore, the liquidity gap, the difference between the optimal liquidity ratio and the liquidity ratio can be used as a proxy for liquidity risk. The trend analysis over the sample period of 2006 to 2021 found that liquidity risk significantly affected by internal factors than systematic shocks such as the 2007-2008 global financial crisis and the 2020 Covid-19 pandemic.

This study concludes that to effectively manage liquidity risk, an optimal liquidity measure that depends on the unique nature of the banks counterparties and exposures must be developed.

4.9 Policy Implications of the Research

The first key finding is that there exists a unique optimal liquidity ratio for each bank. Banking regulators should then not use a general approach and should consider the uniqueness of each bank, Berger and Bouwman (2009) and Horváth et al. (2012) found in their studies that capital regulation had a negative impact on liquidity creation for smaller banks. Based on this, liquidity risk should be treated similarly to the Internal Ratings Based approach (IRB approach) to capital requirements for credit risk. The IRB approach aims to achieve additional risk sensitivity and incentive compatibility, this structured approach can provide a framework which encourages banks to continue to improve their internal risk management practices (BCBS, 2001).

The second key finding suggests bank regulators should drive policy to encourage banks to hold their optimal liquidity. From the regulators perspective this approach would lead to confidence and stability in the banking sector as banks would hold enough liquidity to withstand liquidity shocks and maximize shareholder value.

4.10 Recommendation for Further Research

The debate on the appropriate measure for liquidity risk continues amongst academics and regulators. Academics argue that the LCR and NSFR are not scientifically founded and have different implications based on bank size. Therefore, we recommend that research be conducted aimed at developing a liquidity risk measure that follows guidelines like the IRB approach to capital requirements guidelines.

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