
# UNIVERSITY OF WITWATERSRAND

## WITS BUSINESS SCHOOL

Degree:

**MASTERS OF MANAGEMENT IN FINANCE AND INVESTMENT**

Research Topic:

**BOND MARKET SIZE, LIQUIDITY AND BOND YIELDS IN AFRICA**

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This research is submitted in partial fulfilment of the requirements for the degree of Master of Management in Finance and Investment at Wits Business School, University of the Witwatersrand

**Abstract**

This study investigates the relationship between the size and liquidity of African bond markets to the cost of debt capital in the form of bond yields. While recognizing studies such as Houweling, Mentink, and Vorst (2005) that indicate the size of bond issuance affects the liquidity of bonds in the markets, this study also tests for any connection between size and liquidity for the African region. The empirical analyses were conducted in various African markets that include; Botswana, Egypt, Ghana, Kenya, Mauritius, Namibia, South Africa, Nigeria, Morocco, and Zambia, for a period ranging from 2009 and 2019, using both panel regression with fixed effects and a factor model of sorted portfolios. Although the results of the analysis were mixed across different countries, there is evidence of a negative relationship between liquidity and yields as well as a positive relationship between size and yields. However, we recognize that the results also indicate that size is closely and positively related to liquidity in most of the African countries under study. More research can be done to identify and test other factors that affect bond market liquidity, and how they impact yields to give strength to this research's finding.

**Acknowledgements**

I would like to thank my supervisor, Prof Odongo Kodongo, for his thorough guidance, patience, and reassurance during this research process. I also thank my family for their support and the motivation from my classmates and lectures in the Masters of Management in Finance and Investments. Finally and mostly I thank God, for the opportunity to do this research and for spiritual strength to keep me going.

**Declaration**

University of the Witwatersrand, Johannesburg

Wits Business School

SENATE PLAGIARISM POLICY

Declaration by Students

I Tebogo Masepekere Magoro (Student number: 0605315H) am a student registered for the degree of Masters of Management in Finance and Investments at the University of Witwatersrand's Business School in Johannesburg, South Africa. I hereby declare the following:

- I am aware that plagiarism (the use of someone else's work without their permission and/or without acknowledging the original source) is wrong.
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- I have followed the required conventions in referencing the thoughts and ideas of others.
- I understand that the University of the Witwatersrand may take disciplinary action against me if there is a belief that this is not my own unaided work or that I have failed to acknowledge the source of the ideas or words in my writing.

Signature:  Date: 18 March 2019

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**INTRODUCTION SECTION**

# 1. Introduction

## 1.1. Background and Context

### *1.1.2. Background*

It is said that there the history of bonds dates back to millenniums ago. Whether that is true or not is not the purpose of this paper. Through the years the bond market somehow grew to where it is today. In not-so-distant history governments were issuing bonds to borrow for the funding of wars and as used post-war for development (Garbade, 2008) and provided a haven during the great depression. These bonds were sold largely to other countries' governments or to very wealthy investors. Over the year the world bond market has grown to over USD110 trillion according to Tissot (2018).

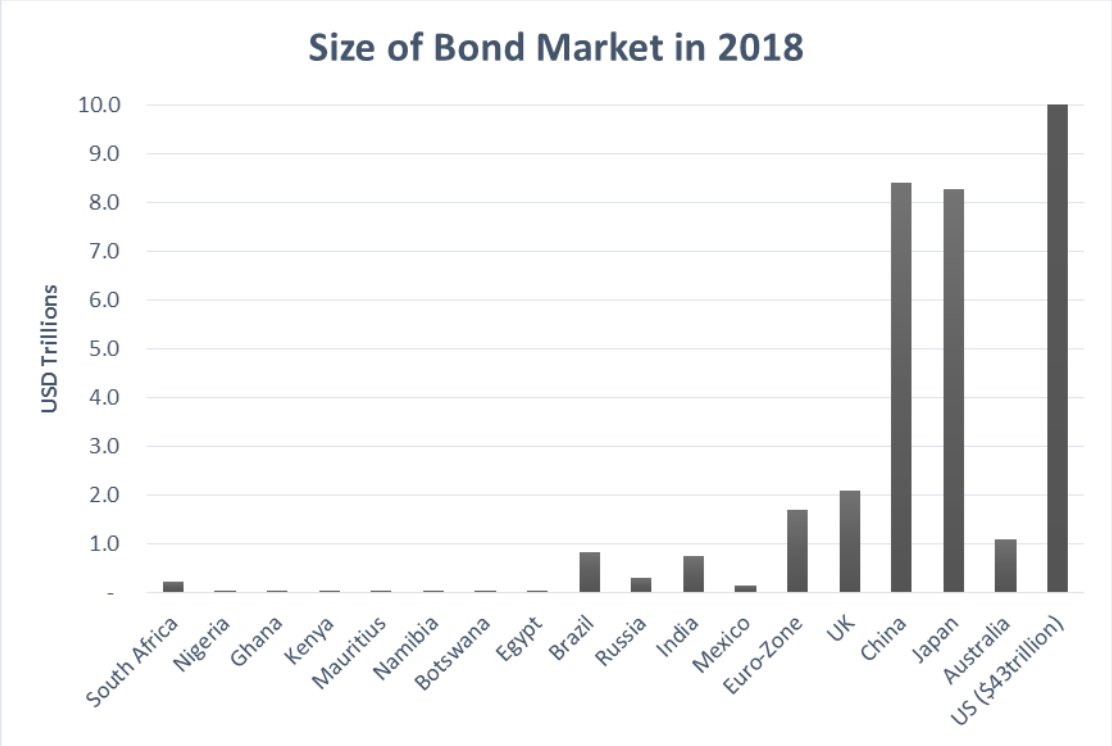


*Figure 1: Size of the Bond Markets by Value (Source – various central banks and exchanges)*

Most bond markets in Africa are relatively small and underpinned by underdeveloped local financial systems as demonstrated by Figure 1. Although the bond markets are rapidly growing (Table 1), there are limitations in some countries due to regulatory restrictions and underdeveloped trading and settlement infrastructure, which dampen the ability of corporates to use the bond markets to finance their productive investments. Because of this, most African bond markets are dominated by the government (public sector) issues. It has been pointed out that the debt markets in Africa are dominated by the Banking sector, where corporates are able to receive debt capital at a more favourable negotiated cost than they would receive in the public bond markets (Mu, Phelps, and Stotsky, 2013). Similarly, due to the underdeveloped bond markets, some African governments either borrow from the central bank or from international sources (Mu, Phelps, and Stotsky 2013; and McCauley and Remolona, 2000). However, as Table 2 shows, African bond markets are steadily growing, which will enable them to assist in growing the local financial market and facilitate funding of investments; in the process, the bond markets will contribute to the development and growth of local economies (Adelegan and Radzewicz-Bak, 2009).

| | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|
| South Africa (ZAR'tn) | 1.8 | 2.0 | 2.2 | 2.4 | 2.7 |
| Nigeria (NGN'tn) | 5.4 | 7.1 | 6.9 | 9.3 | 9.7 |
| Ghana (GHC'10bn) | 0.9 | 0.9 | 1.2 | 4.1 | 6.1 |
| Botswana (P'10bn) | 1.0 | 1.0 | 1.2 | 1.4 | 1.5 |
| Namibia (N$'10bn) | 1.6 | 1.9 | 3.0 | 3.6 | 4.2 |
| Mauritius (R'100bn) | 1.7 | 1.8 | 2.1 | 2.2 | 2.4 |
| Egypt (EGP'100bn) | 4.5 | 6.0 | 7.2 | 7.3 | 7.6 |
| Kenya (KES'tn) | 1.3 | 1.5 | 2.0 | 2.3 | 2.6 |

*Table 1: Growth in Value of Bond Market (in local currency) (Source – various central banks and exchanges)*

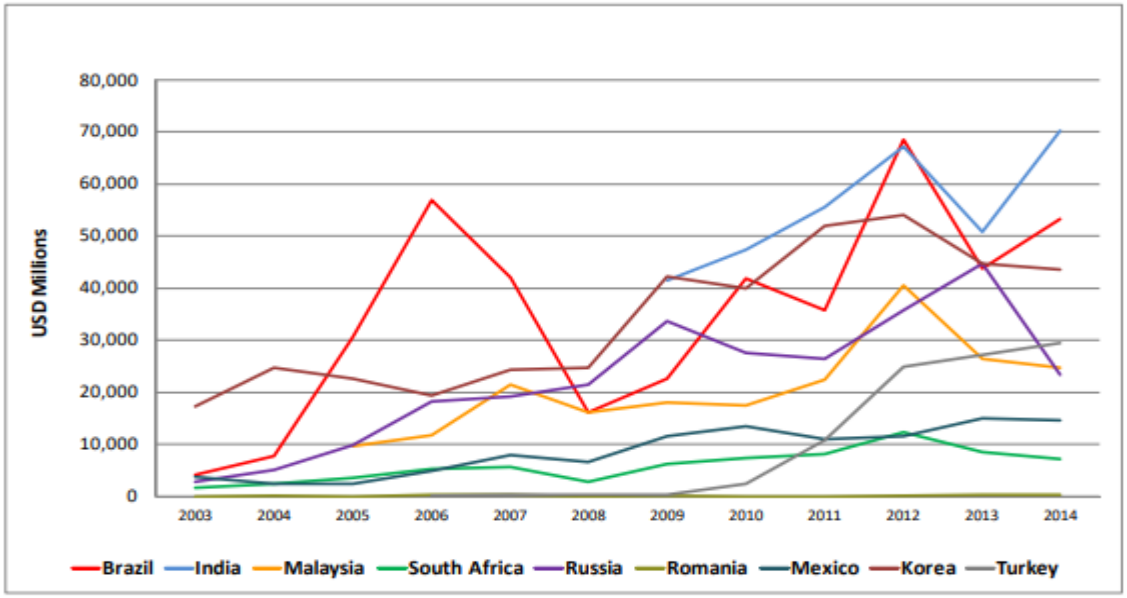


*Figure 2: Corporate Bonds Issuance (source - IOSCO)*

Although many of the continent's markets are small, South Africa has a relatively large and is possibly the most active bond market in the region (Allen, Otchere, and Senbet, 2011). Nevertheless, the South African corporate bond market is still small compared to some other emerging markets (Figure 2) and the liquidity is low with most trading over the counter in the secondary markets (SARB & FCSA's Financial Market Review, 2018). This is not only in Africa, as many other countries including developed markets report low liquidity and activity predominantly in the secondary corporate markets (Luengnaruemitchai and Ong, 2005). However, since the subprime financial crisis, the development of the quality secondary market has been on the radar of many countries. With improved quality offerings in the markets, there will be an improvement in the liquidity of its assets. Studies on liquidity in the African bond market are in their infancy and this paper will be a contribution to this area.

One may ask, but what is liquidity and why should we care about the impact of liquidity in the African bond markets. One way to put it is that liquidity is the ease and speed with which an asset can be bought or sold in the market without decreasing its price dramatically (O'Hara, 1995). Assets that are liquid can be traded easily and not have much reduction in price. In this case, investors are generally willing to pay the price because it is easy to sell when they want. When an asset is illiquid, market participants are not generally willing to pay its intrinsic price because it is not easy to sell the asset whenever they want. Traders in illiquid assets can take longer to find a willing opposite positioned trader to transact with. For this reduced ability to convert the asset to cash, investors generally will only be keen to buy the asset if the price is low enough to compensate for the lack of liquidity, uncertainty of the price that it can be sold for, and the lack of depth in the market for the illiquid asset.

The manifestation of illiquidity (opposite of liquidity) on asset prices can be expressed as the cost of executing a trade. Amihud and Mendelson (1991) give distinct components that constitute transaction costs which reflect the extent of an asset's liquidity. These are the bid-ask spread, the cost of the market impact of the trade, the cost of delays in filling the trade, and the direct costs of brokerage and commissions in fulfilling the trade. Because of these costs, the trade price is not usually the intrinsic price of an asset.

- Bid-ask spread is the difference between the prices at which dealers in an asset are willing to sell an asset in the market and the price they are willing to buy the asset. This difference is a type of cost to investors that compensated the dealers for making available the market and for taking the risk. The bid-ask spread is usually wider in less developed markets and more illiquid assets where it can be harder to find the best price to trade an asset at without incurring higher trading costs (Armitage, Brzeszczynski and Serdyuk, 2014).
- The cost of market impact measures the cost of executing large trades that can move the price of an asset in the market. This cost and regulations can cause investors to break large trades into smaller trades, which will have an elevation in costs impacting the overall trade. Prices will typically move more dramatically in the execution of large trades, with prices increasing with large buy trades and drop with large sell trades. The trader can experience negative price impacts while still trying to fulfil the trade as discussed by Brunnermeier and Pederson (2005).
- When a dealer or investor is trading an asset and is waiting for a willing opposite trader who offers the best prices at which they can complete their transaction, market prices can move against the trader, thereby delaying the execution of the transaction. The trader will then be faced with either abandoning the transaction as prices have moved out of favour at a less desirable level or trade at a less desirable price. The extent or the difference between the initially available prices and the price after the delay is the cost of the delay. Another delay can occur when there is a shortage of traders or dealers to take opposite positions in that asset, which is a reflection of low liquidity (Amihud and Mendelsen, 1991).
- Brokerage and commissions are the fees charged by exchanges, government taxes, and fees by agents in the execution of a trade. These costs can also deter an investor from transacting when they think that the costs are not favourable, and therefore liquidity is impacted.

These transaction costs will have a reduction effect on asset returns and investors will then expect some compensation for bearing the costs reflecting that the asset is not liquid. This will cause investors to lower the price of assets that have higher transaction costs and thereby increasing the expected return on the assets gross of the transaction costs.

The importance of liquidity goes beyond just considering the direct costs. It is important that the liquidity of an asset even that of the market as a whole be known because it affects the ability to convert assets into cash when necessary. Lack of liquidity reflects the level of risk of not being able to have cash available when it is needed. This lack of liquidity can lead to a cash flow crisis for immediate cash flow obligations, which can lead to financial instability or bankruptcy of businesses if not resolved. For this reason, it is also important for a portfolio of assets to have some allocation in the most liquid asset, which is generally cash itself or near cash instruments. As such liquidity allows for the smooth functioning of the financial market system, which gives investors confidence while mitigating some risks.

### *1.1.2. Context*

Some of the early research on the role of liquidity in the bond market can be found in a paper by Sarig and Warga (1989). Since then there have been important works of literature that investigate the characteristics of liquidity and its impact on yields of debt instruments. Some of the attributes about the different methods of measuring liquidity, others on the way liquidity impacts spreads during times of financial crisis as well as liquidity at market level vs at instrument level. Many studies confirm that liquidity positively impacts yields. Nonetheless, there are other studies that confirm that type of liquidity measure will have a different impact on the bond market. Still, others argue that on average liquidity does not impact yields and returns of bonds like Beber, Brandt, and Kavajecz (2007) who concluded that liquidity is not important because credit risk is the most important factor that determined yields. This study will examine if liquidity is priced in the yields on African bond markets and what relationship does it have with the size of the market.

## 1.2. Statement of the problem

The aim of this empirical study is to determine whether liquidity or illiquidity and the size of the bond markets in Africa play a role in informing bond yields.

Over the past few years, the market for bond instruments on the African continent appears to have grown substantially, attracting both local and international investors keep exploiting their higher yields relative to lower yields experienced in developed markets especially post the 2007-2009 financial crisis, for example in 2017 the total outstanding bonds in Africa rose by 13% from the previous year (African Capital Markets News, October 2018). For instance, Ahwireng-Obeng (2016) notes that some African countries have instituted mechanisms to boost liquidity such as merging the once-bonds-only exchanges with equity markets exchanges

and allowing usage of primary dealer system in their issuing of government bonds. This increased investor participation in Africa's bond markets should create greater demand for bonds, increasing their prices and lowering yields (Peiris, 2010). Reduced yields should, in turn, benefit governments and corporates looking to raise capital to meet their investment needs and in the process improve economic output (Amihud and Mendelson, 2000).

However, because there is a paucity of studies on bond markets in the region, it is not clear to what extent yields have declined following increased activity (turnover, liquidity, etc.) in Africa's bond markets. Most of the research done with a focus on African markets has so far focused only on the role of liquidity of the stock markets returns such as Hearn, Piesse, and Strange (2010). In other markets, the majority of studies that have examined the link between (il)liquidity and bond yields have found that (il)liquidity is significantly priced (Houweling, Mentink, and Vorst, 2005; Huang, Sun, Yao and Yu, 2013). Again in other markets, studies such as Helwege, Huang, and Wang (2014) have shown that the issue size of bonds as a type of liquidity measure is priced in the yields.

### 1.3. Research objectives

The research objective of this paper is two-fold:

a. To study the impact of liquidity on the yields of Africa's bond markets;
b. To determine if, in African bond markets, there is a relationship between size and bond market yields in Africa. While other studies have used the issue size of bonds as one of the indirect proxies of liquidity, it would be fruitful to test the connection to other direct measures of liquidity.

### 1.4. Research questions

a. Is there a relationship between the size of the bond market and liquidity in the bond markets in Africa?
b. What impact does liquidity have on bond yields (and thus the cost of debt) in the African bond markets?

### 1.5. Significance of the Study

Given the context that there is very little research done on the impact of liquidity on bonds in Africa, with bond markets that are relatively still underdeveloped that those with comprehensive studies were already done. The contribution of this research will be in academic understanding of the type of role that liquidity plays in African bond markets. The findings of this research will contribute to fuelling the development of research in this area and give

motivation for comparing the commonality or differences of the impact of liquidity in Africa with other emerging and developed markets.

A paper by Hodrick and Moulton, 2009 laid out the role and significance of asset liquidity to portfolio management. To the portfolio managers and investors making decisions regarding the construction of their portfolios, the goal is usually to maintain a balance between gain higher returns while keeping risk lower. In doing so investors consider and make decisions based on various factors before and in the process of constructing and rebalancing their portfolios. These factors include the expected market returns & risk, liquidity, cost of trading and etc. The influence of these factors on portfolio return and risk objectives is highly important when executing trades. During this process, the investor is looking to be able to trade the required number of instruments at a suitable price and this is managed by the investor to ensure stable asset returns.

The point of interest is also for issuers such as the government and corporates, looking to issue bonds in financing for their investment needs, is that when yields are low they are better able to issue more bond because of the lower cost of debt finance (Beau et. al., 2016). This in turn increases the size of the bond market. This paper's ability to evaluate the role of liquidity on yields in Africa will be of significance to these issuers as they analyse the market for a condition that would enable financing at lower yields. One consideration is that in the markets when issuers are expecting that the market conditions will lead to improved liquidity and that their issuance will be liquid, they expect that the cost of capital will decrease (Amihud and Mendelson, 2000).

## LITERATURE REVIEW SECTION

### 2. Introductory Literature Review

This section presents the literature studied on liquidity and market size and how they impact the bond markets, providing a discussion of past papers by different academics on these topics. A theoretical outline will be presented that investigates how liquidity and the size of the market impact asset prices, with a narrowed focus on bond pricing and yields. It has been suggested by Amihud and Mendelson (1986) that there a relationship to be expected between illiquidity and asset returns. This will be followed by a review of identified empirical studies from various articles. The articles will contribute as evidence to existing theories about the effect of liquidity on bonds.

### 2.1. Theoretical Outline

#### *2.1.2. Liquidity Premium*

Early work on understanding liquidity was done by some economists among whom is Keynes (1936) when he introduced the idea of liquidity preference theory. The idea is that people hold money for other reasons than just to as a means to exchange. In his theory liquidity is represented by money or cash at hand, as the most liquid asset. His theory was looking to explain that there are important variables that interact and affect the level of interest rates. Which is the need for savers to keep their saved wealth in cash and the rate of money supply in the economy. Where interest rates represent the willingness to put away money and current consumption. This is defined as the compensation for letting go of liquidity provided by having cash at hand. Keynes (1936) also suggests that interest rates are determined by the supply and demand of money that rely on reasons for people to hold on to cash balances. The demand for

liquidity plays a role in explaining interest rates and their changes. The implication is that investors want to be offered a higher rate of return for holding a less liquid asset than the most liquid cash.

Shackle (1974) discusses this and the basis for liquidity preference. This is in reaction to the uncertainty of what the future beholds, which is unknown. Liquidity provides for people to be able to manage their financial affairs in the future, they are able to roll out the money as needed and thereby gaining the flexibility to be more certain on their liquid position in the future. This supports the theory made by Keynes (1936) and provided a ground for the development of liquidity-based models.

The idea that Keynes implies that the demand and supply of money created for the determination of interest rates, the implication is that the holding of cash or near cash does not mean that interest rates are zero. Keynes's (1936)'s determinations on the liquidity preference theory were received with both positive and some criticism. Robertson (1946) explained that Keynes (1936) only addresses part of the concept of interest rates. The provision made is that different bonds provide different interest rates due to differences in the time and quality of the assets. Robertson (1946) argues that the liquidity preference theory does not explain why default-free near-cash debt instruments like treasury bills as they approach maturity have non-zero yields. The observation is that if bonds have an interest rate and cash at hand has no interest rate. Then the difference in their interest rates, the spread, is determined. However, as the maturity of the bond approaches and gets very short, then there is an existence of interest rates on the near-cash bond, which is no different from cash, but if the liquidity preference theory determines that cash and near-cash have no interest rates. Then this liquidity theory allows for the explanation of spreads between instruments of similar maturity.

The puzzle piece of Keynes's theory and the presentation of near-cash instruments as bearing interest was addressed by Hicks (1939). In the book Value and Capital, he draws on the implication of the liquidity preference theory as it pertains to why bonds of different maturity and quality have different interest rates. With this inspiration, he provides a theory on the liquidity premium and the term structure of interest rates. For this, he considers that a loan is a combination of transactions that are made today and repayment transactions made in the future until the full amount is repaid. The literature observes that there is then a systematic existence of different unknown future interest rates. With this then Hicks (1939) proposes that to attract investors to buy into long-term debt instruments that pay future cash flows requires the compensation of the risk that future interest rates are not known. The implication is that the long rate that aggregates the estimate of the unknown future interest rates would be higher than the current short-term interest rates by the risk premium factor.

With these early theories of the prevalence of liquidity in pricing assets, a conclusion can be made that the determination of the liquidity premium theory asserts that the absence of liquidity

in a long-term asset requires the compensation for taking a risk on unknown future interest rates and asset prices, compensation for providing liquidity and acquiring the non-money and illiquid asset. This concept is researched and used extensively in both academic and real-world applications (Vercelli, 2018).

### *2.1.2. Role of illiquidity on Asset Prices*

In an inspiring paper, Amihud and Mendelson (1986) have assessed and asserted that liquidity affects the prices of financial assets. They considered that market frictions can also contribute to or cause lower liquidity for some assets. Such friction includes trading costs and commissions, which an investor is likely to include in the pricing considerations of an asset. These exogenous costs are treated as regular cash flow items in transacting the asset into its perpetual life. The asset can then be priced by reducing the expected future cash flows, which are in the form of dividends for equities, and deduct the expected transaction costs. The net amounts over the life of the asset are discounted and captured as a sum to form the assets' current price. Costs are therefore a factor that affects or indicates pricing of liquidity.

On the contrary, Eleswarapu and Reinganum (1993) argue that the relationship between asset returns and the bid-ask spread is merely a seasonal effect. In their paper, they investigate the relationship between asset returns and the bid-ask spread in January vs in other months. The paper also determines if the seasonality effect is descriptive of how liquidity impacts return. This is because there is a number of previous research that found that market risk premiums priced by the CAPM model report a January effect and the market return is prominently larger in January as evidenced by Chang and Pinegar (1988). Eleswarapu and Reinganum (1993) also used the same test period (1961-1980) and added an extra 10 years to confirm the results. As they had expected, the liquidity and beta risk premiums are significantly positive in the January months. When the other months are considered, excluding January, the liquidity premium does not seem to be the price. This is confirmed by estimates that are not significantly different from zero. The prevalence of the January effect may be multidimensional and the reason for which is still unclear.

This problem of seasonality in liquidity premium effect on asset returns has been resolved in a study by Brennan and Subrahmanyam (1996), in which they were expanding on the role of liquidity on asset price. In their study, they used a probability test that confirms that there was no significant seasonality in liquidity measured through transaction costs variables which included the bid-ask spread.

The Brennan and Subrahmanyam (1996) paper adjust for other risk factors by using the Fama and French (1993) 3 factors in estimating the relation between returns and illiquidity. Illiquidity is as measured from intraday trade data, which allowed for the differentiating between fixed and variable transaction costs' impacts. In their study, they determined the regression intercept

by controlling for other factor risks. Then using the Fama-French controlled intercept, they used the generalised least squares to examine the impact on returns by market illiquidity. They find that both fixed and variable transaction cost is significant in determining the returns of an asset. However, the bid-ask spread is found not to be consistent as a measure of transaction costs, which could be because the ability of the bid-ask spread to give consistent results is its relation to price levels.

Contrary to the previous paper by Brennan and Subrahmanyam (1996), Brennan, Chordia, and Subrahmanyam (1998) decide to use the monthly value of traded volume to estimate liquidity. This was also because they presumed that this would be a superior way to measure liquidity than the bid-ask spread and availability of data makes it a stronger option. In their study, they also adjust for other risk factors and find that the returns after adjusting for risk are significantly negatively related to trade volume. They thereby conclude that liquidity premium does influence asset prices. This contributes to the collection of literature that confirms the role of liquidity as being meaningful to asset pricing.

Although also confirming the strong relationship between liquidity measured by bid-ask spread and returns, Jacoby, Fowler, and Gottesman (2000) find that returns increase with liquidity in a convex type relationship. They found that contrary to Amihud and Mendelsen (1986) that returns become less sensitive to liquidity the larger the bid-ask spread, Jacoby, Fowler, and Gottesman (2000)'s model indicate that the relationship is convex and that returns are larger for larger spreads. As evidence by Brennan and Subrahmanyam (1996), shows that other market risk factors do affect the results of determining the returns to liquidity relation.

In their study Jacoby, Fowler, and Gottesman (2000) takes out the effect of the bid-ask spread and estimate a liquidity-adjusted capital asset pricing model. In this regard, they derive that liquidity is imbedded in systematic risk and they, therefore, focus on the net after-spread returns of the asset and assume the after-spread returns includes the future unknown bid-ask spreads. Their models also incorporate a non-linear after-spread beta, which is in contrast to other CAPM based studies. The reason for the non-linear beta is because the betas are sensitive to the period length between observations, where using monthly liquidity as measured by the bid-ask spread is stronger on returns than using longer time steps.

### *2.1.2. Liquidity in Bond markets*

As documented above the role of liquidity on asset prices has been documented extensively than we can cover. The general consensus is that liquidity premium is priced into asset prices and the illiquid asset will therefore have higher expected returns. It is important that in the bond market we evaluate the effect on bond yields. It is common for bond yields to be expected to compensate for credit risk. This is the explanation of the spread in corporate bond yields being higher than government bonds (also known as treasury bonds) with similar characteristics,

whereas government bond yields do not account for credit risk because they are deemed to be default-free. A phenomenon was demonstrated by Amato and Remolana (2003), that corporate bond has a spread above the treasury bonds that is wider that what credit risk explains. They explain the excess spread could be due to other risk and market liquidity premia.

Fama and French (1993) had identified two common risk factors in the returns of an instrument in the bond market. These are in relation to maturity and credit risk. They explained that although there is a connection between the bond and equity markets, there are factors in equity asset pricing models that are not so easily considered for bond prices, for example, the value factor calculated using the book-to-market value ratios. Fama & French identified that for bonds, term and default premiums explain the majority of the difference in bond returns.

The maturity premium (term) is derived from the theory around the term structure of interest rates. The difference between the yield of treasury risk-free security with a shorter maturity (generally 1 to 3 months) and the yield of other longer-dated Treasury securities is mainly attributable to the maturity risk premium. This is because interest rates fluctuate over time and that means that because future interest rates are unknown will thus have an element of risk which is priced into longer-dated spot rates.

The default premium (credit risk) is most prominent for corporate bonds and for bonds in emerging and other foreign nations outside the US. This is the risk premium that captures the probability of the issuer defaulting on repaying the bondholder their entitlement to interest or the pay back of the nominal value.

Collin-Dufresne, Goldstein and Martin (2001) study elements that contribute to the changes in credit spreads. In their research, they find that common default risk models only account for about 25% of the change in credit spreads. Their paper sort to explain the residual component of the change in a spread not explained by default. In this regards, they add and test several variables using regression. The regression results showing that the regression residuals of the other variables are highly correlated and point to possible a single source, which implies that there could be an important factor not explained by default and that the prominent factor is probably systematic in nature. In getting an explanation for these unexplained residuals, they add other external factors such as liquidity, financial markets and macroeconomic factors as regressors. After still being unable to connect to a single systematic risk factor. They conclude that the missing factor could be an element that presents the supply and demand dynamics not connected to default or liquidity as concluded by other academics faced with similar results such as Duffie and Singleton (1999).

With the many research that points to the perceived significance of Liquidity as one of the important premiums. The effect of liquidity on bond yields was studied by Helwege, Huang, and Wang (2014). In their study, they consider whether illiquidity in corporate bonds is a distinct premium in bonds yields and not merely capturing part of default risk predominantly

in corporate bonds. This is done by removing the effect that credit risk has on liquidity by analysing the spread between two bonds from the same issuer with similar features, such that their credit risk is the same. The argument is the resulting spread must be due to a spread component that captured the liquidity effect. Various proxies for liquidity are used and these are based on price spreads, trading activity and other factors such as age, issue size and off-the-run feature. The results of the regression show that after credit risk is completely controlled, the regression coefficient related to the liquidity proxies is small. Some of the reasons that the proxy based on prices would have a small effect are because especially corporate bonds tend to have a low frequency of trade, which affect prices by either having missing prices or delay in searching for a willing opposite trader that can lead to unreliable pricing in the deal. This is managed by using the price of other similar bonds, which shows that the liquidity proxies still only explain a small portion of the spread which could be that the spread of bonds with similar features from the same issue is mainly due to random errors. Their study concludes that although liquidity is priced in premium is the bond market, the research results in pointing that most of the liquidity premium captures some credit risk component. With this, one can't help but wonder if in the government bond markets liquidity premium is not significant.

Other pieces of literature that confirm the determination of liquidity in bond yields include Rossi (2014), who found that liquidity account for a significant portion of differences in bond yield spreads of low credit risk bonds. But in high-risk bonds, liquidity was not as significant.

This leads us to think that perhaps investors in lower-rated bonds are not merely seeking to be compensated for liquidity risk. Huang, Sun, Yao, and Yu (2013) studies the bond markets impact of the notion that investors that have no need for liquidity to hold more illiquid assets, which is known as the "Liquidity Clientele Effect". They test the effect based on the spreads of portfolios by some large institutional investors who are mainly insurance companies. The liquidity considerations used are based on the preference of holding corporate bonds. The findings were that there is a persistence in the preferences for the illiquid bond over time and that coincides with the insurer's longer investment horizons and higher ability to hold illiquid bonds. Their paper also shows that this liquidity clientele impacts the liquidity on bonds, which in turn impact the yields spreads in a manner consistent with liquidity premium theories.

### *2.1.2. Corporate and Government Bonds*

Liquidity in corporate bonds has received a lot of attention recently post the financial crisis, with a focus on the contribution of liquidity compared to credit risk. However, in the government bond market, credit risk is assumed to be zero and liquidity in the market could have a different dimension and interpretation.

A prominent factor that has also recently been documented that affects the liquidity between government and corporate bonds in the bond markets is a phenomenon that affects the liquidity

and is evidence that liquidity is an important feature in this market. This phenomenon is flight-to-liquidity. This concept is present also in other asset markets, but it is more dominant in bonds. It has been studied by Longstaff (2004) and others before that when there is instability or volatility in the markets, investors tend to sell out of positions in less liquid assets such as corporate bonds and buy into more liquid assets such as treasury debt. This is consistent with the important role that treasuries (government bonds) play in the bond market as covered by Woodford (1990), who asserted that the size of public debt creates the amount of liquidity in the market. This is also a claim that the size of the market could be related to its liquidity. Longstaff (2004) then considered the impact that flight-to-liquidity has on bond prices and thus on yields.

Economic theory shows that the value of an asset will decrease when there is a flight in its demand such that supply exceeds demand. Standard asset pricing theory is such that the price of an asset today reflects the sum of the value of that asset's expected future cash flows discounted to the present date at the prevailing rates that are consistent with that asset's risk factors. This implies that as there is a flight from corporate bonds to government treasuries, the price of corporate bonds will decrease and their yields will increase, while the government treasuries will see their prices increase and thereby a decrease in their interest rates. The resulting spread between the more liquid and the less liquid bonds will be due to their liquidity as a result of flight-to-liquidity.

#### *2.1.4.1. Corporate Bonds*

The liquidity of Corporate bonds is more comprehensively studied in recent years. This has involved various studies of the credit spread puzzle that asserts that corporate bond yields spread in excess comparable government bonds yields are much wider than the bond's default risk component (Amato and Remolona, 2003). Other prior papers indicated that liquidity is an important component of the corporate spread Sarig and Warga (1989), Houweling, Mentink, and Vorst (2005).

Helwege, Huang, and Wang (2014) have documented that price in corporate bond markets can be problematic in analysis price based liquidity proxies. Sarig and Warga (1989) sort to describe the way that liquidity affects discrepancy in bond prices. Their research shows that when the reported price of bonds are inferior, the liquidity on the bonds is reduced and the change that the price will the updated will be reduced due to lower liquidity and thus the frequency of inferior prices increase. This discrepancy in prices affects the liquidity of bonds and the reliability of using some liquidity proxies. They attempted to investigate liquidity in the bid-ask spread, age of the bond and issue size. They found that bonds that are relatively younger reduced the price discrepancies and that filtering on the bid-ask spread and issue size also reduces the discrepancy, but this results in bonds with different characteristics that the

market. The implication of their study is that illiquid corporate bonds stay illiquid for longer and especially if they are older small issues.

In recognising that the corporate bonds tend to take place in over the counter trades and that price based liquidity measure could pose a number of problems, Houweling, Mentink, and Vorst (2005) use less traditional liquidity proxies. In the study, they find that there's no indirect liquidity proxy that is more highly significant than others in the pricing of corporate bonds. The paper involved the creation of portfolios sorted based on the value of the liquidity measure for each liquidity proxy, where nine liquidity proxies for the bond market were considered. The proxies that were considered included the issue size of the bond, the age of the bond, the availability of prices, volatility in bond yields, if the firm's equity is listed, currency-denominated, whether a bond is an on-the-run bond, dispersion of yields expected by market participants, and several contributors in the bond. Of the portfolios created by the ranking of bond's liquidity measure, the portfolio of bonds with the lowest liquidity values was analysed using two models, where one modelled the liquidity premium as a consistent variable and the other modelled the variation of the liquidity premium over time and the size of the liquidity measure. The results of their research show that there is significant confirmation that liquidity is priced in the corporate bond market. Furthermore, they find no individual liquidity measure is relatively more superior to the others, after running regression models that combine pairs of liquidity proxies. However, it should be noted the results of this study was based on the European corporate bonds market.

#### *2.1.4.2. Government Bonds*

As government bonds are alleged to be exempt from default risk, it implies that these bonds are considered to be safer and provide for the accumulation of value over time. For this reason, the pricing of many other assets depends on the yields of near money default-free government bonds. This also explains why the liquidity preference phenomenon of flight-to-quality and flight-to-liquidity goes in the direction of government bonds Xiong (2017).

That liquidity contributes to the pricing of government bonds was earlier studied by Elton and Green (1998). However, they observe that the impact is not as large as suggested and that it is mainly concentrated on the longer maturity bonds. The relevancy of taxes is also presented in their study in light of discovered connection of the bond coupon to tax effects Scharfer (1982). The reason for their study was to distinguish the factors that can cause noise in government bond prices. The relevance of both taxes and liquidity as measured by trading volumes is found to be small.

Berentsen and Waller (2018) theorise that the returns on government bonds reflect liquidity as opposed to fiscal policy changes as measured through taxes. Cochrane (2019) re-introduces the fiscal theory of price levels that states the concept that price levels reflect fiscal policy rather

than monetary policy through the policy rate. The idea is that the value of the bonds outstanding reflects the discounted future cash flows to be received by the government, of which its main income stream is through taxes. The implication is that as fiscal policy changes, then this will drive the changes in government bond prices and yields. Berentsen and Waller (2018) point out that because these bonds are often used as collateral in the markets, the prices of these bond instead reflect some form of liquidity premium. In their paper, they create a model that takes in the government bond as used for collateral in lending contracts. The indicate that the liquidity premium is present in the price level of the government bonds when the real value of the bonds are low and the opposite is true when the values are high and the price level reflects the fiscal policy impact.

As literature shows that the role of liquidity in government bond price is surrounded by other economic and financial factors described in the last two works of literature mentioned. However, the roles are still reported as being meaningful although it is not consistently clear.

Although not really government bonds, but government-guaranteed bank bond yields can often behave similarly to government bonds in normal and mild crisis market conditions. This is shown in Black, Stock, and Yadav (2016) in the paper about the pricing of the various dimension of liquidity. The objective of the paper was to examine if the government guaranteed bank bonds are pricing in the dimensions of liquidity related to depth, trading costs and resilience. These dimensions of liquidity have been identified as important and relevant by various kinds of literature on market microstructure such as Garbade (1982) and Kyle (1985) among others. Black, Stock, and Yadav (2016) claim that their study is the first to have empirical evidence that shows that resilience liquidity is priced in the bond markets. The approach of their work they are able to easily split the yields spreads into their default and non-default parts. This allowed then to be able to evaluate the effect of the liquidity measures as a combination and individually. Their results showed that all evaluated dimensions of liquidity are significant in the non-default portion of the spread, with resilience and trading costs being more significant. After finding that trade costs, depth and resilience are priced, there is a very small persistent residual that is not is related to default risk during crisis periods, to which they deduce that it is a premium that represents a flight to extreme liquidity as mentioned in Longstaff (2004). The tiny residual being uncorrelated to default is not significant when the effect of taxes are removed.

The study by Black, Stock, and Yadav (2016) is one among other interesting papers that approach liquidity using the bid-ask spread as it shows the tightness of the market as well as turnover volumes as they indicate how deep the market is. This considers the main properties of liquidity as identified by Baker (1996). These extensions allow for the consideration of liquidity from different viewpoints. Some of the dimensions include depth, as measured by trade volumes of the bond issues, which is the extent that a trade can be executed in a short period and not impact the prices. Large trade volumes that don’t affect prices are an indication

that the market is deep. Another is tightness or width as measured by the bid-ask spread is a good measure for liquidity expressed through transaction costs. The spread provides a reward for the market's creation of liquidity. Including trade costs like the charges charged by brokers, costs of processing orders and taxes levied directly affect returns (Atkins and Dyl, 1997).

### *2.1.2. Measuring Liquidity in Bond Markets*

Liquidity is defined in various ways, but the general market and academic research use the definitions as described earlier by O'Hara (1995). Just as widely as the definition and views points of liquidity has been researched, so are the difference in measures. There is no general measure that is a catch-all for liquidity and it can just also be as difficult in finding data for each measure.

Both direct and indirect liquidity measures have been derived and reviewed in various literature on the bond markets, with direct measures posing a challenge in corporate bond markets that are prone to trade on over the counter platforms, Houweling, Mentink, Vorst (2005).

Fleming (2003) examined a wide range of liquidity measures against each other, over times and in different securities. The analysed measures included bid-ask spreads, trading frequency, traded volumes, on-the-runs yield spreads, quote size, trade size and price impact measures. In this paper Fleming (2003) discloses that the bid-ask spread is the most convenient measure to use for evaluating liquidity, followed by moderate measures disclosed as on-the-run yields spread, quote size, and trade size. The weaker measure was found to be traded volumes and trading frequency as evaluated for correlation with times of illiquidity in the market. Order flow as a measure of the price impact of liquidity was found to explain a large proportion of prices. Another measure, one that calculated liquidity at an aggregated level was derived by Bao, Pan, and Wang (2011) using the Roll (1984) measure.

The following are a few of such measures that have been discussed above or have been found to be instrumentally meaningful in bond markets.

- Bid-Ask Spread
  Amihud and Mendelsen (1986) have identified the bid-ask spread relative to price traded as a measure of transaction costs. They focus their study on using a portfolio selection based on ranked average bid-ask spreads. Their paper also controls for other risk premium factors before examining the effect of the bid-ask based liquidity measure. Results indicate that higher spreads imply higher expected returns as expected of a true illiquidity measure. A wide number of papers have used the bid-ask spread as a proxy measure for liquidity.
- Order Flow Price Impact
  One widely used measure for liquidity is that developed by Amihud (2002). A measure called the ILLIQ was developed as the ratio of stock returns to the volume traded on a daily

basis and averaged over a longer time period. The measure was subsequently used and it was found to be highly significant in the bond markets (Fleming, 2003; Huang, Sun, Yao, and Yu (2013)). This is used to show that asset price changes are also in reaction to traded volumes, showing a highly significant and positive response from this illiquidity measure. This liquidity measure uses the same concept as that of Kyle (1985)'s measure. For each asset the ILLIQ is calculated as follows:

$$\text{ILLIQ} = \frac{1}{D}\sum_{t}^{D}\frac{|R_t|}{\text{Vol}}$$

Where D is the number of days in the full period under review, $R_t$ is the return of the stock on day t, Vol is the volume traded on that day.

Amihud (2002) also point that this measure is showing a relationship between liquidity and size of assets as measures by the asset's market value.

A larger Amihud measure indicates that trading a bond causes its price to move more in response to a given volume of trading, in turn, reflecting higher illiquidity

The above are some of the commonly used spread-based and price impact based measures of liquidity. Schulz (2001) has estimated liquidity using regression and regressing a dummy variable of buy and sell trade types to the difference between the price traded at and the bid price of that asset. Similar to the bid-ask spread, Han and Shou (2007) used a quartile of trade prices as the bids-ask spread relative to the average traded price.

- Roll (1984)

  This proxy for liquidity measuring uses the autocorrelation of daily returns between daily consecutive days as follows

$$\text{Roll} = \begin{cases} 2\sqrt{-\text{cov}(r_t, r_{t-1})} & \text{if cov} < 0 \\ 0 & \text{otherwise} \end{cases}$$

  The Roll measure is measured in units of the $t-1$ price. Noting that the covariance has to be negative for this measure to be reliable. This roll measure is telling a similar story to the bid-ask spread in that the more negative the covariance the higher the bid-ask spread of the bond and implying more illiquidity.

  Bao, Pan, and Wang (2011) have used a modification of Roll (1984) by using the negative of the covariance of price returns without regards to where the covariance was negative or not. This measure is described as considering broader liquidity effects on prices outside of just bid-ask spreads than the Roll measure which mainly captures bid-ask spread effects. In addition to the spread based and price impact based measure, there are other measures derived that are based on traded volumes (Hasbrouck, 2009; Kyle (1985), Pastor and Stambaugh (2003).

Among the direct measure presented above are other measures based on trading activity, which have been shown to be highly more significant when activity is high. One such measure is the turnover rate which is a liquidity proxy that measures aggregated daily trading volumes as a percentage of the issue size of the bond. This measure was also coined by Amihud (2002).

Studies by the various author have advised that liquidity in bond markets is also driven by other factors that are specific to the bond market. Factors such as the age of the bond, the coupon rate, the time to maturity and the issued size have been shown to be significant liquidity premiums by Houweling, Mentink and Vorst (2005).

### *2.1.2. The Size Effect*

While this paper is to consider the effect of size on liquidity and yields, we can't close off the review of works of literature without a quick summary of this effect. On various papers bond issue size is reflected as a proxy measure for liquidity. Fisher (1959) indicated that bonds that have a larger issued size must have higher trading frequency and this implies that issue size must be considered as a liquidity proxy. Houweling, Mentink, Vorst (2005) uses size as an indirect liquidity proxy. Using regression models based on Fama and French (1993) regression models with factors for maturity, default risk and interest rate risk being removed, the issue size was found to be significant in bond spreads, however, the effect was small and comparable with other indirect liquidity proxies in terms of superiority. Other papers document inconsistent results in corporate bonds where both positive and negative impacts of issue size on yields have been reported. A study by Crabbe and Turner (1995) has been done to examine the yield effect of liquidity in large corporate debt issues. Their paper tested if liquidity is higher or increasing with larger bond issues. The results did not indicate that larger issue sizes are more liquid and their yields show no sign of a difference between large and small bond issues attributable to liquidity in corporate bond markets. In their paper, Houweling, Mentink and Vorst (2005) mention that liquidity is sometimes said to be indicated by the issued size of bonds and that banks tend to build their portfolios based on the liquidity of bonds. In government bonds, the effect of the size of the bond issues is mainly negative, but meaningful in the determination of yields such that issues that are small tend to have larger yields. As discussed earlier in my literature review, Sarig and Warga (1989) also claim that small issue bonds are prone to have a persistently lower price and persisting illiquidity as investors who buy then will tend to hold them for longer.

## 2.2. Empirical Evidence

The following empirical studies will now be review for evidence of liquidity effect in bond pricing in various markets across the world, this adds to the already mentioned literature that

also confirmed their theory with empirical evidence. Below are details of other empirical works related to the themes presented in this paper.

### *2.2.2. Friewald, Jankowitsch & Subrahmanyam (2012)*

The study titled "Illiquidity or credit deterioration: A study of liquidity in the US corporate bond market during financial crises", Friewald, Jankowitsch & Subrahmanyam (2012) examine if liquidity is priced in the corporate bond markets in the US with a special focus on the effect during a financial crisis. The main goal of their research was to control for credit risk as measured by credit ratings and find a measurable effect of liquidity factors on bond yields spreads that indicate the difference between the yields on corporate bond yields and risk-free debt rates with comparable duration. The liquidity factors considered include trading activity variables and bid-ask and price dispersion measured and the authors aim to quantify these as factors in the pricing of bonds. Another goal of the research is to determine the effect of liquidity in times of crises as they expect that this would be strong because of capital constrains and increased costs in the handling of instruments during a financial crisis.

In order to achieve their goals, they analysed a wide range of data covering the entire corporate bond market in the US as extracted from various sources such as Trade Reporting and Compliance Engine (TRACE), Markit, Bloomberg and Standard & Poor (S&P). The data considered was the period from October 2014 to December 2018, which was broken into sub-periods based on any event that could have affected the market. The daily data were aggregated to weekly data before the regression model was analysed. They were able to collect detailed data and information on corporate bonds and their transactions. This enables them to measure the various liquidity factors. From the collected data, they drew a sample of trade information that were representative of the entire market including the lowest liquid part of the market that presented some bias due to not much trading activity at that level of the market.

The liquidity proxies considered where measured from bond characteristics and this included age, coupon, issue size, and maturity; the trading activity variables which included intervals between trades, the number of trades, and trade volumes; and other liquidity measures such as Amihud (2002) price impact measure, the Roll (1984), the zero-turn measure that tracks days of zero returns, and the trade price dispersion measure as introduced by Jankowitsch, Nashikkar, and Subrahmanyam (2011).

In order to determine the dependent variable, they took the spread of the yields between corporate bonds and zero-coupon risk-free bonds with the same maturity as the duration of the corporate bond. Take the consideration that the durations be equal will adjust for any effect of the corporate bond's coupon. The methodology employed was first to regress the panel data and observe for integration of yield spreads and any autocorrelations. Then they run a regression and a cross-sectional regression process with the change in yields spreads as the

dependent variable and the change in the liquidity proxies as the explanatory variables as well as a variable to account for credit ratings.

The results of the empirical study show that as expected the regression that excludes the liquidity proxies indicated that the credit rating is very significantly priced in yields spreads. Furthermore, the regression that includes all liquidity proxies shows that all are significantly priced. The Amihud (2002) measure and the trading activity measure that measures changes in trade volumes and trade frequency were the most significant. When the regression is run for the sub-periods it is discovered that nearly all liquidity proxies become a lot more significant during the subprime financial crisis, with Amihud (2002) and trade price dispersion factors being the most important. Similar results are found in the cross-sectional regression.

### *2.2.2. Favero, Pagano, von Thadden (2007)*

In contributing to existing literature that trading costs are caused by illiquidity and the confirmation that there is then extra added risk, in a paper that investigates "How Does Liquidity Affect Government Bond Yields?", Favero, Pagano, von Thadden (2007) aimed to answer this question based on yields difference in the Euro area's sovereign bonds. Although the Euro area was able to control for currency risk in their financial markets, however, the government bonds still showed major yield differences. The authors say that market participants perceive that this difference could be due to liquidity differences, and they are seeking to examine this possibility.

The data used in the study was collected for the period from January 2002 to December 2003 at daily frequencies from Euro MTS Group's European Benchmark Market. The collected included bid-ask spreads, volumes on all best bids and best ask prices as well as trading volumes for each bond in all markets. Maturity and yields were derived from this data and various liquidity measures were calculated. Evaluating the spread across countries did show some unexplained variations in the yields, and there is a tendency for the yields to move in unison.

In the empirical evaluation, their paper presented to resolve three hypotheses. First that the yields difference is either not influenced by aggregate risk if risk affects all yields equally or if the aggregate risk is higher for those bonds that are fundamentally risky than the others then the yield differential reflects aggregate risk. The second hypothesis is that the yields difference is depending on differences in transaction costs, and the last is that the aggregate risk negates the effect of transaction costs on the yields differential.

The methodology involved the calculation of the aggregate risk as to the spread between the fixed-rate US Swap and the same maturity government bond in the US because of the relative ease of getting that data for various maturities and its close connection to the aggregate market

risk. Yield differentials from the Euro area with different maturities were derived and after considering other measures the bid-ask spread was adopted for this study. The yields differential will use as the bond yield benchmark for the 10 years and 5-year bonds from Germany and France respectively.

With each country considered separately against the benchmark, the yield differential considered as the dependent variable regressed its lagged variable, the aggregate risk, liquidity, interaction of aggregate risk and liquidity, and the maturity. The regression results show that both the lagged yields and the maturity differentials are significant. With regard to hypothesis 1, the aggregate risk is highly instrumental in the yields difference of all countries as the coefficient is both positive and significant. Again, liquidity as measuring transaction cost is also positive and significant in the second hypothesis. However in considering the third hypothesis, the interaction between liquidity and aggregate risk negative but significant. The conclusion is that both aggregate risk and liquidity explain the yields difference, however, the impact is limited by the connection between fundamental aggregate risks and liquidity.

## 2.3. Conclusion

This literature review delivers a summary insight into the theoretical and empirical developments and analysis of the main concepts that will form the basis of this research paper. The role of liquidity in the bond markets has been presented and although many reviewed papers show that liquidity plays an important role, the measure of liquidity and method of the empirical study can give a variety of results. It was highlighted that the structure of the bond market can make the studying of some liquidity measures meaningless as data concerns can disrupt the efficiency in the study, such as the tendency of the corporate bond market to trade mode over the counter and providing for a price transparency problem and also the clientele effect of the institutional investors like insurance companies that tend to buy and hold bonds for longer periods and thus dampening the liquidity of those bonds and as such, they tend to hold illiquid bonds.

Different liquidity measure has been discussed as used in literature among the corporate and government bond markets and the effect in the pricing of bonds in those markets. Measure for liquidity defined and used by various pieces of literature have also been presented.

Other determinant factors for liquidity in the bonds market related to macroeconomic indicators such as the fiscal policy and central bank repo rate were also discussed as factors in the government bond yields determination and how they relate to liquidity.

We also described two studies and the main results of them, while explaining the methodologies used each time and how they each confirm the bond liquidity characteristics that are significant in the yields and pricing on bond.

## 2.4. Shortcomings in Literatures

Literature is abundant on the role played by liquidity in bond markets and its impact on bond returns or yields. However, most of these studies are on developed markets and only a few studies focus on African markets.

Ngugi and Agoti (2009) evaluated the important role played by the bond market in Kenya to create a platform for government and private issue to access longer-term funding for projects. Liquidity was identified as one of the important puzzle pieces in the development of the public debt market.

Among the few studies on liquidity in African Bond markets is a study on microstructure factors that impact liquidity with a special focus on the South African bond market by Kapingura and Ikhide (2011) found that volume and volatility are both instrumental in the creation of liquidity in the bonds market. They further encouraged that other African countries can benefit from a similar study as this may help policy makers.

However, bond markets in African countries are very small, with very rare secondary markets. In some regions, corporate bonds markets are not even established (Allen, Otchere and Senbet, 2011; Mu, Phelps and Stotsky, 2013). Only very few countries have well-established bond markets and even fewer have secondary markets. The infancy of the bond markets in Africa means that academic research in this area is also limited and as the market develops then we'll see some growth in the research coverage. This study will therefore add to the growing need to study and understand the application of financial theory in African bond markets.

## 2.5. Context of this Paper

The concept of my research is to recognise that liquidity has a role to play in African bond markets. This study adds to understanding just how important is the contribution of liquidity on the pricing of bonds and their yields. This study also investigates draws on the relationship between the size of the market and liquidity as they determine bonds yields. The main dependent variable to be analysed in the study are the bond yields. The liquidity and size of the bond market will be the independent variables, of which a review of their connection will also be evaluated.

**METHODOLOGY SECTION**

# 3. Data Collection and Methodology

## 3.1. Introduction

In this section, the source and type of data to be used in the study will be detailed. The definition of the variables will be made as well as the estimation of the models to be used consistent with panel data analysis.

A lot of research has used the size of bond issuance as one of the measures of liquidity. Crabble and Turner (1995) have used and tested issue size on the corporate bond market as a proxy for liquidity while Helwege, Huang, and Wang (2014) confirmed that size as a liquidity proxy is somewhat significant in determining bond yields. Logically this comes from the idea that with a large bond issue size more investors are able to buy the bond offering and it becomes less costly to transact and with the higher number of potential buyers/sellers, liquidity would be higher.

Like in other studies that have used size as a liquidity proxy, this study will determine if there is a nexus between the issue size in the market and other market liquidity measures and bonds yields. This will be tested both at the macro and micro level of the market. Further to this, the study seeks to determine if size and liquidity act jointly, controlling for other factors to inform bond yields. For this, we consider that both liquidity and size can be viewed in different ways. For instance, size can be measured as the aggregate (market-wide) nominal value of bonds outstanding or as the aggregate market value of bonds outstanding where both measures can be normalized by GDP. The focus of this study will be on aggregate market liquidity and size on individual bonds yields.

## 3.2. Data Collection

### *3.2.1. Time period of study*

The time period to be used will span approximately 10 years from 2009 to 2019, mainly due to the unavailability of suitable data prior to this period. This means that the sample period will be impacted by the change in liquidity after the 2008 subprime financial crisis. This time period is enough to evaluate the impact of liquidity on bond yields considering that there were various events that would have impacted liquidity and allow for the collection of sufficient data was possible. This provides for a robust analytical setting over a period with varying market conditions and also allows for analysing through some of the markets progressive times.

### *3.2.2. Choice of countries*

| | Gross Gov Debt % GDP ( as at 31 Dec 2018) | Total Current Outstanding (as at 8 July 2019) | Number of Current Issues (as at 8 July 2019) | Availability of Data on Bloomberg | Bid-Ask Measure (December 2018) |
|---|---|---|---|---|---|
| Angola | 88.09 | 78,885,492,663.27 | 552 | | |
| Benin | 54.65 | 3,108,189,422.64 | 38 | | |
| Botswana* | 12.92 | 1,695,673,725.00 | 14 | Yes | 0.047836 |
| Burkina Faso | 42.96 | 1,507,968,252.21 | 35 | | |
| Burundi | 58.44 | 550,381,212.00 | 451 | | |
| Cameroon | 37.75 | 1,600,954,850.40 | 70 | | |
| Chad | 46.57 | 151,797,352.00 | 8 | | |
| Congo | 15.65 | 617,304,000.00 | 12 | | |
| Egypt* | 92.62 | 179,727,622,203.50 | 215 | Yes | 0.016236 |
| Equatorial Guinea | 35.86 | 44,465,200.00 | 7 | | |
| Ethiopia | 61.09 | 2,000,000,000.00 | 2 | | |
| Gabon | 58.19 | 4,733,557,475.86 | 25 | | |
| Gambia | 83.15 | 376,621,629.11 | 190 | | |
| Ghana* | 59.56 | 29,994,760,619.25 | 168 | Yes | 0.039792 |
| Guinea Bissau | 56.11 | 93,892,444.45 | 8 | | |
| Ivory Coast | 52.20 | 19,291,082,517.42 | 63 | | |
| Kenya* | 57.16 | 36,695,890,045.51 | 167 | Yes | 0.018675 |
| Lesotho | 38.98 | 9,719,124,377.98 | 55 | | |
| Madagascar | 39.66 | 331,738,985.70 | 62 | | |
| Malawi | 61.30 | 32,204,520.53 | 7 | | |
| Mali | 36.62 | 1,283,538,740.13 | 31 | | |
| Mauritius* | 65.20 | 9,382,708,946.38 | 210 | Yes | 0.043476 |
| Morocco* | 65.18 | 43,489,101,297.10 | 81 | | - |
| Mozambique | 100.43 | 3,369,486,206.82 | 91 | | |
| Namibia* | 47.05 | 6,434,544,609.93 | 90 | Yes | 0.039743 |
| Niger | 55.14 | 1,054,267,135.21 | 27 | | |
| Nigeria* | 28.42 | 95,860,336,205.99 | 304 | | - |
| Rwanda | 40.66 | 1,552,617,546.85 | 123 | | |
| Senegal | 64.45 | 9,207,202,674.53 | 24 | | |
| Seychelles | 58.17 | 371,472,644.80 | 105 | | |
| Sierra Leone | 71.31 | 345,469,914.85 | 64 | | |
| South Africa* | 56.71 | 195,324,668,387.23 | 216 | Yes | 0.010242 |
| Swaziland | 34.86 | 501,471,779.09 | 80 | | |
| Tanzania | 35.99 | 4,580,158,032.17 | 200 | | |
| Togo | 74.60 | 1,868,587,645.91 | 34 | | |
| Tunisia | 76.98 | 12,277,336,592.86 | 57 | | |
| Uganda | 42.15 | 4,203,124,383.40 | 96 | | |
| Zimbabwe | 29.78 | 73,807,497.33 | 22 | | |
| Zambia* | 72.36 | 9,582,782,265.63 | 230 | Yes | 0.054991 |

*Table 2: Statistical Facts about African Government Bond Markets, including foreign issuance (source - Bloomberg, *Countries in this study)*

This research will study the role of liquidity in bond yields in some of Africa's more developed, relatively more active and sizeable domestic bond markets. These are represented individually by government bond markets of Botswana, Egypt, Ghana, Kenya, Mauritius, Namibia, South Africa, Nigeria, Morocco and Zambia. The countries are also chosen because of the availability of their bond data through external data providers like Bloomberg and represent various African regions.

Table 2 above shows a few statistics about various African countries including liquidity measure for December 2018 on those countries that are being used in this study.

To assess the availability of data, a data extract of all active bonds in the African Market was downloaded from the Bloomberg terminal. Thereafter, the bonds were filtered to include only those that are issued in the domestic market of each country respective, with a maturity longer than 1 year and reliable bid and ask yields.

### *3.2.3. Source of data and justification*

The data to be used in this research will be sourced from Bloomberg and the various exchanges and central banks for bonds in each African market under consideration. These data sources will ensure enough coverage of instruments listed in African bond markets where daily and monthly bond yields and trade volumes, S&P credit ratings, the bid and ask yields as well as various bond indenture information are available that may be instrumental in this study. Confirmation of the availability of data was done by collecting random periods of data for a couple of bonds in each of these markets. Although data fields available on Bloomberg and Datastream is very limited for bond markets, there's data to cover liquidity proxies that use daily prices, and bid-ask spreads.

### *3.2.4. Construction of variables*

All markets will be analysed individually based on the individual bonds in a panel using liquidity proxies that are appropriate based on the availability of data. Macro-level variables will be constructed by aggregating the individual bonds in each country. This will enable the analysis of the impact associated with market-wide liquidity measurements. The bid and ask yields will be used to proxy liquidity using the bid-ask yields spread. This is because bond pricing tends to be quoted using their mark-to-market yields for which a sizeable history is available on Bloomberg for the bonds in the countries to be analysed. The bid-ask spread is one of the common liquidity proxies used both in practice and by researchers. It is calculated by taking the difference between the bid and the ask yield of the bond, where a narrow value

indicates higher liquidity and a wider value indicates lower liquidity (Fleming, 2003). A modification of the bid-ask spread liquidity measure as proposed by Amihud and Mendelsen (1986) is calculated as a spread between the bid and ask yields relative to the mid yield. This measure is indicative of transaction costs when trading instruments.

$$\text{Bid} - \text{Ask Spread Liquidity} = \frac{\text{Bid} - \text{Ask Yield Spread}}{\text{Mid Yield}}$$

In this research, only the liquidity measure mentioned above will be used at the bond level based on the availability of data. Data on trading activity and turnover of African bonds are extremely hard to find with only the monthly traded volumes figures available to do turnover estimation for only four of the selected countries (mainly Egypt, Ghana, South Africa and Kenya) for a wider set of local currency bonds of the varying term to maturity. Turnover is another common measure of liquidity and was also used in bond markets by Dick-Nielsen et al (2012). As a measure of liquidity, turnover will be calculated monthly as a ratio of the traded volumes over the total issued amount in the market.

## 3.3. Empirical strategy

### *3.3.1. Issue-level analysis and construction of variables*

Using the Bid-Ask spread liquidity measure, the factor model proposed by Fama and French (1993) on bonds will be adjusted and estimated. The adjustment will be for the control of other factors that are known to affect bonds yields such as maturity and credit risk as used in Fama and French (1993). However, unlike Fama and French (1993) who measured the maturity factor as excess return between long date bonds and the short-dated bonds, at issue level analysis the maturity factor will be measured as the time to maturity of the bond measured in years.

The credit risk factor will be proxied by assigning ordinal numerical scoring from 1 going upwards on the bond's issuer credit ratings, where 1 represents the highest credit rating and the higher the numerical number, the lower the credit rating. This approach to measuring maturity and credit risk has been used by many studies such as Che-Yahya, Abdul-Rahim, Mohd-Rashid (2016) on the Malaysian bond market.

In addition to the maturity and credit risk factors, the model will include a market size factor on the logarithmic scale due to the fact that the nominal size of the market is a very large

number and would be difficult to use meaningfully in a regression analysis as well as to deal with possible outliers. Applying the logarithm on the values will size down the values to a smaller scale that still carry the same differential meaning as the original scale.

The estimation will involve clustering the standard error by two dimensions: across time and across the section. This will control for biases based on time-varying events or biases based on the same issuer or other effects varying across bonds and not already accounted for. The use of a two-step standard error clustering technique is suggested by Patersen (2009). In following the model similar to that used by Dick-Nielsen et al (2012), the regression model that will be investigated for characteristics of liquidity on bond yields can be represented as follows using monthly values for each variable:

$$Yield_{it} = \alpha_0 + \alpha_1 Liquidity_{it} + \alpha_2 CreditRate_{it} + \alpha_3 Size_{it} + \alpha_3 Maturity_{it} + \alpha_4 X + \alpha_5 turnover_t + u_t + v_i + \varepsilon_{it} + \varepsilon_{it} \quad (1)$$

where $Yield_{it}$ is the yields of bond $i$ at time $t$; $Liquidity_{it}$ is the liquidity measure for bond $i$ at time $t$; $CreditRate_{it}$ is the numerical value of the credit rating of the bond $i$ at time $t$; $Size_{it}$ is the amount issued in the of bond $i$ in log scale at time $t$; $Maturity_{it}$ is the time to maturity in years of bond $i$ at time $t$; $turnover_t$ is the turnover of the bond market as a measure of market-level liquidity in the country; $u_t$ is an intercept that will capture effects that vary over time such as country or global markets environmental factor and events that impact all instruments similarly and thus not vary between bonds; $X$ is a vector of other factors identified to have an effect on bond prices; $v_i$ is a variable to capture specific factors on bond $i$ due to other variabilities between bonds at the same time; and $\varepsilon_{it}$ is the error term for bond $i$ at time $t$.

### *3.1.1. Estimation Methodology*

Analysing the impact of liquidity on bond yields involves the analysis using quantitative data of various bonds and markets as cross-sections over a period of time. The main econometric regression approach will be one that is consistent with panel data analysis. In analysing panel data model (1), two methods are available namely the fixed effect and the random effect models. These models differ in that one focuses more on the effect of the changing intercept and explanatory variables across the different bonds or bond portfolios, while any effects that could be correlated with the model's explanatory variables but are not observed are captured

by the error term and will be transformed out from the model. This is typical of the fixed-effect model. On the other hand, the random effect model assumes that the error term is not related to any other variables and that the observations from the error term are important to be analysed.

Because there has been other research that shows that other factors or variables not considered in our model can influence bond yields, in this research the models to be used will be on analysing fixed effects of the panel data for both models regressing the bond yields and regressing bond liquidity as detailed above. With this fixed effective model, there will be an elimination of the fixed bond effect by transforming the variables over time, resulting in time-demeaned panel data. This will be done by averaging the explanatory variables of overtime per bond or bond portfolio.

### *3.1.2. Market-level analysis and methodology*

Part of this study will be to examine the relationship, if any, between size and liquidity and controlling for other bond risk factors. This evaluation will be done similar to Amihud et. al. (2015) and to an extend Houweling et al. (2005) who used bond yields instead of returns to create factor-sorted portfolios. To do so the study will employ two methods, first the measuring of the correlations between the two variables followed by the fitting of a regression model to test the relationship. Measuring the correlation between size and liquidity will help with understanding if there is indeed a close relationship and the direction thereof, but it does not tell if one does cause the other.

In following similar approaches Amihud (2002), Fama and French (1993), and later used in Fama and French (2015), an analysis of the nexus between liquidity and size will be evaluated by creating portfolios sorted by liquidity, size and other controlled factor measures. The bonds are sorted from the most liquid to the least liquid. The list is then broken down into three portfolios at the $30^{th}$ and $70^{th}$ percentiles with high, medium and low liquidity. Then, within each liquidity portfolio, the bonds are sorted from the smallest to the largest with three sub-groups of portfolios created also at the $30^{th}$ and $70^{th}$ percentiles, resulting in a total of 9 portfolios. The average yield in each portfolio group is calculated weighted by the issued amount as a percentage of the total issued amount and also equally weighting the yields. These average yields will be evaluated for any trends when moving from small to large issue size and

when moving from low to high liquidity. However, it should be noted that the results would only tell the relationship between liquidity and size in isolation regardless of other factors that could impact this relationship.

It is should be noted that the bond portfolios will be constructed and rebalanced on an annual basis this is recognising that these markets can be prone to lower liquidity than the developed counterparts and there'll then be no need for a more frequent rebalancing. A factor model will then be used to examine if size, among other factors that are controlled for, has a role to play in determining liquidity in the markets. In following the construction in Amihud (2002), Amihud et al (2015), Hearn et al (2010), and Fama and French (2015), the factors for liquidity, size, maturity and when evaluating at Africa region the factor for credit risk will be done through calculating the average yields spreads between the portfolio groups and detailed below.

The liquidity factor will be constructed by sorting the bonds from highest to lowest liquidity value, and subsequently divided into 3 portfolio groups at the $30^{th}$ and $70^{th}$ percentile. Within the 3 liquidity portfolios, the bonds will be ranked by their issued amount size and divided further into 3 size portfolios. This will result in 9 liquidity-size portfolios whose bonds' yields will be averaged using the bonds' issued amounts. The 3 low liquidity portfolios' average yields will be averaged, and averaging the 3 high liquidity portfolios' average yields. The liquidity factor based on liquidity-size portfolios is then the spread between the high liquidity yields to the low liquidity yield.

In a similar way the liquidity factors based on liquidity-maturity portfolios, liquidity-credit portfolios will also be constructed. The liquidity factor LIQ to be tested is then the average of the liquidity-size factor, liquidity-maturity factor, and liquidity-credit risk factor.

The size factor will be constructed using 3x3 size-liquidity, size-maturity and size-credit risk portfolio factor and averaging their yields. The maturity and credit factors will be derived in a similar way.

A regression model is estimated where the liquidity proxy is regressed on the risk factors including size, maturity and credit risk adopted for the bond markets based on the ideas from Amihud et al, 2015, Fama and French (2015).

$$LIQ_{pt} = \alpha_0 + \alpha_1 SMB_{pt} + \alpha_2 SML_{pt} + \alpha_3 HML_{pt} + \varepsilon_{pt} \quad (2)$$

where $LIQ_{pt}$ is the country p factor for liquidity at time t; $SMB_{pt}$ is the country p factor for size at time t; $SML_{pt}$ is the country p factor for maturity at time t; $HML_{pt}$ is the country p factor for credit risk at time t; and $\varepsilon_{pt}$ is the error term for the country, p, at a time, t. The factor model is to be tested at the country and overall African level, with the factors being calculated afresh for the overall regional testing.

## DATA ANALYSIS SECTION

### 4. Data Analysis

In the first model considered in this research paper, the impact of liquidity, issue size, time to maturity, the credit rating of the government, and the turnover rate on the bond yields are analysed on a country-by-country basis across the sampled countries. Due to challenges and unavailability of complete data for all countries, some countries may have some variables missing and the analyses are performed using only the available fields. Over and above that, not all countries had data for the full analysed period.

The bonds used were bonds issued in local currency for each country. For each month in the analysis, any bonds that displayed outlying data points for yields or missing any field were removed.

| | LIQUIDITY | ISSUE SIZE | MATURITY | CREDIT RATING** | TURNOVER |
|---|---|---|---|---|---|
| *Botswana* | Yes | Yes | Yes | | |
| *Egypt* | Yes | Yes | Yes | Yes | Yes |
| *Ghana* | Yes | Yes | Yes | | |
| *Kenya* | Yes | Yes | Yes | | Yes |
| *Mauritius* | Yes | Yes | Yes | | |
| *Morocco** | | Yes | Yes | | |
| *Namibia** | | Yes | Yes | Yes | |
| *Nigeria* | Yes | Yes | Yes | Yes | |
| *South Africa* | Yes | Yes | Yes | Yes | Yes |
| *Zambia* | Yes | Yes | Yes | Yes | |

*Table 3: Available Data fields per Country*

** Bid and Ask are the same and not usable for the bid-ask spread based liquidity measure.*

*** Where credit rating is missing, the time series of ratings was no reliable or remained in contact over the analysis period.*

### 4.1. Descriptive Statistics

This paper's research question is about finding the impact that liquidity has on the observed yields in the bond markets. To do so, bid yields, ask yields, issued amount, maturity date data were collected from Bloomberg on a monthly basis over the 10 years ending 31 December 2018. The data were collected for all bonds that had the required data during that time period,

but not necessarily for the full period, allowing for the inclusion of bonds that were newly issued or that matured during the period. The countries' credit ratings were collected from available online sources, the main source being www.tradingeconomics.com using their collection of Moody's rating changes during the period under analysis. Table 4 describes how the credit rating was converted into numerical ordered variables were 1 is the highest credit rating and 22 is the lowest credit rating.

| S&P Ratings | Assigned Value |
|---|---|
| AAA | 1 |
| AA+ | 2 |
| AA | 3 |
| AA- | 4 |
| A+ | 5 |
| A | 6 |
| A- | 7 |
| BBB+ | 8 |
| BBB | 9 |
| BBB- | 10 |
| BB+ | 11 |
| BB | 12 |
| BB- | 13 |
| B+ | 14 |
| B | 15 |
| B- | 16 |
| CCC+ | 17 |
| CCC | 18 |
| CCC- | 19 |
| CC | 20 |
| C | 21 |
| D | 22 |

*Table 4: Credit Rating Values*

The rest of the data was constructed as follows:

- Liquidity was calculated as the ratio of the bid-ask yield spread over the mid yield.
- Log size is calculated as the logarithm of the issued amount of the bond.
- Maturity is the number of days left to the maturity date of the bond.
- For those countries whose trade volumes were available from their central banks or their trading exchanges, the Turnover rate was calculated as the total nominal value traded divided by the total issued amount for the bonds available in this study.

| | | *Botswana* | *Egypt* | *Ghana* | *Kenya* | *Mauritius* | *Morocco* | *Namibia* | *Nigeria* | *South Africa* | *Zambia* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| MIDYIELD | Observations | 312 | 3717 | 1295 | 3553 | 639 | 277 | 685 | 1492 | 3503 | 3181 |
| | Mean | 4.732 | 14.465 | 19.802 | 12.399 | 4.686 | 2.957 | 9.689 | 11.964 | 7.548 | 20.79 |
| | Median | 4.589 | 14.607 | 19.339 | 12.113 | 4.678 | 2.656 | 10.01 | 12.522 | 8.718 | 19.47 |
| | Maximum | 6.504 | 53.494 | 27.25 | 20.263 | 7.014 | 4.354 | 12.609 | 21.298 | 12.953 | 30.129 |
| | Minimum | 2.358 | 8.005 | 4.584 | 3.865 | 3.17 | 2.405 | 3.846 | 2.652 | 0.048 | 15.853 |
| | Std. Dev. | 0.775 | 2.749 | 3.427 | 1.548 | 0.809 | 0.544 | 1.795 | 3.678 | 3.075 | 3.063 |
| | Skewness | -0.015 | 1.503 | 0.061 | 1.144 | 0.121 | 1.013 | -1.611 | -0.458 | -1.016 | 0.645 |
| | Kurtosis | 2.68 | 20.668 | 2.025 | 6.818 | 2.005 | 2.669 | 5.607 | 3.241 | 2.649 | 2.147 |
| | Jarque-Bera (p-values) | 0.51 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| LIQUIDITY | Mean | 0.038 | 0.032 | 0.031 | 0.029 | 0.039 | | | 0.015 | 0.03 | 0.039 |
| | Median | 0.037 | 0.017 | 0.028 | 0.021 | 0.039 | | | 0.008 | 0.021 | 0.033 |
| | Maximum | 0.17 | 0.834 | 0.329 | 0.299 | 0.062 | | | 0.849 | 1.453 | 0.148 |
| | Minimum | 0.014 | 0.001 | 0.001 | 0.001 | 0.015 | | | 0.002 | 0.002 | 0.002 |
| | Std. Dev. | 0.016 | 0.052 | 0.017 | 0.024 | 0.005 | | | 0.037 | 0.055 | 0.017 |
| | Skewness | 2.793 | 5.229 | 5.159 | 3.287 | -0.077 | | | 12.495 | 13.106 | 2.306 |
| | Kurtosis | 18.684 | 51.182 | 77.663 | 20.818 | 6.039 | | | 219.183 | 266.307 | 9.387 |
| | Jarque-Bera (p-values) | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | | | 0.000 | 0.000 | 0.000 |
| LOGSIZE | Mean | 8.195 | 9.071 | 8.256 | 8.409 | 7.645 | 8.719 | 8.102 | 9.127 | 9.002 | 6.742 |
| | Median | 8.264 | 9.128 | 8.305 | 8.478 | 7.657 | 8.727 | 8.087 | 9.125 | 9.304 | 6.738 |
| | Maximum | 8.303 | 9.465 | 9.25 | 8.796 | 8.414 | 9.193 | 8.387 | 9.822 | 10.443 | 8.339 |
| | Minimum | 7.575 | 7.361 | 5.108 | 6.162 | 6.688 | 8.132 | 7.171 | 8.197 | 6.939 | 3.796 |
| | Std. Dev. | 0.16 | 0.282 | 0.428 | 0.314 | 0.432 | 0.289 | 0.175 | 0.389 | 1.025 | 0.822 |
| | Skewness | -1.879 | -1.098 | -0.996 | -2.76 | -0.454 | -0.316 | -1.64 | -0.427 | -0.548 | -0.546 |
| | Kurtosis | 5.793 | 4.332 | 8.249 | 17.306 | 2.306 | 2.141 | 10.512 | 2.38 | 2.043 | 3.307 |
| | Jarque-Bera (p-values) | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 |

| | | *Botswana* | *Egypt* | *Ghana* | *Kenya* | *Mauritius* | *Morocco* | *Namibia* | *Nigeria* | *S. Africa* | *Zambia* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| MATURITY | Observations | 312 | 3717 | 1295 | 3553 | 639 | 277 | 685 | 1492 | 3503 | 3181 |
| | Mean | 3215.026 | 1367.319 | 904.57 | 2625.283 | 2161.196 | 2484.838 | 4702.81 | 2397.956 | 4174.599 | 2386.386 |
| | Median | 2154.5 | 1201 | 693 | 2228 | 1508 | 1145 | 4033 | 1364 | 3308 | 2153 |
| | Maximum | 9115 | 3660 | 5433 | 10583 | 7282 | 10157 | 11003 | 7297 | 13728 | 5478 |
| | Minimum | 0 | 2 | 0 | 11 | 18 | 291 | 471 | 14 | 15 | 2 |
| | Std. Dev. | 2825.11 | 957.065 | 856.106 | 2172.568 | 1807.642 | 2528.635 | 2766.548 | 2282.145 | 3046.262 | 1417.535 |
| | Skewness | 0.789 | 0.583 | 2.543 | 1.094 | 0.972 | 1.321 | 0.528 | 0.852 | 1.054 | 0.536 |
| | Kurtosis | 2.336 | 2.422 | 11.8 | 3.997 | 3.262 | 3.779 | 2.182 | 2.227 | 3.484 | 2.318 |
| | JB (p-values) | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| CREDIT | Mean | 7 | 15.378 | 15.828 | 14 | 8 | 10 | 10.327 | 13.812 | 10.312 | 15.199 |
| | Median | 7 | 16 | 16 | 14 | 8 | 10 | 10 | 14 | 10 | 15 |
| | Maximum | 7 | 17 | 16 | 14 | 8 | 10 | 11 | 15 | 12 | 16 |
| | Minimum | 7 | 11 | 15 | 14 | 8 | 10 | 10 | 13 | 8 | 15 |
| | Std. Dev. | | 1.365 | 0.378 | | | | 0.469 | 0.593 | 1.16 | 0.399 |
| | Skewness | | -1.879 | -1.736 | | | | 0.738 | 0.079 | 0.065 | 1.51 |
| | Kurtosis | | 5.984 | 4.015 | | | | 1.544 | 2.624 | 2.221 | 3.281 |
| | JB (p-values) | | 0.000 | 0.000 | | | | 0.000 | 0.006 | 0.000 | 0.000 |
| TURNOVER | Mean | | 0.057 | | 0.003 | | | | | 2.862 | |
| | Median | | 0.052 | | 0.002 | | | | | 2.717 | |
| | Maximum | | 0.215 | | 0.008 | | | | | 6.216 | |
| | Minimum | | 0.003 | | 0.001 | | | | | 1.457 | |
| | Std. Dev. | | 0.04 | | 0.001 | | | | | 0.82 | |
| | Skewness | | 1.229 | | 1.902 | | | | | 0.955 | |
| | Kurtosis | | 4.959 | | 8.368 | | | | | 3.907 | |
| | JB (p-values) | | 0.000 | | 0.000 | | | | | 652.708 | |

*Table 5: Model 1 Summary Statistics*

Before we begin examining the empirical analysis, we present a brief discussion of the descriptive statistics of the variables used in this empirical study. Table 5 reports the summary statistics per country. Average yields appear to be highest in Ghana and Zambia with both the mean and median being close to 20%, while the lowest yields are observed for Morocco, Mauritius and Botswana at levels below 5%. This may just be a reflection of the credit risk inherent in these markets during the period under analysis. Ghana and Zambia, and Egypt have the highest mean and medians on the credit risk value, while Morocco, Mauritius and Botswana are showing the lowest mean and median credit risk. Analysis by Amadou (2015) and Olabisi and Stein (2015) shows that African bond yields are highly reflective of the credit ratings as indicators of credit risk, although there are other factors that also explain the difference in yields across different countries like investor bias to better-developed markets. The other yields feature in between two extremes. Although there are a number of maximum and minimum outliers (for example in Egypt) in comparison to the mean yield, the deviations are on average much smaller with a standard deviation of no greater than 4% in all countries.

Looking at the liquidity variable, measured as the bond bid-ask spread over the average yield, they are fairly consistent across the different markets, with only slightly narrower spreads for Nigeria and South Africa. This can be signalling that liquidity is better in these two countries but is relatively similar across Africa. The longest maturity observed in the study is over 37 years; we do allow for a bond to be included on the day of maturity which explains the minimum maturity of 0 in some instances. The value of issue size is highest in South Africa, Nigeria and Egypt. Issuance sizes varied greatly from the minimum to the maximum, however, it is Zambia that tends to have small values being issued per bond.

Due to data constraints, the only countries where turnover data were available in South Africa, Kenya and Egypt. Of these 3 countries, South Africa has the highest turnover rate which is almost in line with the observed narrower bid-ask spread liquidity measure. The credit rating for South Africa has also been varying over time, which will be helpful in observing the influence of credit risk rating on liquidity.

It is clear from the other descriptive statistics calculated that none of the variables in any country can be assumed to be normally distributed. There are elements of Skewness and abnormal kurtosis. The JB measure is also significant for all variables in all countries, rejecting the hypothesis of normality. The main implication of this would be that the standard errors would be affected and thus the confidence intervals. However, by the Central Limit Theorem, the means from non-normal distributions are approximately normally distributed when the number of observations is very large and approaching infinity. These ideas are also described by publications such as Nisbert et al (2018).

| *Botswana* | CREDIT | LIQUIDITY | LOGSIZE | MATURITY | MIDYIELD | |
|---|---|---|---|---|---|---|
| LIQUIDITY | | 1 | | | | |
| LOGSIZE | | 0.100841 | 1 | | | |
| MATURITY | | -0.445692 | -0.016927 | 1 | | |
| MIDYIELD | | -0.428991 | 0.021957 | 0.749886 | 1 | |

| *Egypt* | CREDIT | LIQUIDITY | LOGSIZE | MATURITY | MIDYIELD | TURNOVER |
|---|---|---|---|---|---|---|
| CREDIT | 1 | | | | | |
| LIQUIDITY | -0.07589 | 1 | | | | |
| LOGSIZE | 0.146988 | 0.167152 | 1 | | | |
| MATURITY | 0.111966 | -0.232519 | 0.157175 | 1 | | |
| MIDYIELD | 0.302677 | -0.005727 | 0.266305 | 0.278544 | 1 | |
| TURNOVER | -0.356574 | -0.035081 | -0.040757 | -0.019613 | -0.164055 | 1 |

| *Ghana* | CREDIT | LIQUIDITY | LOGSIZE | MATURITY | MIDYIELD |
|---|---|---|---|---|---|
| CREDIT | 1 | | | | |
| LIQUIDITY | -0.360738 | 1 | | | |
| LOGSIZE | -0.080211 | -0.069076 | 1 | | |
| MATURITY | 0.016197 | -0.144923 | 0.398816 | 1 | |
| MIDYIELD | -0.036461 | -0.240689 | 0.119734 | -0.021018 | 1 |

| *Kenya* | CREDIT | LIQUIDITY | LOGSIZE | MATURITY | MIDYIELD | TURNOVER |
|---|---|---|---|---|---|---|
| LIQUIDITY | | 1 | | | | |
| LOGSIZE | | -0.108852 | 1 | | | |
| MATURITY | | -0.26963 | 0.193568 | 1 | | |
| MIDYIELD | | -0.168993 | 0.115665 | 0.406861 | 1 | |
| TURNOVER | | 0.098686 | -0.033541 | 0.039674 | -0.078318 | 1 |

| *Mauritius* | CREDIT | LIQUIDITY | LOGSIZE | MATURITY | MIDYIELD |
|---|---|---|---|---|---|
| LIQUIDITY | | 1 | | | |
| LOGSIZE | | 0.046161 | 1 | | |
| MATURITY | | -0.317323 | -0.192129 | 1 | |
| MIDYIELD | | -0.311736 | -0.215019 | 0.95043 | 1 |

| *Morocco* | CREDIT | LIQUIDITY | LOGSIZE | MATURITY | MIDYIELD |
|---|---|---|---|---|---|
| LOGSIZE | | | 1 | | |
| MATURITY | | | -0.146933 | 1 | |
| MIDYIELD | | | -0.100457 | 0.991049 | 1 |

| *Nambia* | CREDIT | LIQUIDITY | LOGSIZE | MATURITY | MIDYIELD |
|---|---|---|---|---|---|
| CREDIT | 1 | | | | |
| LOGSIZE | -0.181447 | | 1 | | |
| MATURITY | -0.188364 | | -0.249224 | 1 | |
| MIDYIELD | -0.202654 | | 0.19071 | 0.515433 | 1 |

| *Nigeria* | CREDIT | LIQUIDITY | LOGSIZE | MATURITY | MIDYIELD |
|---|---|---|---|---|---|
| CREDIT | 1 | | | | |
| LIQUIDITY | 0.073289 | 1 | | | |
| LOGSIZE | -0.028972 | -0.095984 | 1 | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| MATURITY | -0.053743 | -0.211088 | 0.247857 | 1 | | |
| MIDYIELD | 0.07523 | -0.111829 | 0.305767 | 0.139535 | 1 | |

| *South Africa* | CREDIT | LIQUIDITY | LOGSIZE | MATURITY | MIDYIELD | TURNOVER |
|---|---|---|---|---|---|---|
| CREDIT | 1 | | | | | |
| LIQUIDITY | 0.007227 | 1 | | | | |
| LOGSIZE | -0.153389 | -0.070649 | 1 | | | |
| MATURITY | -0.116957 | -0.163588 | 0.379103 | 1 | | |
| MIDYIELD | 0.216076 | -0.378367 | -0.387222 | -0.110688 | 1 | |
| TURNOVER | 0.101601 | -0.013279 | -0.022886 | -0.046713 | -0.001307 | 1 |

| *Zambia* | CREDIT | LIQUIDITY | LOGSIZE | MATURITY | MIDYIELD |
|---|---|---|---|---|---|
| CREDIT | 1 | | | | |
| LIQUIDITY | 0.069989 | 1 | | | |
| LOGSIZE | 0.025203 | 0.213941 | 1 | | |
| MATURITY | -0.04792 | -0.539431 | -0.188308 | 1 | |
| MIDYIELD | 0.199177 | 0.180861 | -0.070229 | 0.002276 | 1 |

*Table 6: Model 1 Correlations*

Table 6 reports the correlation between the bond level variables in each market. The correlations reveal that there is a negative relationship between bond yields and bond liquidity. This is to be expected, based on Favero et al (2007) and Beber et al. (2009), who found that yields spreads are negatively related to bid-ask spread as liquidity proxies. However, the correlations, in this case, are not particularly too strong, indicating a possible absence of multicollinearity in the models to be estimated.

An interesting observation can be made that, in most countries, the size of the bond issue is positively related to its yield and in others (e.g. Egypt and South Africa), it is negatively related. Similarly, in some markets (e.g. Egypt and Mauritius) the relation between issue size and liquidity is positive while in other markets (e.g. Kenya, Ghana and South Africa) it is negative. However, it is more common in larger and more developed bond markets such as South Africa, Nigeria, and Kenya that the connection is negative, meaning that larger issuances have narrower bid-ask spreads and tend to then be more liquid as documented by McCauley & Remolona (2000). Another similar finding was made by Mu, Phelps and Stotsky (2013) where they identify that interest rate spreads are inversely related to the development and market capitalization of the local government bond market. This is in contrast to the correlation between the turnover rate and the issue size, which is negative but very small. The persistent negative correlations between yields and liquidity measured by the bid-ask spread as well as the correlation between yields and liquidity in the form of turnover rate are suggestive of an inverse impact of liquidity on bond yields.

## 4.2. Results of Bond Level Regressions

| | *Botswana* | *Egypt* | *Ghana* | *Kenya* | *Mauritius* | *Morocco* | *Namibia* | *Nigeria* | *S. Africa* | *Zambia* |
|---|---|---|---|---|---|---|---|---|---|---|
| Constant C | -13.319* | 17.674*** | 47.040*** | 11.507*** | 4.115*** | 1.931*** | -1.613 | -49.131*** | 19.793*** | -9.329 |
| | (7.183) | (6.79) | (8.766) | (1.817) | (0.47) | (0.304) | (7.733) | (15.537) | (4.355) | (15.119) |
| LIQUIDITY | -1.296 | 4.312 | -46.678*** | -1.899 | 0.873 | | | -18.353** | -2.175*** | 52.907*** |
| | (2.134) | (4.741) | (11.254) | (3.711) | (2.094) | | | (7.347) | (0.439) | (9.849) |
| LOGSIZE | 2.012** | 0.043 | -0.227 | 0.017 | -0.045 | 0.062 | 1.850** | 6.315*** | -0.539 | -0.344* |
| | (0.892) | (0.669) | (0.7) | (0.226) | (0.041) | (0.042) | (0.861) | (1.789) | (0.455) | (0.177) |
| MATURITY | 0.000*** | -0.001*** | 0.004*** | 0.000*** | 0.000*** | 0.000*** | -0.000*** | -0.002*** | -0.001*** | 0.001*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| CREDIT | | -0.123* | | | | | -0.145 | 0.491** | -0.355*** | 1.849* |
| | | (0.071) | | | | | (0.147) | (0.242) | (0.081) | (0.966) |
| TURNOVER | | -3.094 | | -157.063*** | | | | | 0.0145 | |
| | | (3.667) | | (55.353) | | | | | (0.038) | |
| Periods included: 98 | 52 | 98 | 59 | 92 | 8 | 9 | 54 | 108 | 85 | 40 |
| Cross-sections included: 119 | 10 | 119 | 75 | 93 | 110 | 37 | 17 | 34 | 66 | 135 |
| Cross-section random S.D. | 0.252 | 1.62 | 2.447 | 0.904 | 0.237 | 0.063 | 0.745 | 2.284 | 2.102 | 0.865 |
| Idiosyncratic random S.D. | 0.261 | 1.449 | 1.656 | 1.071 | 0.089 | 0.022 | 0.436 | 2.333 | 0.524 | 2.062 |
| Rho (Cross-section random) | 0.483 | 0.555 | 0.686 | 0.416 | 0.876 | 0.891 | 0.745 | 0.489 | 0.941 | 0.15 |
| R-squared | 0.436 | 0.093 | 0.365 | 0.081 | 0.63 | 0.784 | 0.208 | 0.196 | 0.204 | 0.113 |
| Hausman Test | 1.000 | 1.000 | 1.000 | 0.864 | 0.223 | 0.000 | 1.000 | 1.000 | 1.000 | 1.000 |

*Table 7: Model 1 Regression*

*The dependent variable in this regression is MIDYIELD, which represents Bond Yields*

**,**,*** represents significance at 90%, 95%, 99% confidence levels respectively, S.D. represents standard deviation*

*Figures in brackets represent the standard errors*

As can be observed in Table 7, the relation between liquidity and yields shows mixed results, wherein Ghana, Nigeria and South Africa the relation has negative coefficients that are significant at a 95% level. For these countries, when liquidity is high, the yields would tend to be narrower whereas when there is high illiquidity, the yields would tend to be high. Of those markets that are showing a positive relationship, only Zambia is significant at the 99% level. This is the complete opposite of Ghana, Nigeria and South Africa. Expectations, as in literature, is that illiquidity would cause the yields spreads to be wider (Sarig and Warga, 1989) as observed from Ghana, Nigeria and South Africa.

In the case of the log of the bonds' issued amounts, the logsize measure does not play a significant role in bond yields for most countries and only Botswana, Namibia Nigeria and Zambia report statistical significance at 95%. All of the significant coefficients are positive and indicate that larger bond issued amounts tend to attract higher yields. This is in contrast to Sarig and Warga (1989) who find that smaller sized bonds have persistently low price and thus higher yields due to market participants opting to buy and hold these for the long-term. Findings in Table 4 indicate that even large size bonds may have higher yields in African markets also possibly due to institutional investors such as pension funds and insurers opting to buy and hold rather than trade in bonds. This will also adversely impact liquidity.

There is a clearly significant role that maturity plays in determining yields. It can be observed that the coefficients appear very small, and this is because in this study maturity was measured as the number of days. Meaning that for a 10-year maturity the variable for "Maturity" will be approximately 3650 (depending on the number of leap years in between). However, this does not take away the significance of maturity. In six out of 10 of the covered countries, there is clearly a positive relationship, which indicates that the market may be preferring short-dated maturities as these tended to have narrower yields and thus higher prices, during the study period.

This can also point to the shape of the yields curve being upward sloping with higher yields as maturity time increases. In contrast, the other four countries show that time to maturity has a negative impact on yields (negative coefficient estimates). What this tells us is that the market yield curves tend to be downward sloping with longer maturity timelines generally associated with lower yields. It also can be that the market is preferring the longer-dated bonds, with the higher demand (relative to supply) causing them to attract narrower yields and higher prices than shorter maturities. This is inconsistent with the Liquidity preference theory (Hicks, 1939 and Vercelli, 2018) and agrees with market segmentation theory (Culbertson, 1957; and Greenwood and Vayanos, 2010)[1]. As documented by Kessel (1971),

[1] In finance the liquidity preference theory says that an individual would demand higher interest rate and return for securities that have a higher risk (for example longer dated bonds) than holding cash at hand, Hicks (1939). On the other hand, market segmentation theory indicates that investors have changing preference that differ according to security characteristics (Culbertson,1957). For example, pension funds' preference for

the term structure of interest rates can change over time as the market gets exposed to various economic conditions and investors fear losing the value of their investments.

The credit rating for South Africa has been varying widely over the years and the regression is showing that it is negatively impacting yields and the relationship is statistically significant t 99%. As the credit rating variable, which is calculated as an increasing number for deteriorating credit ratings, increases, it means that the credit rating is deteriorating and that the bond yields are reacting by narrowing. This seems to be contrary to Chen, Cheng and Wu (2011), who documents that with a deteriorating credit rating yields should be widening.

Only in one country, Kenya is the turnover rate significant in driving yields. The coefficient is highly negative and significant at the 99% level. This result indicates that as activity in terms of traded volumes increase, yields will tend to narrow as prices increase.

However, looking at the resulting R-Squares of the model fitted on the data in all the markets, most are below 50%, which is not unusual for this kind of study. Helwege, Huang, and Wang (2014) tested several liquidity proxies some of which are used in this study. Their study also showed low explanatory power form the variables in explaining bond yield spreads. In their study, they were also further tested the model by adding several macroeconomic variables in their model, which had the effect of improving the R-square and confirmed that bond yields can be affected by macroeconomic conditions.[2]

In an attempt to improve the model's explanatory power, the model was modified by adding two other macroeconomic variables, namely, the 3 months government rates and the spread between the 10-year government bond curve rate and the 2-year government bond curve rate. The data for these variables were collected from Thompson Reuter's Eikon using each country's government bonds benchmark curve. This is similar to those added by Helwege et al (2014).

The resulting fitted model is as follows:

$$Yield_{it} = \alpha_0 + \alpha_1 Liquidity_{it} + \alpha_2 CreditRate_{it} + \alpha_3 Size_{it} + \alpha_3 Maturity_{it} + \alpha_4 X + \alpha_5 turnover_t + \alpha_6 3Months_t + \alpha_7 10to2Spread_t\, u_t + v_i + \varepsilon_{it} \quad (3)$$

where, in addition to the variables of the original model, the 3-months treasury benchmark rate is represented by the variable "$3Months_t$" and the spread between the 10 year and the 2-year government benchmark interest rates is represented by the variable "$10to2Spread_t$".

longer dated instruments which means more demand in the longer maturities and if theirs is not enough issuances of that side, the curve can become more inverted especially during periods when the short rates are higher than normal.

[2] There are other possible variable that would impact bond yields and and are not included in this study one of the reasons being that of data collection challenges such as Coupons rates, Treasury Tbill rates, foreign investor participants and various other macroeconomic factors Kapingura and Ikhide (2011).

| | Botswana | Egypt | Ghana | Kenya | Mauritius | Morocco | Namibia | Nigeria | S. Africa | Zambia |
|---|---|---|---|---|---|---|---|---|---|---|
| Constant | -5.297 | 1.044 | 26.333*** | 8.886*** | 3.278*** | 0.936 | -28.558*** | 17.312*** | 12.136*** | -28.357** |
| | (5.306) | (4.845) | (4.199) | (1.967) | (0.404) | -0.612 | (4.055) | (3.536) | (2.248) | (12.381) |
| LIQUIDITY | -0.813 | 2.802 | -38.667*** | -5.825* | -1.907 | | | -2.504*** | -1.215*** | 30.383*** |
| | (1.795) | (3.361) | (6.190) | (2.991) | (1.431) | | | (0.582) | (0.435) | (6.352) |
| LOGSIZE | 1.024 | 1.000** | 1.161*** | 0.222 | -0.041 | 0.073** | 3.673*** | -0.295* | -0.023 | -0.247** |
| | (0.669) | (0.431) | (0.200) | (0.237) | (0.030) | (0.035) | (0.444) | (0.165) | (0.179) | (0.117) |
| MATURITY | 0.000*** | 0.000*** | 0.000*** | 0.000*** | 0.000*** | 0.0002*** | 0.000*** | 0.000* | -0.000*** | 0.000 |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| CREDIT | | 0.159 | | | | | 0.540*** | -0.307 | -0.307*** | 3.047*** |
| | | (0.113) | | | | | (0.183) | (0.223) | (0.093) | (0.834) |
| TURNOVER | | 3.743 | | -134.729*** | | | | | -0.090*** | |
| | | (2.328) | | (51.504) | | | | | (0.032) | |
| 3 Months Bmk Rate | -0.187*** | 0.135*** | 0.619*** | 0.1791*** | 0.064 | 0.370** | 0.207*** | 0.148*** | 0.249*** | 0.128*** |
| | (0.069) | (0.025) | (0.036) | (0.046) | (0.053) | (0.186) | (0.022) | (0.032) | (0.067) | (0.029) |
| 10Yr to 2Yr Bmk Spread | 0.354* | -0.282*** | -0.279 | -0.076 | 0.383** | 0.046 | -0.262 | -0.463*** | 0.045 | 0.137 |
| | (0.186) | (0.057) | (0.291) | (0.093) | (0.152) | (0.280) | (0.180) | (0.110) | (0.068) | (0.145) |
| Periods included | 52 | 121 | 59 | 108 | 8 | 9 | 54 | 108 | 121 | 40 |
| Cross-sections included | 10 | 123 | 75 | 75 | 110 | 37 | 17 | 75 | 123 | 135 |
| Cross-section random S.D. | 0.239 | 0.898 | 0.647 | 0.831 | 0.206 | 0.063 | 0.413 | 3.049 | 1.882 | 0.693 |
| Idiosyncratic random S.D. | 0.269 | 1.452 | 1.205 | 0.936 | 0.086 | 0.022 | 0.404 | 3.244 | 0.678 | 1.878 |
| Rho (Cross-section random) | 0.441 | 0.277 | 0.224 | 0.441 | 0.851 | 0.892 | 0.511 | 0.469 | 0.885 | 0.120 |
| R-squared | 0.544 | 0.276 | 0.752 | 0.300 | 0.687 | 0.844 | 0.442 | 0.114 | 0.414 | 0.515 |

*Table 8: Model 1 Regression with macroeconomic factors*

*The dependent variable in this regression is MIDYIELD, which represents Bond Yields*

**,**,*** represents significance at 90%, 95%, 99% confidence levels respectively, S.D. represents standard deviation*

*Figures in brackets represent the standard errors*

The results of this model in Table 8 indicate that indeed the R-squared have improved with most countries recording a high statistically significant coefficient of the 3 Months government rate. However, the slope of the government bond yields curve is only highly significant in Egypt and Nigeria, with a significance at 99%. Overall, these results imply that macroeconomic factors are important components in determining bond yields.

### 4.3. Portfolio Based Market Level Regression

In this section of the data analysis, a regression is run to answer the research question about the relationship between issuance size and liquidity in the bond markets as represented by model 2 from the methodology section (page 36). We first determine the factor portfolio and calculate the average yield spread for each factor.

The following is the grouping similar to Amihud (2002), Amihud et al (2015), Hearn et al (2010), and Fama and French (2015) with slight modifications where there are fewer bonds. For each country, on a monthly basis, the bonds are sorted and ranked by liquidity (calculated as the bids-ask spread over the mid yield). The ranked bonds are then grouped into 3 by liquidity if there are more than 9 bonds available or into 2 groups if there are less than 9 bonds. The “low” group is the group in the top 30% of liquidity measure, the ”mid” group is the group in the mid 40% of liquidity and the “high” group is the group in the bottom 30%. These 3 LIQ groupings are done to recognise that the bid-ask liquidity measure is high for instruments that have lower liquidity and low for those that are more liquid.

Within each liquidity group, the bonds are further sorted and grouped by their issued amounts from small to medium to big size (SMB). The result is 9 portfolios (or 4 if there are few bonds available) that represent the LIQ breakdown by SMB. Following the same procedure, the LIQ groups are broken down by maturity from short (smallest 30%), to medium (middle 40%) to long (largest 30%), to represent the 9 LIQ portfolios broken down by SML. For each LIQ and SMB group, as well as LIQ and SML group the bonds yields are averaged based on the issuance amount. Thereafter, the LIQ-SMB and LIQ-SML factors are calculated as the difference in yields between the portfolios with low liquidity from those with high liquidity, then the LIQ_SMB and LIQ_SML are averaged to get the overall LIQ factor for each month.

The SMB factors and SML factors are constructed in the same way, where, for SMB, the factor represents the average spread between the big issuance portfolio and the small issuance portfolio yields, and the SML factor represents the average spread between the long maturity and the short maturity portfolio yields.

*4.3.1. Summary Statistics and Correlations between the Factors*

| | Africa | Botswana | Egypt | Ghana | Kenya | Nigeria | S. Africa | Zambia |
|---|---|---|---|---|---|---|---|---|
| Observations | 121 | 52 | 121 | 59 | 92 | 108 | 121 | 30 |
| *LIQ* | | | | | | | | |
| Mean | 1.5545 | 4.4701 | 0.1096 | 0.3067 | 0.9446 | 1.0339 | 3.4847 | -2.0370 |
| Median | 1.5319 | 4.3408 | -0.1380 | 0.1964 | 0.9083 | 1.3106 | 4.8502 | -2.5173 |
| Maximum | 4.1015 | 5.7962 | 4.7578 | 4.1382 | 3.7400 | 6.8522 | 6.9729 | 0.9713 |
| Minimum | -0.8285 | 2.7235 | -4.5909 | -3.5172 | -0.8419 | -6.3410 | -4.2008 | -4.6476 |
| Std. Dev. | 0.9379 | 0.7252 | 1.5864 | 1.7109 | 0.8166 | 3.3277 | 2.7387 | 1.7422 |
| Skewness | 0.0490 | -0.1293 | 0.1990 | -0.1942 | 0.9093 | -0.6432 | -0.5075 | 0.3693 |
| Kurtosis | 2.9898 | 2.8348 | 3.9409 | 2.4722 | 5.0253 | 2.9237 | 1.9829 | 1.9997 |
| J-B | 0.0490 | 0.2039 | 5.2617 | 1.0557 | 28.4003 | 7.4735 | 10.4103 | 1.9326 |
| p-value of J-B | 0.9758 | 0.9031 | 0.0720 | 0.5899 | 0.0000 | 0.0238 | 0.0055 | 0.3805 |
| *SMB* | | | | | | | | |
| Mean | 0.9328 | 4.7303 | 1.5403 | 0.6392 | 0.7705 | 0.6452 | -0.3264 | -3.4309 |
| Median | 0.8466 | 4.5641 | 1.3500 | 0.6289 | 0.4085 | 0.2254 | -0.4386 | -4.8705 |
| Maximum | 3.4241 | 5.3649 | 4.0336 | 2.9891 | 4.1502 | 6.4175 | 3.2131 | 0.5185 |
| Minimum | -1.1049 | 4.1725 | -1.3448 | -3.5252 | -0.2813 | -3.9620 | -2.8882 | -7.1901 |
| Std. Dev. | 0.9935 | 0.3642 | 1.3620 | 1.5149 | 1.0303 | 2.8480 | 1.2378 | 2.8461 |
| Skewness | 0.3062 | 0.3982 | 0.1014 | -0.6346 | 1.9667 | 0.4249 | 0.5018 | 0.2565 |
| Kurtosis | 2.8069 | 1.8005 | 1.9167 | 3.3731 | 5.9856 | 2.0189 | 2.8108 | 1.3698 |
| J-B | 2.0784 | 4.4916 | 6.1233 | 4.3026 | 93.4759 | 7.5819 | 5.2577 | 3.6509 |
| p-value of J-B | 0.3537 | 0.1058 | 0.0468 | 0.1163 | 0.0000 | 0.0226 | 0.0722 | 0.1611 |
| *SML* | | | | | | | | |
| Mean | 1.153 | 4.7765 | 1.1493 | 0.1433 | 1.5592 | 0.6357 | 0.0676 | 2.7077 |
| Median | 1.1246 | 4.7206 | 1.2977 | -0.0001 | 1.4623 | 0.8833 | -0.232 | 4.0683 |
| Maximum | 3.9141 | 7.2227 | 3.7561 | 4.2123 | 4.1105 | 7.0285 | 3.8949 | 6.0574 |
| Minimum | -2.3575 | 3.6852 | -1.7756 | -4.8895 | -0.2318 | -6.4175 | -3.506 | -3.8314 |
| Std. Dev. | 1.1504 | 0.8289 | 1.3449 | 1.8875 | 0.8697 | 3.2228 | 1.4899 | 2.9614 |
| Skewness | -0.3745 | 0.6363 | -0.2688 | -0.0537 | 0.9406 | -0.4224 | 0.2264 | -0.5993 |
| Kurtosis | 4.4334 | 2.8544 | 2.2923 | 2.732 | 4.1157 | 2.7855 | 4.3157 | 2.0407 |
| J-B | 13.1882 | 3.5552 | 3.9822 | 0.205 | 18.3386 | 3.4189 | 9.7605 | 2.9459 |
| p-value of J-B | 0.0014 | 0.169 | 0.1365 | 0.9026 | 0.0001 | 0.181 | 0.0076 | 0.2293 |

*Table 9: Model 2 Summary Statistics.*

*J-B represents the Jarque-Bera statistic; SMB represents …; SML represents …*

The liquidity premiums in South Africa and Botswana are generally larger than those in the other markets as observed from the mean and the medians as seen in Table 9. This is contrary to what we would expect from South Africa, which is has been identified by Allen, Otchere and Senbet (2011) to have liquidity akin to more matured markets than other African countries. However, it can be noticed from Table 5 on page 3, that liquidity in South African bonds can vary greatly between bonds, with summary statistics showing the highest kurtosis

(meaning large presents of low liquid observations) and more negatively skewed than the other countries. The premium in Zambia is negative on average, while in the other countries it is smaller. The size premium is showing similar statistical magnitude as the liquidity premium for Botswana, however, for Zambia, the premium is highly negative. This means that the large-sized bond issuances tend to have higher yields than the smaller sized issuance, which is consistent with the finding in Table 7. The size premium in South Africa is in the low negatives on average, while for the rest of the markets it is in the low positives. Again, maturity premium is highly positive for Botswana, whereas it's now highly positive also for Zambia. The contribution of maturity to the other bond markets is smaller.

| *Botswana* | LIQ | SMB | SML | *Nigeria* | LIQ | SMB | SML |
|---|---|---|---|---|---|---|---|
| LIQ | 1 | | | LIQ | 1 | | |
| SMB | 0.3876 | 1 | | SMB | 0.3574 | 1 | |
| SML | 0.4159 | 0.4880 | 1 | SML | 0.8324 | 0.2550 | 1 |
| | | | | | | | |
| *Egypt* | | | | *South Africa* | | | |
| LIQ | 1 | | | LIQ | 1 | | |
| SMB | -0.3540 | 1 | | SMB | 0.1383 | 1 | |
| SML | 0.2157 | 0.5793 | 1 | SML | -0.1190 | 0.1947 | 1 |
| | | | | | | | |
| *Ghana* | | | | *Zambia* | | | |
| LIQ | 1 | | | LIQ | 1 | | |
| SMB | -0.1078 | 1 | | SMB | 0.7778 | 1 | |
| SML | -0.0397 | 0.5819 | 1 | SML | -0.5628 | -0.9439 | 1 |
| | | | | | | | |
| *Kenya* | | | | *Africa* | | | |
| LIQ | 1 | | | LIQ | 1 | | |
| SMB | 0.5006 | 1 | | SMB | 0.6343 | 1 | |
| SML | 0.4178 | 0.7529 | 1 | SML | 0.3598 | 0.4620 | 1 |

*Table 10: Model 2 Correlations*

Table 10 shows that the Correlation between factors is highest and positive for liquidity (LIQ) and maturity (SML) for Nigeria and lowest for Ghana and South Africa. In other countries the correlation between liquidity and maturity is medium to low, except for Zambia is slightly medium-high with a negative value. The positive correlations between liquidity and maturity are consistent with the findings by Hotchkiss and Jostova (2017) that age is a contributing variable to the liquidity of a bond. Between liquidity and size premiums, the highest correlation is for Zambia with a positive relationship. In the other markets, the correlation is mainly less than a positive 0.5. For Kenya, we have a strong positive indication that size and maturity premiums are highly positively correlated, but the opposite is observed

in the case of Zambia where a strong negative correlation is observed. The results are mixed across the markets, but as can be seen in Figure 3, which represents the African market, there are possible co-movements. Similarly, all positive correlations of liquidity and size are consistent with Hotchkiss and Jostova (2017).

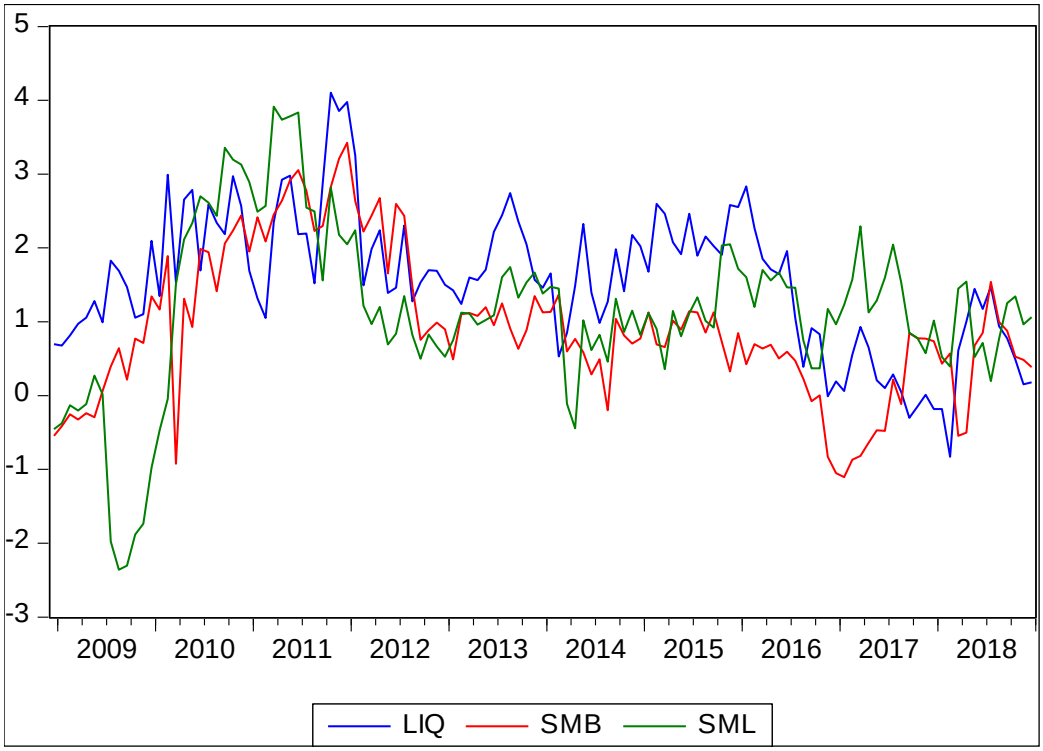


*Figure 3: Liquidity, Size and Maturity Factors for the combined African Market (measured as yield spreads (%))*

### *4.3.2. Factor Model Regression*

In Table 11, using the factor model detailed in the methodology section to determine the relationship between liquidity and size, and liquidity and maturity, initial findings show that the intercept (constant) is positive in all markets and statistically significant in 4 out of the 7 analysed countries. For South Africa, the intercept is high in value which is not expected because of the proposed larger market and more developed secondary market infrastructure, which should be more accommodative to efficient price discovery. One possible explanation for the positive alpha (intercept) may be that the chosen factors do not capture all the priced risks. Kapingura and Ikhide (2011), have indicated that there are other variables such as market microstructure factors like market volatility, volumes, inflation, the central bank's repurchase rate, exchange rate, foreign investor participation as well as the performance of the stock market as they contribute to the liquidity of the South African bond market: such variables have been excluded in the model tested here due to data paucity.

The size factor is positively significant at 99% in Zambia, Nigeria and Kenya. In South Africa and Botswana, the significance is weaker and only at 90%. Interestingly, the coefficient for SMB for Egypt is negative and significant at 99%. This implies that in this market, higher liquidity is found among smaller issuance than larger ones. This is contrary to many in the literature such as Bao, Pan, and Wang (2011) and Heck, Margaritis, and Muller (2015), who document that bond liquidity decreases with size, meaning that those with larger issued size would be expected to have relatively higher trade activity.

| | *Botswana* | *Egypt* | *Ghana* | *Kenya* | *Nigeria* | *South Africa* | *Zambia* |
|---|---|---|---|---|---|---|---|
| Constant | 0.9437 | 0.5442*** | 0.3946 | 0.5443*** | 0.3965** | 3.6247*** | 0.2078 |
| Std. Error | 1.1949 | 0.1739 | 0.2494 | -0.1678 | 0.1786 | 0.2555 | 0.2019 |
| t-Statistic | 0.7897 | 3.1303 | 1.5825 | -3.244 | 2.22 | 14.1883 | 1.0292 |
| SMB | 0.4826* | -0.8397*** | -0.1446 | 0.3406*** | 0.1814*** | 0.3713* | 1.3834*** |
| Std. Error | 0.2882 | 0.1026 | 0.1844 | 0.1102 | 0.0629 | 0.2033 | 0.1266 |
| t-Statistic | 1.6745 | -8.1854 | -0.784 | 3.0896 | 2.8836 | 1.8263 | 10.9244 |
| SML | 0.2604** | 0.7471*** | 0.0316 | 0.0885 | 0.8186*** | -0.2788* | 0.9238*** |
| Std. Error | 0.1266 | 0.1039 | 0.148 | 0.1306 | 0.0556 | 0.1689 | 0.1217 |
| t-Statistic | 2.056 | 7.1911 | 0.2132 | 0.6776 | 14.7243 | -1.6502 | 7.5907 |
| R-squared | 0.2177 | 0.3918 | 0.0124 | 0.2545 | 0.7154 | 0.0413 | 0.8739 |
| P-Value of F-statistic | 0.0024 | 0.0000 | 0.7049 | 0.0000 | 0.0000 | 0.0833 | 0.0000 |

*Table 11: Model 2 Regression*

*The dependent variable in this regression is LIQ, which represents Liquidity*
**,**,*** represents significance at 90%, 95%, 99% confidence levels respectively*

Table 11 also reports results that indicate larger issuances tend to have significantly more liquidity. SML for the maturity premium has a positive coefficient and is significant for Botswana, Egypt, Nigeria and Zambia at 95% or higher. The coefficient is positive tells us that longer-dated maturities tend to have better liquidity in these markets. The opposite is observed in South Africa, with a negative coefficient only significant at 90%. All significant coefficient is less than 1, meaning that the impacts are not large on liquidity. However, there is evidence of both size and maturity factors in the liquidity of the bond market.

In addition to the regression model above, factor spanning regressions are executed to test if the maturity factor (SML) can be explained by the size factor (SMB). This is done by regressing SML against SMB to analyse both the constant and the coefficient of SMB in SML. These results are displayed in Table 12, where the intercept is strongly positive and significant at 99% in Kenya, while in Egypt it is only significant at 90%. Zambia has a negative intercept, which also confirms that SML and SMB have a negative correlation as documented in Table 9, and

this result is significant at 95%, These three results indicate that in the two countries, both SMB and SML are important for the formation of the factor portfolios and contribute to average yields in the respective bond markets as implied by Huberman and Kandel (1987). For the other countries, the intercept is not significant; however, all coefficients of SMB on SML are significant at 99% and in South Africa the significance is at 95%, indicating that SML is redundant as a risk factor in these countries.

| | Constant | | SMB | |
|---|---|---|---|---|
| | Coefficient | t-statistic | Coefficient | t-statistic |
| Botswana | -0.477 | -0.358 | 1.111 | 3.953 |
| Egypt | 0.268 | 1.772 | 0.572 | 7.753 |
| Ghana | -0.32 | -1.461 | 0.725 | 5.402 |
| Kenya | 1.069 | 14.245 | 0.636 | 10.854 |
| Nigeria | 0.45 | 1.455 | 0.289 | 2.715 |
| S. Africa | 0.144 | 1.044 | 0.234 | 2.165 |
| Zambia | -0.662 | -2.302 | -0.982 | -15.121 |

*Table 12: Factor Spanning Regressions*

*The dependent variable in this regression is SML, which represents Maturity.*

## CONCLUSIONS AND RECOMMENDATIONS

The aim of this paper was to study the impact if any, that liquidity and bond size has on yields in African bond markets while also testing for the relationship between liquidity and size. The study is done by adopting the bid-ask spread as a measure of liquidity and also including effects of credit risk, maturity and market turnover rates in the estimated models. Coefficients of regression models were mixed, but still indicated a connection between the size and liquidity. The impact that liquidity has on bond yields was mainly negative in those markets that displayed statistical significance, showing that bonds that are relatively more liquid have lower yields thus higher prices. This is consistent with other researchers' finding such as Dick-Nielsen et al (2012) and Houweling, Mentink, and Vorst (2005).

This research has also shown that when the size has a statistically significant impact on yields, the sign of the impact is positive, meaning that bonds with larger issued amounts have higher yields. This is counter-intuitive: other research, such as Sarig and Warga, 1989, and Houweling, Mentink, and Vorst (2005), have found that bond issued amounts are mostly significant and mostly negatively related to yields. However, Houweling, Mentink, and Vorst (2005) does caution that positive relationship can be found in regressions; indeed, positive relationship in corporate bonds have been documented by other researchers such as McGinty (2001) as cited by Houweling, Mentink, and Vorst (2005). More research would be valuable to verify or challenge this finding.

When size and liquidity are conditioned on bond yields and ranked into portfolios by liquidity and size, there is evidence that liquidity is higher for larger bond market size, consistent with research findings of Sarig and Warga (1989) and McCauley & Remolona (2000). However, this relationship is not conclusive because some countries still display a contradiction of results in that size appears to have a positive impact on yields, while liquidity has a negative impact.

Further research in this area will be helpful to distinguish the impact that other factors, not included in this paper, have on the cost of debt capital in African bond markets. There are not enough studies on the liquidity of the African bond market and while data availability can be a significant challenge, the development of research in the topic would go far in advancing knowledge and understanding of the African markets as the development of this debt financial markets grows.

Key takeaways for portfolio managers and investors in African markets is that these markets behave somewhat different from the rest of the world based on available research. Although liquidity does impact bond yields in most of the countries used in the study, there is evidence that other macroeconomic factors are also important. The lesson from the study is that each

countries factors should be monitored together to gauge the sensitivities on yields when making investment decisions. For economic policy, this study indicated that yields in the African bond markets are significantly impacted by macroeconomic factors across the countries, respectively. Another policy implication from the results in this study is that the behaviour of the bond market across the continent is not uniformly impacted by the size of the market or the perceived liquidity. This means that it is important that policymakers keep a good guard on country-specific factors in making decisions that can impact the ability of the market to keep yields at levels that would be both attractive to both issuers and investors.

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