Macroprudential Liquidity Stress Test: An application to Jamaican Deposit Taking Institutions (DTIs)

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Abstract

This paper develops a macroprudential liquidity stress test model for Jamaican DTIs. It incorporates idiosyncratic, unknown and macroeconomic factors using quarterly data ranging from March 2005 to December 2020. Idiosyncratic factors are captured by the capital adequacy ratio, and lagged values of the aggregate systemic liquidity risk index (ASLRI). The ASLRI is constructed in this paper as a single yet comprehensive measure of both funding and market liquidity risk. Concurrently, the macroeconomic variables examined include the consumer price index (CPI), gross domestic product (GDP) and government expenditure, while unknown factors are represented by the residuals from the models. The framework identifies key liquidity risk triggers and macroeconomic factors by employing the autoregressive distributed lag (ARDL) approach. The results demonstrate that systemic liquidity risk in the Jamaican financial system is primarily influenced by idiosyncratic and unknown factors across different time horizons. Macroeconomic conditions also influence the ASLRI for the DTI sector with a more significant impact in the medium to long-term. Moreover, the ASLRI is primarily driven by funding liquidity risk (FLR). However, market liquidity risk (MLR) explains more of the volatility in the ASLRI as idiosyncratic and macroeconomic factors were substantially more significant. This result indicates that the key transmission channels for increased liquidity risk exposures for the banking system is through trading (financial market) activities. The results also showed that run-off rates in customer deposits are highly influenced by idiosyncratic and unknown factors across all time horizons. Meanwhile, macroeconomic factors do not influence customer deposits until the medium term. The results of this paper highlight the importance of liquidity stress testing of deposit-taking institutions to mitigate the impact of liquidity stresses. Additionally, regulators should ensure that banks have solid capital buffers that enable them to withstand extreme and unexpected shocks to their balance sheets and thus ensure that they can act as effective financial intermediaries even in periods of turbulence.

JEL Codes: G20, G21, G32, G33

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[1] The views expressed in this paper are solely of the author and do not necessarily reflect those of the Bank of Jamaica.

1.0 Introduction

Many academics believe that the 2007-2009 global financial crisis (GFC) was the most pronounced disturbance to the banking system since the Great Depression in the 1930s.[2] According to Teply and Vabrel (2012), the GFC evolved from a credit crisis which became pronounced between mid-2007 and mid-2008. It was characterized by excessive risk-taking activities by banks, which resulted in a 'housing market crash' in the U.S. real estate market (Williams 2010). As a result, housing prices plummeted along with the values of securities tied to the U.S real estate market, and led to an international banking and liquidity crisis with the failure of Lehman Brothers in September 2008.[3] The GFC taught many lessons, and raised fundamental questions concerning liquidity risk, which is the focus of this paper.

The BCBS (2013b) noted that stress testing is necessary to develop a complete liquidity risk profile for institutions as a viable alternative to the "one-size-fits-all" liquidity metrics. Stress testing is important to assess financial system resilience. Moreover, results from these tests may inform contingency planning to chart the course for how banks react in periods of high liquidity stress. Schuerman (2014) supports this view, suggesting that in light of the GFC the standard approaches of regulatory requirements and ratios are insufficient. Schuerman strongly argues for stress testing as a tool to achieve resilience.

Several issues however, have arisen in relation to liquidity stress tests. Of note, the constituents of a good stress test are still universally unclear and practices differ widely among banking regulators in different jurisdictions (BCBS, 2013b). The BCBS therefore urged regulators to conduct system-wide liquidity stress tests in light of the fact that individual banks lack the necessary data and so they use diverse assumptions and scenarios which can make supervision and assessment of systemic liquidity risks tedious.[4] Secondly, bank-specific liquidity stress tests only consider first-round effects, and ignore second-round or systemic effects. According to the BCBS (2013b), this oversight results in ignorance of the fact that banks' actions can have a significant impact on the market. Clerc et al (2016) showed that through indirect contagion, captured through second-round effects, the activities of many firms during the GFC produced negative spillover effects on other firms, and this amplified the crisis. Thirdly, most liquidity stress tests utilize scenarios that are independent of solvency stress tests, and do not capture the important link between liquidity and solvency risk (Taruna et al., 2020).

Finally, the IMF (2008) noted that liquidity risk has multiple dimensions, which makes quantification challenging. Clerc *et al.* (2016) substantiated this claim noting that second-round effects, which have more pronounced impacts on the banking system than first round effects are difficult to capture. For this reason, several macro stress-testing models omit liquidity risk from the assessment of risks. The BCBS has therefore recommended horizontal liquidity stress tests which outline a common set of scenarios and assumptions. Similarly, Taruna *et al.* (2020) emphasized the need for consistent macro scenarios to determine possible contagion channels through which stresses are amplified. Clerc *et*

[2] Strahan (2012), Williams (2010), Singhania and Anchalia (2013), Gopinath (2020) and Eigner and Umlauft (2015) share this view.
[3] Lehman Brothers Holdings Inc. was the fourth-largest investment bank in the U.S. before declaring bankruptcy. (see Williams, 2010)
[4] Schmieder et al. (2012) and Melecky and Podpiera, (2012) support this view.

al. (2016) identified two primary contagion channels in which second-round effects are propagated. These are the market price channel and the information channel.[5]

Against this background, this paper seeks to develop a macroprudential liquidity stress test model for the Jamaican DTIs. Moreover, this paper contributes to the literature in three (3) main ways. First, it produces an aggregate systemic liquidity risk index (ASLRI) as a measure of both funding and market liquidity risk. Second, it develops a macroprudential liquidity assessment of Jamaican DTIs which seeks to establish consistent macroeconomic scenarios to be utilized in stress testing models. Finally, it determines the key liquidity triggers which is a result of idiosyncratic, macroeconomic, or unknown factors, and determines whether liquidity stresses are predominantly idiosyncratic or systemic. Whilst we acknowledge that liquidity crises that originate in the banking sector can have spillover negative effects on the liquidity and solvency position of non-bank financial institutions (NBFIs), this will be the focus of future research.

The rest of the paper is organized as follows: Section 2.0 outlines a review of literature on liquidity stress tests and liquidity risk measurement, whilst Section 3.0 assesses liquidity risk measurement in Jamaica. Sections 4.0 discusses the data utilized, and outlines the methodology and model. Finally, the empirical results, post-estimation diagnostics as well as conclusions and policy implications are discussed in Sections 5.0, 6.0 and 7.0, respectively.

2.0 Literature review

Liquidity risk measurement takes several forms, ranging from simple bank-run type models and liquidity ratios to more complex integrated approaches. Several academics have developed bank-run type models which consider the behavior of deposits in the onset of unexpected withdrawals that result in liquidity stress for banks.[6] The limitation, however, with using bank-run models as measures of liquidity in general, is that they only focus on one aspect of funding liquidity risk, therefore not providing a holistic measure of the liquidity conditions. As another measure, Muranaga and Ohsawa (1997) used bid-ask spread methodologies to capture market liquidity risk. This is consistent with the widely held view that larger bid-ask spreads are associated with infrequently traded stocks, and this infrequency is directly related to rising securities prices and a clear indication of a lack of liquidity in financial markets. However, bid-ask spreads are also insufficient, as they also critically understate liquidity risks.

In contrast, many academics have developed aggregated indices as multidimensional measures of liquidity and liquidity risk. The most notable work on aggregated index approaches to quantifying liquidity risk is from the IMF.

[5] The market price channel shows how funding liquidity and market liquidity risk interact with each other and spiral out of control. Brunnermeier & Pedersen (2009) argue that during a liquidity crisis, both market risk and funding risk interact and strengthen each other, thus amplifying the liquidity stress; Reputation risks spread quickly leading to amplified systemic liquidity problems through this channel. Dang et al. (2013) agree with this view, that financial and information linkages are major transmission channels.

[6] Teply and Vrabel (2012) examined the two main categorizations of bank run models which include: bank runs as self-fulfilling prophecies following the novel work of Diamond and Dybvig (1983) and also models relating bank runs to business cycles, following also the work of Zhu (2001), Zhu (2005), Alonso (1996) and Chari and Jagannathan (1988).

The IMF has attempted to measure systemic liquidity risk by constructing aggregated liquidity indices using market data (Gobat *et al*., 2011). In one approach, a systemic liquidity risk index was developed to capture and monitor current systemic liquidity conditions, as opposed to stress testing for potential systemic liquidity risk. The theoretical construct of this index examines arbitrage principle violations that arise out of market liquidity dry-up by using covered interest rate parity.[7] The idea behind this arbitrage approach is that the magnitudes of the spreads are an indication of investors' ability to reallocate their funds to maximize their returns while minimizing risk. Thus, smaller price differentials suggest smaller transaction costs and other microstructure features, indicating good liquidity conditions. Larger spreads therefore indicate periods of liquidity stress. Although the typical interpretation of arbitrage violations is considered to represent both market and funding liquidity risk, two limitations of this approach involve the lack of availability of data and the granular nature of data required. In addition, these measures ignore important run-offs rates in deposits – a critical component of banks' liquidity risks.

Severo (2012) developed a similar systemic liquidity risk index (SLRI) using data on arbitrage violations across different asset classes.[8] The findings suggest that the level of bank returns is not directly affected by the SLRI, however their volatility increases as a result of deteriorating liquidity conditions. Furthermore, while bank size was not strongly correlated to exposure to the SLRI, the SLRI is positively associated with the Net Stable Funding Ratio (NSFR). Mishra *et al.* (2012) also constructed a systemic liquidity index (SLI) for India, and found that banks' equity index was inversely related to the SLI. An assessment by the IMF (2011) found a similar result. This suggests that banks' equity prices are likely to exhibit volatility in high liquidity stress periods, and therefore highlights the need to capture liquidity stress emanating from trading activities (market liquidity risk). The SLI developed by Mishra *et al.* (2012) has this very crucial limitation, in that it only captures systemic liquidity stress due to funding liquidity risk, and ignores considerations for market liquidity risk. This is consistent with their observation that crises typically start with funding liquidity risk events in one or a few institutions before spreading to the entire financial system through contagion channels, thus heightening market liquidity risk and propagating into a systemic liquidity crisis.[9]

This paper agrees with Clerc *et al.* (2016) and Brunnermeier & Pedersen (2009) who highlight the importance of examining funding and market liquidity risk at the same time as they are interlinked and often interact with each other to exacerbate liquidity stress. To this end, we develop an aggregate systemic liquidity risk index (ASLRI) consistent with Mishra *et al.* (2012), but improve upon the methodology to account for both funding and market liquidity risks.

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[7] Covered interest rate parity looks at the relationship between interest rates and the spot and forward currency values of different jurisdictions. Arbitrage is a violation of parity which must hold, and so covered interest rate parity suggests that there is no opportunity for benefit from differences in interest rates that exist between any two countries.

[8] The arbitrage relationships examined include Covered Interest Parity (CIP), CDS-Bond basis for non-bank corporations, on-the-run versus off-the-run U.S. treasuries and interest rate swap spread. This analysis involved CIP derived from 7 different currencies, and considered the 3-, 6- and 12-month horizons. Bai and Collin-Dufresne (2019) note that CDS-bond basis measures the difference between credit default swap (CDS) spread and cash-bond implied credit spread.

[9] Mishra et al. (2012) used four indicators representing various market segments to capture funding liquidity conditions, namely: weighted average call rate adjusted for the Reserve Bank's repo rate, the 3-month CP rate adjusted by the 3-month CD rate, the weighted average 3 month overnight indexed swap rate (OIS), and the difference between the 3-month CD rate and the 3-month implied deposit rate.

The Bank of Jamaica currently utilizes several systemic risk indicators (SRIs) and composite indices as part of its macroprudential surveillance toolkit to monitor financial system stability.[10] However, outside of the funding liquidity stress test and the computation of simple liquidity metrics, there are no prior studies or frameworks which focus on liquidity risk measurement. Furthermore, these frameworks only utilize simple liquidity ratios to assess balance sheet liquidity. [11] Given the inherent gaps in the liquidity risk framework for Jamaica, this paper adds to the literature by developing the ASLRI as a single measure of systemic liquidity risk. This index will then be used to determine key liquidity triggers for the DTI sector, as well as establish consistent macroeconomic scenarios.[12]

3.0 Liquidity Risk Measurement in Jamaica

The Jamaican banking system is making advancements towards compliance with Basel III liquidity requirements, in particular as it relates to the implementation of the LCR. In contrast, the implementation of the NSFR ratio is still in its infancy stages. Despite the LCR being relatively new, authorities have observed that all DTIs within the system are already fully compliant with the LCR requirements. This is due to the fact that the institutions generally hold high levels of liquidity, such that their stock of high-quality liquid assets (HQLAs) is sufficient to cover more than 100% of their net cash outflows for a 30-day period.

From a funding liquidity perspective, the banking system is generally robust to liquidity procyclicality in light of banks' high liquidity levels. According to Landau (2009), procyclicality refers to the tendency for various financial variables to fluctuate around trends in economic variables based on business cycles. In particular, liquidity procyclicality exists when the credit-to-GDP gap and liquidity moves in opposite directions, indicative of a negative relationship. A number of studies point to the need for further market discipline in markets prone to procyclical behavior.[13] However, within the Jamaican context from a funding liquidity perspective, there is no evidence of liquidity procyclicality as banks' holdings of liquid assets are invariably high (see Appendix B: Figure 1 and Appendix A: Tables 1a & 1c).[14]

In contrast, there is a significant positive relationship between the ASLRI and the credit-to-GDP gap, which suggests that the Jamaican DTI sector may be prone to liquidity procyclicality, but purely from a market liquidity risk standpoint (see Appendix B: Figure 2 and Appendix A: Tables 1b & 1c). This arises from the fact that when the economy is experiencing a boom, banks are likely to pursue more aggressive asset growth strategies in purchasing more high-return, high-risk investments. As banks increase their investments in these high-risk instruments, this reduces their

[10] These indicators utilize both cross-sectional and time-series data from balance sheets, income statements, other macroprudential risk factors and macroeconomic data to assess existing and emerging risks, market conditions and the potential impact of shocks.
[11] Liquidity conditions are measured and incorporated into the composite indices by way of the following indicators: deposits to total loans, deposits to total assets, domestic and foreign liquid assets to total assets and liquid assets to total deposits ratios.
[12] Literature surrounding the use and selection of idiosyncratic, macroeconomic and unknown factors which influence liquidity risk is further discussed in the Data and Methodology section.
[13] Studies include Taruna et al. (2020), Levy-Yeyati et al. (2010), Cho and Hahm (2014), Lee et al. (2016), Jung et al. (2017) and Yang and Yi (2019)
[14] This is evidenced by a weak though negative correlation between the credit-to-GDP gap and the two liquidity measures (liquid assets to total assets - LA/TA, and liquid assets to short term liabilities – LA/ST).

stock of liquid assets as well as increases their exposure to solvency and market liquidity risk mainly through interest rate and foreign exchange rate fluctuations. Despite the fact that systemic liquidity risk is primarily driven by funding risk, market liquidity risk is more volatile (see Appendix B: Figure 3). As such, it is anticipated that the main transmission channel for increased liquidity risk in the banking system, is through market liquidity risk.

Bank of Jamaica also currently use a myriad of other liquidity indicators to measure the level of liquidity risk in the banking system. In particular, the indicators are monitored with the aim of mitigating and preventing excessive maturity mismatches and market illiquidity in the financial system. These indicators include liquid assets to total assets and the liquid assets to short-term liabilities ratios and are broad measures of liquidity in the financial system. In addition, liquidity conditions in financial markets and in relation to specific banking activities are assessed individually in areas ranging from intermediation, market liquidity, maturity transformation, and liquidity transformation.[15] The intermediation ratios include volatile deposits to total loans and volatile non-deposit liabilities to total loans. Also, market liquidity ratios include the Amihud index of market depth for both the foreign exchange and stock market, the TRE Spread, foreign exchange bid-ask spread and DTIs interest spread. Other indicators relate to maturity transformation, and liquidity transformation, which are both broken down on a sectoral basis.[16] The indicators are briefly discussed in the data and methodology section below.

Additionally, in order to assess bank resilience to liquidity risk, the Bank of Jamaica, Financial Stability Department performs routine funding liquidity stress tests to assess liquidity risk of individual banks and within the overall financial system. The funding liquidity risk stress test assesses the impact of hypothetical changes in deposits, on the level of liquid assets and the capital adequacy ratio (CAR) of financial institutions in the Jamaican financial system. The focus on solely funding risk from a stress testing standpoint may be attributed to the finding of a high, positive correlation between the ASLRI and the funding liquidity risk index (FLR) sub component. This result suggests that liquidity risk in the Jamaican DTI sector is primarily driven by funding risk (see Appendix: Figure 2). The methodology for the stress test uses a modified Martin Čihák approach (IMF, 2007), which models a liquidity drain which may result from a run on banks, that affects all FIs in the system simultaneously. The impacts of haircuts or shocks in relation to liquidation of assets in case of a liquidity shortfall are also assessed.[17] In particular, this assessment looks at the post-shock shortfall in liquid assets and loss in interest income due to liquidation for individual banks, and the system as a whole. Results from DTIs stress tests reported in the last financial stability report (FSR), showed that DTIs are generally resilient to hypothetical shocks to deposit-withdrawals.[18]

[15] The Central Bank of Jamaica is directly responsible for the regulation and supervision of DTIs.

[16] Maturity transformation is calculated as (LT assets – LT liabilities- nonredeemable equity)/ total financial assets.; liquidity transformation is calculated as ST liabilities [≤30 days]/ liquid assets

[17] Parameters which include foreign to domestic currency denomination conversions, haircuts applied to different types of assets determined by the market value of the asset and also the penalty rate of the Central Bank, weightings applied to both liquid assets and various currency denominations, hypothetical shocks applied to withdrawal of deposits, and the choice of liquid components.

[18] The latest financial stability report was the FSR 2019 published on the Bank of Jamaica website.

4.0 Data, Methodology & Model

4.1 Description of Data and Sources

To construct a model for macroprudential liquidity stress testing for DTIs in Jamaica, this paper utilizes quarterly data for all eleven (11) DTIs in the Jamaican financial system over the period 2005 to 2020. The dependent variable is the aggregate systemic liquidity risk index (ASLRI), which is an aggregate measure of systemic liquidity stress. Moreover, the explanatory variables include the GDP growth rate (GDP), the inflation rate (CPI), government expenditure (GOVTEXP), and the capital adequacy ratio (CAR). These variables will be discussed in subsequent section below.

4.2 Composition of the Aggregate Systemic Liquidity Risk Index (ASLRI)

The Aggregate Systemic Liquidity Risk Index (ASLRI) is a single quantitative measure of systemic liquidity risk. It consists of nine (9) indicators in which the first four (4) capture funding liquidity risk.[19] The remaining indicators capture market liquidity risk (see Appendix A: Table 2). The indicators comprise some core and encouraged financial soundness indicators (FSIs) for deposit-taking financial institutions (DTIs). Other indicators are also identified as specific to the Jamaican context. [20] The indicators and construction of the index are briefly described below.

Funding Liquidity Risk Indicators

1. ***DTIs - deposits to total loans {D-TL}:*** Customer deposits to total loans is an asset-based encouraged FSI, which compares stable funding (deposits) with total loans. The intuition behind this measure of funding liquidity is that there is a tendency for much greater dependence on more volatile (unstable) sources of funds to meet short-term debt obligations in the presence of illiquid asset portfolios.[21] Therefore a decrease in this measure is an indication of low levels of stable deposits relative to loans, which means there is a lack of liquidity in the market, hence heightening the level of funding risk. Mathematically, the ***D-TL*** indicator is defined as:

$$\frac{\boldsymbol{Customer\ Deposits}}{\boldsymbol{Total\ Loans}} \qquad [1]$$

2. ***DTIs - volatile non-deposit liabilities to total loans {NDL-TL}:*** Volatile non-deposit liabilities include all other volatile liabilities.[22] Similar to the first, this indicator captures short-term funding liquidity risk, and is computed as follows:

$$\frac{\boldsymbol{Non\ Deposit\ Liabilities}}{\boldsymbol{Total\ Loans}} \qquad [2]$$

[19] All nine (9) indicators represent idiosyncratic liquidity risk exposures.
[20] FSIs are taken from source paper: International Monetary Fund Staff. (2008). *Financial Soundness Indicators: Compilation Guide*. International Monetary Fund; Jamaican specific indicators were developed by the financial stability department of the Bank of Jamaica (BOJ).
[21] See Dziobek *et al.* (2000) for a discussion.
[22] We assume that all short-term liabilities (deposit or non-deposit) are volatile at some points in time, especially during periods of uncertainty or high liquidity stress. Hobbs et al. (2000) noted that liquidity is closely related to confidence in the system to satisfy liability obligations as they become due. They concluded that funding volatility is characterized into three (3) main areas, namely the type of depositor, insurance coverage (status) and maturity (where longer maturity dates indicate more stable funds, implying less volatility).

3. ***Maturity Transformation {Mat-Trans}:*** Maturity transformation is computed as the difference between long-term (LT) assets and LT liabilities (LT assets - LT liabilities) to total financial assets.[23] An increase in maturity transformation indicates greater usage of short-term funding sources to finance longer term assets thus leading to greater maturity mismatch between assets and liabilities. This indicator therefore captures long-term funding liquidity risk, and is computed as follows:

$$\frac{\boldsymbol{LT\ assets - LT\ liabilities\ (nonredeemable\ equity)}}{\boldsymbol{Total\ Financial\ Assets}} \qquad [3]$$

4. ***Liquidity Transformation {Liq-Trans}:*** Liquid assets to short-term liabilities[24] captures liquidity mismatches between assets and liabilities. It gives information about the extent to which DTIs are able to withstand unexpected withdrawal of funds whilst avoiding liquidity problems. In addition, the short-term liabilities considered are those 30 days or less. An increase in this liquidity transformation ratio suggests an overreliance on short-term debt financing. Mathematically, the ***"STL-LA"*** indicator is defined as:

$$\frac{\boldsymbol{ST\ Liabilities\ (\leq 30\ days)}}{\boldsymbol{Liquid\ Assets}} \qquad [4]$$

<u>Market Liquidity Risk Indicators</u>

The IMF (2008) noted that two (2) very important dimensions of liquidity are "market depth" and "tightness".[25] As such measures such as the Amihud Indices of Market Depth which capture liquidity conditions in the foreign exchange and stock market respectively are utilized.[26] Indicators capturing market tightness are also included such as foreign exchange bid-ask spread, TRE Spread and Interest Spread.

1. ***Foreign Exchange Market - Amihud index of Market Depth {FX-Amihud}:*** The Foreign Exchange Market Amihud index captures the sensitivity of price changes to overall foreign exchange market activity. It is calculated by the absolute value of daily changes in the JMD/USD forex price divided by daily volumes traded (DVT). A reduction in this index suggests that daily volumes traded have little impact on prices in this market, thus implying greater market depth. Mathematically, the daily ***"FX-Amihud"*** indicator is defined as:

$$\boldsymbol{ABS\left[\frac{FX_t - FX_{t-1}}{FX_{t-1}} * 100/DVT_t\right]}\ [27] \qquad [5]$$

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[23] Maturity transformation involves the use of short-term funding sources to invest in longer-term assets.
[24] Liquid assets to short-term liabilities is an asset-based core FSI for DTIs
[25] Market depth is concerned with the capacity of a market to withstand large trading volumes with little to no impact on prices, while tightness refers to the costs incurred to execute transactions regardless of market price.
[26] Amihud Indices of Market Depth quantify the response of returns (that is the daily price response) to one dollar of trading volume. The lower the sensitivity of prices to the level of volume traded, the less deep the market, indicative of market illiquidity. As such, greater market depth suggests a more liquid market. See Amihud (2002) more a more detailed analysis; for aggregation purposes, monthly FX-Amihud and Equity-Amihud indices will be generated as at end-month, by taking the average of their daily counterparts.
[27] where FX is the exchange rate (J$=US$1.00), representing asset prices.

2. ***Stock Market - Amihud index of Market Depth {Equity-Amihud}:*** The Stock Market Amihud index captures the degree of responsiveness of price changes to the overall stock market activity. It is calculated by the absolute value of daily changes in the Jamaica Stock Exchange (JSE) Main Index value divided by the daily level of trading (DVT). Similarly, a reduction in this index suggests that daily volumes traded have little impact on prices in this market, thus implying greater market depth. Mathematically, the daily ***"Equity-Amihud"*** indicator is defined as:

$$\boldsymbol{ABS\left[\frac{SI_t - SI_{t-1}}{SI_{t-1}} * 100/DVT_t\right]} \text{ [28]} \qquad [6]$$

3. ***Foreign Exchange bid-ask spread {FX-Spread}[29]:*** A number of studies have highlighted the use of bid-ask spreads as a measure of liquidity overall, and in foreign exchange markets in particular.[30] It is a widely held view that larger bid-ask spreads are associated with infrequently traded assets and this infrequency is directly related to rising securities prices. The FX spread is therefore validated as a measure of the degree of liquidity within the foreign exchange market. It is calculated as the difference between the current bid price and the current offer price in the FX market for the JMD/USD currency pair. As such, a narrowed FX spread indicates improved liquidity conditions in the FX market. Mathematically, the ***"FX-Spread"*** indicator is defined as:

$$\boldsymbol{FX\ Spread = FX\ sale\ price\ (Ask) - FX\ purchase\ price\ (bid)} \text{ [31]} \qquad [7]$$

4. ***TRE Spread {TRE-Spread}:*** The TRE spread captures both counterparty risk and liquidity risk in the money market. It measures the premium priced in the repo rate for default risk, and is computed as the difference between the average monthly value of daily 30-day private money market rates (PMMR) and the 30-day Treasury bill (T-bill) rate.[32] The higher the value of the TRE spread, indicates higher price differentials between the interest rates on debt instruments and the risk-free rate. This therefore suggests, that markets are more illiquid, as larger spreads indicate a higher probability of default or inability to satisfy debt obligations.[33] Mathematically, the ***"TRE Spread"*** indicator is defined as:

$$\boldsymbol{TRE\ Spread = 30day\ PMMR - 30day\ Tbill\ Rate} \qquad [8]$$

5. ***DTIs - Interest Spread {Interest-Spread}:*** The DTIs interest spread measures the difference between the average weighted loan and deposit rates for each sub-sector (commercial banks, building societies and merchant banks

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[28] where SI is the value of the JSE Main Index, representing asset prices.
[29] Foreign exchange bid-ask spreads are referred to as foreign exchange spread in short.
[30] Muranaga and Ohsawa (1997) developed a general framework for measuring market liquidity risk, using bid-ask spread methodologies. Additionally, Sarr et al. (2002), Banti et al. (2012), Bessembinder (1994), Lund (2011) and Bollerslev & Melvin (1994) highlight the use of bid-ask spreads as a measure of liquidity risk in FX markets.
[31] where FX is the exchange rate (J$=US$1.00)
[32] The premium for default risk is represented by the difference between the interest rate on debt instruments and the risk-free rate. The default risk premium is therefore an insurance to investors, against the likelihood of default by the issuer of a security.
[33] Duffee (1999) noted that liquidity differences, taxes and repo rates are among the factors which result in deviations in corporate asset prices from Treasury bond prices, and all are subsumed into a random stochastic process known as "default risk. See also Fisher (2002).

sub-sectors) and is weighted by relative asset size.[34] It is also widely used in the literature to assess profitability and competitiveness of the banking sector. However, the justification of the use of this indicator as a measure of liquidity, is highlighted by an overwhelming amount of studies which find a significant negative relationship between profitability and liquidity whilst a few studies find a positive relationship.[35] It is viewed that liquidity and profitability are inversely related, in that institutions who pursue more aggressive growth strategies (which are hence more profitable) tend to lose sight of their liquidity or cash positions. Moreover, since such strategies involve investment in high-yield, longer term, and hence more risky investments, liquidity management becomes more difficult as the funds which are often needed to satisfy short-term debt obligations are tied-up in more illiquid assets (for example loans).[36] Narrowed spreads therefore characterize lower liquidity risk. The reverse argument also holds true.[37] Mathematically, the ***"Interest Spread"*** indicator is defined as:

$$\sum_{i=1}^{n} w_i * s_i = w_1 s_1 + w_2 s_2 + w_3 s_3 + \cdots + w_n s_n \quad [38] \qquad [9]$$

4.3 Construction of the ASLRI

Having identified the indicators to be used in the ASLRI, the next step is to normalize each indicator to convert them into a common unit. This is accomplished using the following formula:

$$N.I_{it} = \frac{I_{it} - \min(I_i)}{\max(I_i) - \min(I_i)} \qquad [10]$$

where $N.I_{it}$ represents the normalized indicator at time t and I_{it} represents the value of the indicator at time t; $\max(I_i)$ and $\min(I_i)$ represent the largest and smallest values respectively of each indicator. Following the normalization process, each indicators' values will range between zero (0) and (1), where a value of zero (0) would represent the weakest value of the indicator. The normalized indicators are then aggregated into two (2) sub-indices using the following equations:[39]

[34] Weighting by relative asset size is a consideration for the size of each commercial bank's portfolio relative to the entire commercial banking sector

[35] Hossain & Alam (2019), Eljelly (2004), Raheman & Nasr (2007) and Saleem & Rehman, R. U. (2011), all found a significant negative relationship between profitability and liquidity. However, Lartey et al. (2013), Ahmad (2016), Vieira (2010) and Khan and Ali (2016) found a positive relationship.

[36] On the other hand, deposits are more liquid since a fraction of deposits are held as cash in reserves, and are thereby less risky. As such, lending rates are by definition, higher than deposit rates and a narrowed interest spread indicates lower profitability and hence improved liquidity conditions across the market.

[37] Taruna et al. (2020) and Fisher (1993) noted that fire sales during the GFC which resulted in significant haircuts on asset prices, moved corporate yields closer to T-bill rates (resulting in narrowing interest spreads) in the crunch for liquidity. This observation provides evidence and further validates the use of interest spreads as a measure of market liquidity risk.

[38] where i = represent each sub-sector ; w_i = weight applied to each sub-sector and is defined as $\frac{Assets_i}{Total\ DTIs\ Assets}$; and $s_i = i_{lending} - i_{deposit}$. $i_{lending}$ and $i_{deposit}$ represent the weighted average lending rates and weighted average deposit rates respectively, by institution in each subsector.

[39] Each indicator was weighted equally in the ASLRI as we assume that all the indicators are equally important. Notably, there is no statistical or empirical evidence to suggest otherwise as further work is needed to statistically assess which areas are more highly impacted by liquidity stress scenarios, coupled with expert Judgement. As noted in the approaches of Mishra *et al.* (2012) in their development of the systemic liquidity index (SLI) and Teply and Vrabel (2012) who developed the VT index measuring market liquidity risk, the methodologies surrounding indicator selection, aggregation, and validation of an index must be derived from idiosyncratic and country specific factors (historical or otherwise), as well as careful consideration for the characteristics of the specific market to which the index would be applicable.

(1) FLR,

$$\overline{F_t} = \frac{\sum_{i=1}^{4} F_{it}}{4} \qquad [11]$$

Where FLR denotes the funding risk sub-index represented by $\overline{F_t}$; F_{it} represents each of the funding risk indicators at time t.

(2) MLR,

$$\overline{M_t} = \frac{\sum_{i=1}^{5} M_{it}}{5} \qquad [12]$$

Where MLR denotes the funding risk sub-index represented by $\overline{M_t}$; M_{it} represents each of the market risk indicators at time t.

The mathematical construct of the ASLRI is therefore given by:

$$ASLRI_t = \frac{4\overline{F_t} + 5\overline{M_t}}{9} \qquad [13]$$

Mishra *et al.* (2012) highlighted the need to validate any index that is constructed, both in terms of the variables included as well as the signaling power of liquidity risk conditions in financial markets. As such, the ASLRI is validated through the correlations between each of the liquidity risk measures (see Appendix A: Table 4). Notably, in terms of magnitude, all the correlations except one, are relatively small. These results suggest that the selected liquidity risk indicators included in the analysis capture different aspects of the multi-dimensional concept of liquidity.

In terms of signaling power, the ASLRI was regressed against both the liquid assets ratio (LA/TA) and the liquid assets to short-term liabilities ratio (LA/ST). For the ASLRI to be validated as a good measure of liquidity risk, it is expected that there will be a negative relationship between the ASLRI and the liquidity ratios. Results show a negative and statistically significant relationship between both liquidity ratios and the ASLRI, in support of the expected hypothesis (see Appendix A: Table 3 and Appendix B: Figure 3).

4.4 Macroeconomic Variables

Literature on the macroeconomic determinants of liquidity risk is vast, as several academics have examined this relationship using various measures. In one strand of literature, the impact of various monetary and fiscal policy variables on liquidity is examined. Chowdhury *et al.* (2018) using nine (9) macroeconomic variables found a positive relationship between market liquidity and the aggregate money supply, government expenditure and credit to the private sector.[40] On the contrary, the central bank policy rate, short-term domestic interest rate and government borrowing are strongly associated with market illiquidity. Therefore, implying an inverse relationship with liquidity.[41]

Other studies have found a significant relationship between liquidity risk and GDP growth rates. Chowdhury *et al.* (2018) validated the use of GDP as a macroeconomic determinant of liquidity.[42] They noted that unexpected productivity falls are likely to impact illiquidity conditions through liquidity outflows, price volatility, and increased inventory risks. Although results from the literature are mixed, there is a compelling number of academics who find a significant positive relationship between GDP and liquidity risk.[43,44] As such, we expect that higher levels of economic growth will reduce liquidity buffers through banks pursuit of increased lending opportunities, thus increasing liquidity risks.

Similarly, a number of studies identify inflation as a significant macroeconomic determinant of liquidity. Chowdhury *et al.* (2018) found that excessive inflationary pressures are likely to adversely impact (market) liquidity.[45] Taruna *et al.* (2020) also studied this relationship between liquidity and the consumer price index (CPI), but deepened their analysis to examine the relationship across different time horizons.[46] They found that both GDP and CPI contributed to liquidity runs in the short run, confirming that both GDP growth and inflation are inversely related to liquidity, and hence exhibits a positive relationship with liquidity risk. [47,48] Moreover, as it relates to runoff rates in customer deposits, macroeconomic conditions were found to trigger liquidity runs across all three (3) time horizons (Taruna et al. 2020). Confirming this result is Jameel and Hayee (2017) who found that industrial production growth rate and domestic interest rates are co-integrated with stock market liquidity, implying evidence of a long run relationship.

[40] Aggregate money supply is proxied by the rolling 12-month growth rate of base money; Blinder and Solow (1973) assert that government spending increases national income with a multiplier effect and facilitates increased monetary flows, which evidences the positive effect on liquidity; Blanchard (2009) noted that the GFC financial crisis was propagated through credit rationing with the tightening of lending policies by banks, and so credit to the private sector gives a measure of banks' volume of lending and willingness to loosen credit standards following a fiscal policy shock.

[41] Sheefeni and Nyambe (2016) found that the monetary policy rate is positively associated with banks' liquidity although the relationship was insignificant; Gagnon and Gimet (2013) use the three-month Treasury bill rate as a proxy for short term domestic interest rate. Chordia et al. (2001) and Soderberg (2008) also consider the effect of short-term domestic interest rate shocks on liquidity; Fisher (1988) stated that government borrowing from commercial banks 'crowds out' private investment, and thus impacts liquidity negatively, through increased competition for private savings.

[42] Annual percentage change in GDP is typically used as a proxy to capture the effect of business cycle developments on liquidity conditions in financial markets. However, exceptions are Chowdhury et al. (2018), Goyenko and Ukhov (2009) and others who use monthly growth rate of industrial production (IP) to capture business cycle developments.

[43] Jameel and Hayee (2017), Vodova (2011) and Bhati et al. (2015) are among the academics who find a significant positive relationship. Notably, Chen et al. (2018) found that current period annual percent change in GDP along with its 1 period lagged value (annual percent change in GDP last year) are statistically significant in explaining liquidity risk, and both exhibit this positive relationship. In Contrast, Al-Khouri (2012) and Choon et al. (2013) found a negative relationship between GDP and liquidity risk.

[44] In support of this finding, Aspachs et al. (2005) stated that banks tend to hoard liquidity during economic downturns where there is a lack of lending opportunities, and lend aggressively during periods of economic expansion, as more lending opportunities arise.

[45] Sheefeni and Nyambe (2016), Vodova (2011), and Ferrouhi and Lehadiri (2013) are among the papers who found a similar negative relationship between inflation and banks' liquidity. On the contrary, Al-Khouri (2012) found the relationship to be positive.

[46] Taruna et al. (2020) classified time horizons as follows: 3-month, 6-month and 12-month time horizons represent short term, medium term and long term respectively. They also assessed the relationship between GDP and liquidity risk.

[47] Liquidity here is measured by the stock of High-Quality Liquid Assets (HQLA)

[48] This finding was however counterintuitive to the authors' expectations that macroeconomic variables are more likely to have a long run impact, given that macroeconomic variables transmission takes place with a lagged effect.

Inflation and the exchange rate however we not cointegrated, implying no long run relationship with stock market liquidity (Jameel and Hayee, 2017).

From the above analysis on macroeconomic variables, we observe that the results are largely mixed, and vary based on jurisdiction(s) and datasets used. Furthermore, the methodologies and approaches used are also very different. Based on the variables which have been identified in literature, the monetary policy variables, some of the fiscal policy variables inclusive of government borrowing, and in general the foreign exchange rate, will already be captured in the dependent variable.[49] As a consequence, these variables would be highly correlated with the ASLRI and so they are omitted from the model to avoid an overspecification bias. In this paper therefore, the model will be estimated using GDP, CPI, and government expenditure as the macroeconomic variables.

4.5 Idiosyncratic Factors

Many papers have identified several idiosyncratic factors associated with liquidity risk.[50] Many of these variables are however highly correlated with the ASLRI, and as such are not included in the model. For our purposes, the construct of the ASLRI uses indicators that not only capture the build-up of liquidity risk, but also capture other important areas associated with liquidity, such as profitability, size and competition.[51] These areas largely encompass the idiosyncratic factors which have been identified in the literature. In this model therefore, in line with Taruna et al (2020), idiosyncratic factors are represented by lagged values of the ASLRI (the dependent variable).

We note however, that the ASLRI does not address the important link between liquidity and solvency as suggested by Schuerman (2014) and Schmieder *et al.* (2012). As such we include the capital adequacy ratio (CAR) as a measure of DTIs solvency position. Many academics have found the CAR to be statistically significant in explaining liquidity conditions. However, even though an overwhelming amount of literature find a negative relationship between the CAR and liquidity risk, a few authors have found a positive relationship.[52] We anticipate and therefore hypothesize that CAR and liquidity risk are inversely related. This stance is in line with the commonly shared perspective that capital acts as a cushion against risk (and in particular liquidity risk).[53] In particular, we note that during periods of high liquidity stress, banks with higher levels of capital adequacy have the ability to use their capital to satisfy short term debt obligations. This circumvents the costs associated with having to liquidate more permanent assets, which are significantly costlier. In support of this view, Hassan et al. (2013) suggest that the risks which may lead to failure and bankruptcy are significantly reduced when banks have enough capital to absorb potential losses associated with

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[49] The monetary policy variables include the central bank policy rate, short term domestic interest rates, money supply, credit to the private sector.

[50] Amongst the common idiosyncratic factors identified in the literature are bank size, return on assets (ROA), non-performing loans (NPLs) [proxy for credit risk] and return on equity (ROE). See: Alzoubi (2017), Jedidia and Hamza (2015), Vodova (2011), Vodova (2012), Vodova (2013), Waemustafa & Sukri (2016) and Wójcik-Mazur & Szajt (2015).

[51] The IMF (2008) noted that the spread between loan and deposit rates (traditionally lending spreads) are typically used in literature as measures of profitability and competitiveness in the banking sector.

[52] Muharam (2012), Jedidia & Hamza (2015), Shamas et al. (2018), Sukmana & Suryaningtyas (2016), Rahman & Banna (2015), and Alzoubi (2017) are among the studies that report a significant negative relationship. In contrast, Iqbal (2012), Abdul-Rahman et al. (2018) and Akhtar et al. (2011) found a positive relationship between CAR and liquidity risk.

[53] See Repullo (2004), Ojo (2010), Bonfim and Kim (2012) and all literature reported to have found a negative relationship between capital and liquidity risk, suggesting that well capitalized banks have reduced exposure to liquidity risk.

these risks. As such, the use of the CAR in this model is justified in that it captures interactions in macroeconomic variables which may influence liquidity measures.

4.6 Empirical Model

Consistent with Taruna et al. (2020), this paper models systemic liquidity risk as a function of idiosyncratic and macroeconomic factors using the ARDL (p, q) approach. The baseline panel specification is outlined as follows:

$$y_{i,t} = a_i + \sum_{j=1}^{p} \beta_{i,j}\, y_{i,t-j} + \sum_{j=0}^{q} \gamma_{i,j,k}\, X_{i,t-j,k} + \sum_{j=0}^{q} \delta_{i,j}\, CAR_{i,t-j} + \varepsilon_{i,t} \qquad [14]$$

where $y_{i,t}$ is a vector representing quarterly values of the dependent variable (ASLRI), for each individual institution (i) at time (t); a_i represents the fixed-effects coefficient (constant term); $\beta_{i,j}$ represents the coefficients of lagged values of the ASLRI, represented by $y_{i,t-j}$; $\gamma_{i,j,k}$ represents the coefficients of the macroeconomic variables, represented by the vector $X_{i,t-j,k}$; k denotes GDP, CPI, GOVEXP; p and q represent the maximum lags for dependent variable and the regressors respectively; and $\varepsilon_{i,t}$ denotes the error term, and represents unknown factors.[54] The optimal lag orders p and q are equal and predetermined, so that no lags, up to 6 months, and 6-12 months represent the contemporaneous short-, medium-, and long-term horizons (see Appendix A: Table 5).

5.0 Empirical Findings

The empirical analysis on the relationships between systemic liquidity risk, idiosyncratic factors, macroeconomic variables and unknown factors are reported in this section. Section 5.1 summarizes the preliminary descriptive statistics, bivariate correlation analysis and stationarity results. Section 5.2 discusses the relationships between the aggregate systemic liquidity risk index and idiosyncratic factors, macroeconomic variables and unknown factors across all time horizons for the Jamaican DTI sector. Concurrently, each of the aforementioned factors are checked against the sub-indices of the ASLRI – i.e. FLR and MLR – to ascertain both consistent macroeconomic scenarios as well as whether the liquidity risk triggers identified in section 5.2 primarily drive funding or market liquidity risk. Meanwhile, section 5.3 presents analyses on each DTI sub-sector assessing the same relationships existing among the factors identified in the previous section. In section 5.4 further analyses are presented on customer deposits, while section 5.5 presents an assessment of the existence of unknown factors in the regressions.[55]

[54] According to Taruna et al. (2020), unknown factors may be interpreted as the effects of plausible panic scenarios on the banking system, arising from periods of stress or uncertainty.

[55] The main focus as it relates to the results is in the relationships (signs) and the significance of the variables utilized in the regressions. As such, no attention is paid to the magnitude of the coefficients. This is because many of the factors which may be significant in explaining variability in systemic liquidity risk are actually components of the ASLRI, and aggregation could have potentially reduced the detection of such key relationships with individual variables. In such an instance, a non-parametric approach (such as signaling) would serve as more appropriate than regression analysis. Based on the focus of this paper, such a task is outside of the scope of this paper.

5.1 Preliminary Statistics

The summary statistics for all the idiosyncratic variables for the DTI sector, as well as the macroeconomic variables utilized in the paper are presented in Tables 6a and 6b. For estimation purposes both GDP and government expenditure are used in their natural logarithmic form. Contrary to expectations, the levels relationship between each of the regressors and the dependent variable for the DTI sector are generally weak and positive (see Appendix A: Table 7a). The relatively low correlations may suggest that at least in the short-run, estimations are likely to produce insignificant results. Notwithstanding, it is anticipated that there is cointegration among the variables, in particular the macroeconomic variables, indicative of a long-run relationship.[56] Notably, there is a strong, positive correlation between the CPI and GDP, as well as GDP and government expenditure, which is consistent with economic theory.[57] The variables were then disaggregated to facilitate analyses for each DTI sub-sector, of which the preliminary correlations are also presented (see Appendix A: Table 7b). Notably, there is a strong negative correlation between the ASLRI and the CAR for Commercial Banks. Meanwhile the macroeconomic variables all exhibit high positive correlations with the ALSRI. In contrast, the bi-variate relationships among each of the variables for building societies and merchant banks are generally weak.

In order to ensure the appropriateness of the ARDL model specification, the Im, Pesaran, and Shin (IPS) unit root test was used for the panel model of the DTI sector (see Appendices: Table 8a). Results showed that CAR_FX, LN_GDP, and MLR was all stationary in levels, therefore I(0), whilst the ASLRI, CPI, LN_GOVTEXP and FLR were stationary in first differences, and therefore I(1). Additionally, the Phillips-Perron (PP) unit root test was done to ensure stationarity of the time series models for each DTI sub-sector. For commercial banks, the ASLRI and MLR are I(0), while CAR_FX and FLR are I(1). In contrast, for building societies the CAR_FX and MLR are I(0), while the ASLRI and FLR are I(1). Similarly, for merchant banks the ASLRI and FLR are I(0), while the CAR_FX and MLR are I(1) (see Appendices: Table 8b).[58]

5.2 Baseline Results – DTI Sector

The baseline scenario assesses the relationship between the ASLRI and the key variables for the DTI sector (see Appendix A: Table 9a). The results suggest that macroeconomic conditions (GDP and GOVTEXP) are associated with changes in the ASLRI in the short-term – a similar finding to that of Taruna et al. (2020). In the medium term, CPI, GDP and GOVTEXP influence changes in the ASLRI. Meanwhile in the long-term, idiosyncratic factors (CAR_FX) and macroeconomic conditions (CPI, GDP and GOVTEXP) influence aggregate systemic liquidity risk in

[56] The BOJ noted in its quarterly monetary policy report (QMPR) that within the Jamaican economy, monetary policy decisions affect inflation, as well as many other macroeconomic variables with a lag of typically 4 to 8 quarters (BOJ QMPR, 2021). This coincides with the medium- to long-term horizon of this paper

[57] It is anticipated that as the economy grows, inflation also rises. Similarly, as a bi-product of economic growth, government expenditure is likely to rise given the expected increase in incomes and hence tax revenues.

[58] Optimal lag length selection and cointegration tests were not necessary, due to the fact that the lag lengths were predetermined, and included the contemporaneous short-term, medium-term, and long-term, thus also assuming that there is cointegration (or the presence of a long-run relationship).

the DTI sector. The finding that macroeconomic conditions influence systemic liquidity risk in the short-term, is contrary to expectations, given that the effects of changes in macro conditions are typically realized with a lag of 4 to 8 quarters. As such, the effects of changes in macroeconomic factors are expected to be realized in the long-term horizon given this model specification. The long-term results support this expectation, evidenced by the high statistical significance of the lagged values of the macroeconomic variables, in particular, the CPI and GOVTEXP.

In relation to expected hypotheses, results support the claim that there is an inverse relationship between the capital adequacy ratio (inclusive of foreign exchange exposure (CAR_FX)) and liquidity risk in the DTI sector, albeit a weak statistical significance. This outturn confirms the fact that the more well-capitalized an institution is, it reduces their exposure to risks.[59] In addition, the results revealed a negative relationship between the ASLRI and the CPI, which is counterintuitive to expectations and the findings of Chowdhury *et al.* (2018), and Taruna *et al.* (2020). This finding is however supported by Al-Khouri (2012) who found a positive relationship between inflation and banks' liquidity. The rationale here is that an increase in inflation may increase bank costs especially if unanticipated, which leads to reduced profitability (Al-Khouri, 2012). Given the inverse relationship between profitability and liquidity, increased liquidity levels will result, thereby reducing the level of liquidity risk. Contrary to expectations, a similar negative relationship was found between GDP and liquidity risk in the long-term. This finding is supported by Al-Khouri (2012), and Choon et al. (2013). The rational here is that as GDP increases, consumers' confidence in the banking system as well as their income increases, which may improve deposit rates, and hence liquidity conditions in the banking system. At the very least, this scenario reduces the probability of withdrawals, thereby preserving current liquidity conditions. This leads to a reduction in liquidity risk, and supports the finding of a negative relationship. Finally, a significant negative relationship was found between GOVTEXP and liquidity risk consistent with expectations and the finding of Chowdhury *et al.* (2018).[60]

An investigation of the ASLRI was done to assess the potential impact of the baseline explanatory variables on the components of the ASLRI (funding and market liquidity risk). Results from the FLR estimation suggest that funding liquidity stresses in the Jamaican financial system are predominantly influenced by unknown factors and macroeconomic conditions with a lagged transmission effect (see Appendix A: Table 9b). This is evidenced through the high statistical significance of the lagged values of the CPI and GOVTEXP in the long-run. In the medium term the CPI is also statistically significant. Notwithstanding, the results from the FLR estimation generally indicate that funding liquidity risk is more significantly associated with changes in unknown factors across all time horizons.

Findings from the MLR estimation presents strong evidence to support the fact that market liquidity risk in the Jamaican DTI sector is determined to a high degree by macro-economic conditions (i.e. the CPI and GOVTEXP) (see Appendix A: Table 9c). Changes in market liquidity risk are strongly associated with changes in the CPI in the short-

[59] More specifically, higher levels of capital may be related to reduced profitability which is associated with lower rates of return, and hence less risk. This finding is supported by an overwhelming amount of literature to include, Muharam (2012), Jedidia & Hamza (2015) and Shamas et al. (2018).

[60] As a fiscal policy response, governments may increase their spending to provide liquidity to problem banks during a liquidity crunch, to alleviate the risks emanating from unexpected deposit withdrawals and excessive maturity mismatches. This explains the existence of a negative relationship between government spending and liquidity risk.

, medium-, and long-term horizons, whilst changes in GOVTEXP strongly influences changes in market liquidity risk in the short- and long-term. Meanwhile in the medium-term changes in MLR are also strongly associated with changes in GDP with a lagged effect. Notably, in the long-run, changes in the MLR is also determined by idiosyncratic factors, evidenced through the high statistical significance of lagged values of the MLR and CAR_FX.[61]

5.3 DTI Sub-Sector Estimations

A further breakdown of each DTI sub-sector, could provide more information to identify key liquidity risk triggers for each sub-sector. In addition, the analyses may provide insight to regulatory and supervisory authorities, as to which sub-sector faces greater potential liquidity risk exposures and their origins– whether through funding or arising from financial markets. The estimations for each DTI sub-sector followed a time series ARDL model specification outlined below:

$$y_t = \alpha + \sum_{j=1}^{p} \beta_i \, y_{t-i} + \sum_{j=0}^{q} \gamma_i \, X_{t-i} + \sum_{j=0}^{q} \delta_i \, CAR_{t-i} + \varepsilon_t \qquad [15]$$

The models estimated in this section follows closely the aforementioned methodology.

Results from commercial banks' estimations indicate that systemic liquidity risk in the commercial banking sector is primarily influenced by unknown and idiosyncratic factors. Notwithstanding, macroeconomic conditions (CPI) also take effect in the medium-term. Results also suggest that systemic liquidity risk for commercial banks is predominantly transmitted through financial markets. The ASLRI is influenced by unknown factors and idiosyncratic factors (lagged ASLRI) across all time horizons. In the medium and long-term, changes in macroeconomic conditions (CPI) are also associated with changes in the ASLRI (see Appendix A: Table 10a). However, neither idiosyncratic nor macroeconomic factors appeared to be associated with changes in funding liquidity risk, suggesting that funding liquidity risk in the commercial banking sector are predominantly influenced by unknown factors. Consequentially, the results from the FLR estimation for the commercial banking sub-sector are not presented. The results as it relates to market liquidity risk however, are consistent with the findings from the ASLRI estimation for commercial banks. The main findings indicate that changes in the MLR are associated with unknown factors as well as idiosyncratic factors (lagged MLR) across all time horizons. In addition, changes in macroeconomic conditions (CPI) influence changes in market liquidity risk in the medium and long-term. Concurrently, changes in government expenditure also weakly influence market liquidity risk conditions in the long-term (see Appendix A: Table 10b).

[61] These results may suggest that despite the fact that aggregate systemic liquidity risk is primarily driven by funding risk, market liquidity risk emanating from historical price volatility and trading activities explains a greater degree of the volatility in aggregate systemic liquidity risk. As such, the transmission channels through which the effects of adverse macroeconomic conditions are realized, are predominantly through risks arising from financial markets (See Appendix B: Figure 2).

These results largely suggest that market liquidity risk has a greater impact on the commercial banking sub-sector, compared to funding liquidity risk. This confirms the prior finding that while systemic liquidity risk is primarily driven by funding risk, market liquidity risk is more volatile and explains more of the fluctuations in overall systemic liquidity risk for commercial banks, and by extension the DTI sector. [62,63] This further suggests that given banks high leverage against potential liquidity risks, there is no evidence to support liquidity procyclicality for the commercial banking sub-sector. Consequently, commercial banks are generally robust to changes in macroeconomic conditions. Incidentally, only severe shocks to macroeconomic variables that are substantial enough to erode their generally high liquidity levels, will cause concerns for regulators from a liquidity risk standpoint – pointing to the resilience of the commercial banking sub-sector.

Similarly, building societies are primarily influenced by unknown and idiosyncratic factors. Results from the baseline scenario for building societies suggest that aggregate systemic liquidity risk is primarily determined by unknown factors across all time horizons, with idiosyncratic factors (lagged ASLRI) taking effect in the medium and long-terms (see Appendix A: Table 11a). More specifically, funding liquidity risk is predominantly influenced by unknown factors and idiosyncratic factors, particularly CAR_FX in the medium-term, and lagged FLR in the long-term (see Appendix A: Table 11b). As it relates to market liquidity risk, the MLR is statistically significant at all levels across all time horizons, with macroeconomic conditions (CPI) having an impact in the long-run (see Appendix A: Table 11c).[64] This outturn indicates that liquidity risk in the building societies' sub-sector arises primarily through market liquidity risk channels.

Regarding merchant banks, aggregate systemic liquidity risk is also primarily associated with changes in unknown and idiosyncratic factors at least for the short and medium-terms. In the baseline scenario, changes in the ASLRI are influenced by changes in unknown factors and idiosyncratic factors (lagged ASLRI) across all time horizons. Additionally, changes in the CAR_FX are highly statistically significant, only in the medium and long-terms. In the long-run macroeconomic factors (CPI and GOVTEXP) are also statistically significant at the 5% and 10% levels respectively (see Appendix A: Table 12a). Moreover, changes in FLR are primarily driven by unknown and idiosyncratic factors lagged FLR), with changes in the CAR_FX being also weakly associated with changes in FLR in the medium-term (see Appendix A: Table 12b). However, only changes in unknown factors influence changes in the MLR in the short-term, as neither idiosyncratic nor macroeconomic factors are significant. As such the results for the short-term are not presented. Meanwhile, a combination of unknown factors, idiosyncratic factors (CAR_FX) and macroeconomic factors (GOVTEXP) are associated with changes in MLR in the medium and long-terms (see Appendix A: Table 12c). Notably, results indicate that there is a positive relationship between the CAR_FX and market liquidity risk, which is counterintuitive to prior expectations.[65] The rationale here is that, despite the fact that capital

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[62] Commercial banks accounted for approximately 90 per cent of the DTI sector as at end 2020. The relative share of the commercial banking sector is measured by the share of commercial banks' assets to total DTI assets.

[63] In addition, this outturn suggests that for the commercial banking sub-sector, liquidity stresses are predominantly idiosyncratic rather than systemic. As such other bank-specific factors in addition to those which affect funding, as so identified by Taruna et al. (2020), are more significant determinants of liquidity risk for the banking system.

[64] For all of these models, in terms of the expected direction of impacts, the results were consistent with all priori hypotheses.

[65] This finding is however supported by Iqbal (2012), Abdul-Rahman et al. (2018) and Akhtar et al. (2011) who also found a positive relationship between the CAR and liquidity risk.

adequacy is a cushion against risk, institutions with higher levels of capital are also incentivized to take on even more risk. In some instances, the direct impact of the initial increased risk may be material enough to erode their counterbalancing capacity, but as capital levels reduce it also leads to further increase in risk which is an indirect impact.

5.4 Further Analysis of Customer Deposits

Further analysis of customer deposits is necessary for a comprehensive investigation into factors influencing systemic liquidity risk. This is due to the fact that deposits represent the most stable source of funding for the banking system, and therefore increases in run-off rates in deposits are a cause for concern. These analyses could therefore provide important information to ascertain whether a run on customer deposits are primarily influenced by idiosyncratic, unknown or macroeconomic factors.

The results showed that unknown factors as well as macroeconomic factors (CPI and GOVTEXP) are associated with changes in customer deposits for the DTI sector (see Appendix A: Table 13a). Similar to the ASLRI estimations, changes in unknown factors are associated changes in customer deposits across all time horizons. Additionally, in the short and medium term, there is a positive and statistically significant relationship between GOVTEXP and customer deposits, consistent with expectations. The rationale here is that when the government spends in the economy, it indirectly creates more income and investment opportunities for consumers which may lead to higher deposits. As such, this creates more liquidity for the banking system and reduces funding liquidity risk. Conversely, there is a negative and statistically significant relationship between CPI and customer deposits in the medium and long-terms – consistent with the finding of Taruna *et al.* (2020). This indicates that a run of customer deposits is significantly influenced by increases in inflationary pressures.[66]

Importantly, this result provides evidence to support the claim of Taruna *et al.* (2020) that an initial run on customer deposits may be caused by idiosyncratic and unknown factors in the short-run. Over time however, deteriorating macroeconomic conditions may interact with these unknown and bank-specific factors to exacerbate the liquidity risks in the system in the medium to long-term. The results for the commercial banking sub-sector were similar to the findings for the DTI sector as anticipated.[67] In particular, changes in customer deposits are primarily influenced by unknown factors across all time horizons.[68]

In relation to building societies and merchant banks, changes in customer deposits is primarily influenced by unknown factors across all time horizons. Meanwhile, macroeconomic conditions are not associated with changes in customer deposits for either sub-sector. However, idiosyncratic factors (CAR_FX) are highly statistically significant across all

[66] This is an expected result, as uncertainties about inflation can cause consumers and investors to lose confidence in the stability of market conditions especially as inflation may directly adversely influence several bank specific factors, such as a spike in interest rates.
[67] This is due to the fact that the DTI sector is dominated by commercial banks, which account for the largest share of total DTI assets.
[68] Furthermore, macroeconomic conditions (CPI and GOVTEXP) are statistically significant in the medium-term with the expected relationships holding true (see Appendix A: Table 13b).

time horizons for building societies, with the expected positive impact (see Appendix A: Table 13c). This indicates that building societies maintain high levels of liquidity.

5.5 The existence of unknown factors in the regression models

Taruna *et al.* (2020) suggested that unknown factors such as herding behavior, reference bias, and narrative are associated with bank runs in the short-term and medium-term. Additionally, unknown factors could arise from depositors' fear of losses in wealth and perceptions about the health of the financial system. Following Taruna *et al.* (2020), it is necessary to check for the presence of unknown factors in each of the regression models, so as to determine whether these factors significantly impact liquidity risk in the financial system. In so doing, the residuals from the regression models are extracted, and used as a regressor to re-estimate the models. Whilst the focus had not previously been on the R^2 for the models, it is expected that the residuals should be significant in the regressions, as well as the residuals coefficient and resulting R^2 from the re-estimated models would be approximately equal to 1 to complete the robustness checks for the models. The interpretation here is that if the models are close to being a perfect fit, we can conclude that unknown factors, which are represented by the residuals from each of the models are significant in explaining variations in the dependent variable.

The results from all the panel estimations with the residuals as a regressor indicated that the resulting regression matrices were near singular, indicating perfect multicollinearity. These results suggest that the respective independent variables in each of the models could be completely explained by the variations in the regressors. As such, the panel estimation models with the fixed effects pooled mean group estimator are a perfect fit and thereby justifies the existence of unknown factors influencing aggregate systemic liquidity risk in the DTI sector. At the same time, the DTI sub-sector OLS estimations with the residuals as regressor yielded similar results (see Appendix A: Tables 14-16).[69]

6.0 Diagnostic Tests

The paper utilized a combination of panel data and time series analyses for the methodology. As it relates to the panel models which were estimated for the DTI sector, the fixed-effects regression model was selected. More specifically, the pooled mean group (PMG) estimator was used. This is due to the fact that the Hausman specification test could not be applied due to the lack of sufficient cross sections (cross-sectional), and therefore random effects would not be a suitable model. The panel models satisfied all the Gauss-Markov assumptions.

However, for each DTI sub-sector, time series analyses were done. As such, a series of tests are performed on the models to ensure that the models were correctly specified, and hence avoid spurious results. All results presented have satisfied all the following tests:

[69] The results from the DTI sub-sector estimations all reported residual coefficients and R-squared equal to 1, and hence also justifies the existence and significance of unknown factors in the regressions.

6.1 Multicollinearity

The Variance Inflation Factor (VIF) is used to detect the presence multicollinearity in the models, so as to ensure reliability and consistency of the coefficients. The results showed that many of the models suffered from severe multicollinearity (i.e. VIF greater than 10) particularly as it relates to the medium and long-term regressions, as more lags of each of the variables were added. To correct these models, the lagged values of many of the regressors which possessed a VIF greater than 10 were removed from the regressions and the reduced models were then retested to ensure that multicollinearity was removed, and then the models re-estimated.

6.2 Serial Correlation

The Breusch-Godfrey serial correlation Lagrange Multiplier (LM) test for autocorrelation was applied to ensure that there was no serial correlation in the models. In all the models, we fail to reject the null hypothesis that there is no serial correlation of any order up to 4 lags.

6.3 Heteroskedasticity

The Breusch-Pagan test was also applied to all the models to determine whether or not there was heteroskedasticity present in the regressions, so as to ensure validity of the econometric analyses. By nature of the fact that many of the variables were estimated in logarithmic form (which is one of the ways to correct for heteroskedasticity), we also failed to reject the null hypothesis of homoskedasticity for all models. Therefore, the final models reported had no heteroskedasticity.

6.4 Stability

The Cumulative Sum Control Charts (CUSUM) test and CUSUM of squares test were used to test the stability of the models and assess the presence of structural breaks in the model, so as to ensure that forecasted errors have not drifted away from their expected values. Results showed that all the models were stable, as the recursive residuals generally stayed within the 5% target range. This suggests that results from the models can be used to appropriately inform forecasts. As it relates to structural changes however, a few of the models' residuals deviated from the 5% target range indicating that there is evidence of structural changes in the models, particularly for the customer deposit regressions for building societies and merchant banks. In order to confirm the presence of structural breaks in the data, line graphs of all the series were plotted to ascertain the dates of structural breaks in the datasets and the Chow Breakpoint test applied. The results showed that the *F-Statistics* were statistically significant in all the tested models, hence we reject the null hypothesis of no breakpoints. Structural change dummies were subsequently incorporated into the models with structural changes.

6.5 Optimal Lag Selection and Cointegration

Finally, as it relates to optimal lag order selection and cointegration, it was predetermined that there exists a long-run relationship amongst the variables in all the models with the pre-selection of lag orders (No lags, 2 lags and 4 lags) to represent the contemporaneous short-, medium-, and long-term horizons. As such these tests were no applied to the models.

Given that all the models satisfy all the Gauss-Markov assumptions, the results are unbiased and efficient, and can therefore be suitably applied to draw conclusions and inferences, and potentially informing policy.

7.0 Conclusion & Policy Recommendations

An aggregate systemic liquidity risk index was developed using a comprehensive range of liquidity indicators which capture liquidity conditions and identify potential vulnerabilities across various markets within the Jamaican DTI sector. The results demonstrated that the Jamaican banking system is generally robust to liquidity risk given the generally high levels of liquidity. However, the main liquidity risk triggering factors are unknown and idiosyncratic factors. More specifically, market liquidity risk poses greater potential threats to liquidity as results confirm that market liquidity risk is a more volatile component of systemic liquidity risk.

The key drivers of both funding and market liquidity risk for the DTI sector are unknown factors and macroeconomic factors particularly in the medium and long-term horizons. These factors however contribute to more of the volatility in market liquidity risk. The key macroeconomic transmission channels for liquidity risk in the DTI sector are through inflationary pressures, which may arise from changes in monetary policy and shifts in fiscal policy regimes which highly influence the government's projected expenditures. Hence, these two variables can be utilized when conducting macroprudential liquidity stress tests.[70] The generally weak results however from a liquidity risk perspective, suggest that banks' key liquidity indicators are seldom influenced by macroeconomic conditions, except for severe shock scenarios. In such instances, an initial shock to either idiosyncratic or unknown factors in the short-run may have potentially pervasive effects if deteriorating conditions persist for extended periods.

Moreover, results revealed that the Jamaican DTI sector is prone to liquidity procyclicality, evidenced through the relationship between the ASLRI and the credit to GDP gap. However, potential risks created by this procyclicality, becomes material to the banking system primarily through market liquidity risk channels. This is an indication to policymakers that greater market discipline is important to minimize potential risk exposures emanating from banks' financial market activities. Furthermore, run-off rates in customer deposits are highly influenced by idiosyncratic and unknown factors across all time horizons. Macroeconomic conditions (the CPI and GOVTEXP) are not associated

[70] Regression analysis showed that CPI and GOVTEXP were the factors that most explained changes in the ASLRI, and would aid in forming consistent macroeconomic scenarios. This is because across most time horizons and models, the same variables were significant.

with run-off/haircut rates in customer deposits in the short-term, but take significant effect in the medium-term. The findings therefore confirm that liquidity stresses in the Jamaican banking system are predominantly idiosyncratic rather than systemic. The results of this paper highlight the importance of liquidity stress testing of deposit-taking institutions to mitigate the impact of liquidity stresses. Additionally, regulators should ensure that banks have solid capital buffers that enable them to withstand extreme and unexpected shocks to their balance sheets and thus ensure that they can act as effective financial intermediaries even in periods of turbulence. In better understanding the unknown factors which influence liquidity risk (such as herding behavior, reference bias, as well as depositors' fear of losses in wealth and perceptions about the health of the financial system), further work is needed to assess proxies to properly quantify these factors. Subsequently, these can be used as inputs into assessing changes in the ASLRI.

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Appendices

Appendix A – Tables

Table 1a: Correlation Matrix for detecting Liquidity Procyclicality in the Jamaican banking System

Correlation Matrix for Liquidity Instruments & Credit-to-GDP gap			
	CR	LA/TA	LA/ST
CR	1.0000	-0.0023	-0.0406
LA/TA	-	1.0000	0.9766
LA/ST	-	-	1.0000

Note: CR – means credit-to-GDP gap

Table 1b: Correlation Matrix for ASLRI & Credit-to-GDP Gap

Correlation matrix for ASLRI & Credit-to-GDP gap		
	ASLRI	CR
ASLRI	1.0000	0.5300
CR	-	1.0000

Note: CR – means credit-to-GDP gap

Table 1c: Student's t-distribution test for linear relationships liquidity ratios, ASLRI & credit-to-GDP gap

Relationship	t	df.	Sig. (2 tailed)
LA/TA - CR	0.0140	*40*	2.021
LA/ST - CR	0.2500	*40*	2.021
ASLRI - CR	3.9031	*40*	2.021

Note: CR – means credit-to-GDP gap

Table 2: Summary of variables and data used to construct the ASLRI

	Indicators	**Impact**	**Data**	**Sub-index**
1.	DTIs - volatile deposits to total loans	-	Deposits, total DTI loans	FLR
2.	DTIs - volatile non-deposit liabilities to total loans	-	Non-deposit liabilities, total DTI loans	FLR
3.	Maturity Transformation	+	LT assets, LT liabilities, DTIs Financial Assets	FLR
4.	Liquidity Transformation	+	ST liabilities ($\leq$ 30 $days$), Liquid Assets	FLR
5.	Foreign Exchange Market - Amihud index of Market Depth	+	Weighted average selling rate (J$=US$1.00), daily volumes traded (DVT)	MLR
6.	Stock Market - Amihud index of Market Depth	+	(JSE) Main Index value, daily volumes traded (DVT)	MLR
7.	Foreign Exchange bid-ask spread	+	FX selling price, FX buying price (J$=US$1.00)	MLR
8.	TRE Spread	+	30-day private money market rates (PMMR), 30-day Treasury bill (T-bill) rate	MLR
9.	DTIs - Interest Spread	+	Weighted average loan rate, weighted average deposit rate	MLR

Note: The effect of an increase in each indicator on the AFSI is indicated by the corresponding signs shown in the column headed "Impact".

Table 3a: Correlation Matrix for Liquidity Instruments & ASLRI

Correlation Matrix for Liquidity Instruments & ASLRI			
	ASLRI	LA/TA	LA/ST
ASLRI	1.0000	-0.0023	-0.0406
LA/TA	-	1.0000	0.9766
LA/ST	-	-	1.0000

Table 3b: Student's t-distribution test for linear relationships liquidity ratios & ASLRI

Relationship	**t**	**df.**	**Sig. (2 tailed)**
LA/TA - ASLRI	4.9422	56	2.000
LA/ST - ASLRI	5.9188	56	2.000

Table 4: Correlation Matrix for Components of ASLRI

	D_TL	**NDL_TL**	**MAT_TRANS**	**LIQ_TRANS**	**FX_AMIHUD**
D_TL	1				
NDL_TL	0.2609	1			
MAT_TRANS	-0.2870	-0.0672	1		
LIQ_TRANS	0.3838	0.0494	-0.2000	1	
FX_AMIHUD	0.3421	0.2724	0.1390	0.2417	1
EQUITY_AMIHUD	0.0128	0.1078	-0.3240	-0.0951	-0.2187
FX_SPREAD	0.3640	0.2916	0.1669	0.1397	0.8216
TRE_SPREAD	-0.1744	-0.1477	-0.1100	0.0495	-0.1006
INTEREST_SPREAD	-0.0409	-0.3163	-0.3188	0.0855	-0.5558
	EQUITY_AMIHUD	**FX_SPREAD**	**TRE_SPREAD**	**INTEREST_SPREAD**	
EQUITY_AMIHUD	1				
FX_SPREAD	-0.2561	1			
TRE_SPREAD	0.2349	-0.2709	1		
INTEREST_SPREAD	0.2556	-0.5669	0.1600	1	

Table 5: Summary of explanatory variables, hypotheses, and data sources

Abbrev.	**Explanatory Variables:**	**Data**	**Hypotheses**	**Expected Sign**
GDP	GDP	GDP at current prices	H_0: There is a positive relationship between GDP growth and liquidity risk (ASLRI)	(+)
CPI	Inflation	Consumer Price Index	H_0: There is a positive relationship between inflation (CPI) and liquidity risk (ASLRI)	(+)
GOVTEXP	Government expenditure	Government Expenditure	H_0: There is a negative relationship between government spending (GOVTEXP) and liquidity risk (ASLRI)	(−)
CAR_FX	Capital adequacy ratio + FX exposure	Tier 1 Capital + Tier 2 Capital / (Risk Weighted Assets + FX Exposure)	H_0: There is a negative relationship between capital adequacy (CAR_FX) and liquidity risk (ASLRI)	(−)

Note: FX Exposure is calculated as the absolute value of the Net Open Position

Table 6a: Descriptive Statistics for DTI sector and Macroeconomic Variables

	DTI Sector		Macroeconomic Variables		
	ASLRI (DTI)	CAR_FX (DTI)	CPI	GDP	GOVTEXP
Mean	0.691484	21.78312	72.1268	352103.4	35195.3
Median	0.696021	19.06286	74.7189	348533	33581.38
Maximum	1.056548	150.3812	109.0121	540822.6	67294.73
Minimum	0.334853	11.478	32.6756	170095.6	15290.94
Std. Dev.	0.141134	16.45164	22.7214	112601.5	11855.77
Skewness	0.18768	5.011238	-0.2341	0.0701	0.5672
Kurtosis	2.624926	30.98198	1.7761	1.7632	3.0117
Jarque-Bera	2.252605	7067.532	4.5794	12.3939	10.2978
Probability	0.32423	0	0.1013	0.0020	0.0058
Sum	132.765	4182.359	4616.1160	67603853	6757497
Sum Sq. Dev.	3.804506	51695.35	32524.5900	2.42E+12	2.68E+10
Observations	192	192	64	64	64

Table 6b: Descriptive Statistics for each DTI Sub-Sector

	Commercial Banks		Building Societies		Merchant Banks	
	ASLRI	CAR_FX	ASLRI	CAR_FX	ASLRI	CAR_FX
Mean	0.7655	15.1758	0.6193	21.0434	0.6896	29.1301
Median	0.7768	14.5500	0.6077	20.5198	0.6694	20.1892
Maximum	1.0565	20.3619	1.0084	32.1419	1.0054	150.3812
Minimum	0.3349	12.5126	0.3695	17.0217	0.4922	11.4780
Std. Dev.	0.1431	1.9750	0.1235	2.6737	0.1175	26.6415
Skewness	-0.5076	1.1822	0.4826	2.2546	0.6022	2.7590
Kurtosis	3.1094	3.4382	3.3460	10.1927	3.1354	10.2596
Jarque-Bera	2.7803	15.4211	2.8032	192.1815	3.9172	221.7317
Probability	0.2490	0.0004	0.2462	0.0000	0.1411	0.0000
Sum	48.9907	971.2533	39.6376	1346.7790	44.1367	1864.3260
Sum Sq. Dev.	1.2903	245.7433	0.9603	450.3733	0.8701	44715.6300
Observations	64	64	64	64	64	64

Table 7a: Correlation Matrix for the DTI sector and Macroeconomic Variables

	DTI Sector		Macroeconomic Variables		
	ASLRI	CAR_FX	CPI	GDP	GOVTEXP
ASLRI	1				
CAR___FX	0.0504	1			
CPI	0.3044	0.2220	1		
GDP	0.2985	0.2317	0.9785	1	
GOVTXP	0.3674	0.2371	0.8009	0.8370	1

Table 7b: Correlation Matrix for each DTI Sub-Sector

	Commercial Banks		Building Societies		Merchant Banks	
	ASLRI	CAR_FX	ASLRI	CAR_FX	ASLRI	CAR_FX
ASLRI	1		1		1	
CAR___FX	-0.6867	1	-0.0158	1	0.3226	1
CPI	0.7803	-0.6853	0.3904	-0.2560	-0.2578	0.4899
GDP	0.7187	-0.6626	0.3914	-0.2281	-0.2051	0.5036
GOVTXP	0.6254	-0.5601	0.5452	-0.2220	-0.0036	0.5053

Table 8a: Im, Pesaran, and Shin (IPS) Unit Root Test Results for DTI Sector

Variables	Levels	1st Difference	Order of Integration
ASLRI	0.3078	0.0000	I (1)
CAR_FX	0.0006	0.0000	I (0)
CPI	0.9585	0.0000	I (1)
LN_GDP	0.0000	0.0000	I (0)
LN_GOVTEXP	0.2568	0.0000	I (1)
FLR	0.4276	0.0000	I (1)
MLR	0.0118	0.0000	I (0)

Table 8b: Phillips-Perron (PP) Unit Root Test Results for each DTI Sub-Sector and Macroeconomic Variables

Category/ Sub-Sector	Variables	Levels	1st Difference	Order of Integration
Commercial Banks	ASLRI	0.0313	0.0000	I (0)
	CAR_FX	0.1751	0.0000	I (1)
	FLR	0.5001	0.0000	I (1)
	MLR	0.0000	0.0000	I (0)
Building Societies	ASLRI	0.3343	0.0000	I (1)
	CAR_FX	0.0279	0.0000	I (0)
	FLR	0.8394	0.0000	I (1)
	MLR	0.0045	0.0000	I (0)
Merchant Banks	ASLRI	0.0137	0.0000	I (0)
	CAR_FX	0.7960	0.0000	I (1)
	FLR	0.0205	0.0000	I (0)
	MLR	0.0723	0.0000	I (1)
Macroeconomic Variables	CPI	0.8287	0.0000	I (1)
	LN_GDP	0.0202	0.0000	I (0)
	LN_GOVTEXP	0.0404	0.0001	I (0)

Table 9a: Results of Model 4A: ASLRI Estimation – DTI Sector

VARIABLES	Short term ($L = 0$)	Medium term ($L = 2$)	Long term ($L = 4$)
Idiosyncratic Variables			
D(D_ASLRI(-1))	0.0763 (0.0590)	0.0410 (0.0756)	0.1426 (0.1944)
D(D_ASLRI(-2))			0.1301 (0.2017)
D(D_ASLRI(-3))			0.0095 (0.0716)
D(CAR_FX)	-0.0004 (0.0068)	-0.0007 (0.0070)	-0.0027 (0.0038)
D(CAR_FX(-1))		-0.0037 (0.0041)	-0.0083 (0.0084)
D(CAR_FX(-2))			-0.0069* (0.0038)
D(CAR_FX(-3))			0.0024 (0.0035)
Macroeconomic Variables			
D(D_CPI)	-0.0009 (0.0012)	-0.0139*** (0.0016)	-0.0143*** (0.0027)
D(D_CPI(-1))		-0.0142*** (0.0028)	-0.0102*** (0.0022)
D(D_CPI(-2))			0.0007 (0.0017)
D(D_CPI(-3))			-0.0080*** (0.0018)
D(LN_GDP)	0.1192* (0.0699)	0.1324 (0.1175)	-0.0669 (0.1384)
D(LN_GDP(-1))		0.1930** (0.0888)	-0.1167 (0.2949)
D(LN_GDP(-2))			0.3249* (0.1783)
D(LN_GDP(-3))			-0.5411** (0.2454)
D(D_LN_GOVTEXP)	-0.0587*** (0.0083)	-0.0297*** (0.0048)	-0.3362*** (0.0396)
D(D_LN_GOVTEXP(-1))		0.0015 (0.0139)	-0.2706*** (0.0378)
D(D_LN_GOVTEXP(-2))			-0.2338*** (0.0232)
D(D_LN_GOVTEXP(-3))			-0.1358*** (0.0026)

Note: *(1)* Robust standard errors in parentheses; *** $p<0.01$, ** $p<0.05$, * $p<0.1$ indicate significance at 1%, 5% and 10% respectively; *(2)* L = 0 lags representing the short-run; L = 2 lags representing the medium term; L = 4 lags representing the long-run.

Table 9b: Results of Model 4B: FLR Estimation – DTI Sector

VARIABLES	Short term ($L = 0$)	Medium term ($L = 2$)	Long term ($L = 4$)
Idiosyncratic Variables			
D(D_FLR(-1))	-0.0173 (0.0324)	-0.0140 (0.0227)	0.0188 (0.2434)
D(D_FLR(-2))			0.0640 (0.1777)
D(D_FLR(-3))			-0.0116 (0.0208)
D(CAR_FX)	0.0000 (0.0076)	0.0007 (0.0074)	-0.0016 (0.0026)
D(CAR_FX(-1))		-0.0041 (0.0027)	-0.0070 (0.0046)
D(CAR_FX(-2))			-0.0038 (0.0027)
D(CAR_FX(-3))			-0.0033 (0.0033)
Macroeconomic Variables			
D(D_CPI)	-0.0004 (0.0021)	-0.0050*** (0.0013)	-0.0099*** (0.0016)
D(D_CPI(-1))		-0.0066 (0.0040)	-0.0067*** (0.0022)
D(D_CPI(-2))			-0.0006 (0.0006)
D(D_CPI(-3))			-0.0029 (0.0027)
D(LN_GDP)	-0.0353 (0.1470)	-0.0391 (0.1886)	-0.0638 (0.1696)
D(LN_GDP(-1))		-0.1353 (0.0844)	-0.3504 (0.2234)
D(LN_GDP(-2))			0.2639 (0.1940)
D(LN_GDP(-3))			-0.3763 (0.2668)
D(D_LN_GOVTEXP)	0.0079 (0.0091)	-0.0035 (0.0077)	-0.1043*** (0.0140)
D(D_LN_GOVTEXP(-1))		-0.0043 (0.0042)	-0.0991*** (0.0158)
D(D_LN_GOVTEXP(-2))			-0.0903*** (0.0103)
D(D_LN_GOVTEXP(-3))			-0.0580*** (0.0056)

Note: *(1)* FLR means funding liquidity risk – a sub-index of the ASLRI *(2)* Robust standard errors in parentheses; *** $p<0.01$, ** $p<0.05$, * $p<0.1$ indicate significance at 1%, 5% and 10% respectively; (2) L = 0 lags representing the short-run; L = 2 lags representing the medium term; L = 4 lags representing the long-run.

Table 9c: Results of Model 4C: MLR Estimation – DTI Sector

VARIABLES	Short term ($L = 0$)	Medium term ($L = 2$)	Long term ($L = 4$)
Idiosyncratic Variables			
D(MLR(-1))	0.0229 (0.0424)	-0.0179 (0.0465)	0.0330 (0.0764)
D(MLR(-2))			0.0210 (0.1106)
D(MLR(-3))			-0.1470** (0.0645)
D(CAR_FX)	0.0036 (0.0039)	0.0010 (0.0015)	-0.0003 (0.0015)
D(CAR_FX(-1))		-0.0001 (0.0008)	-0.0016 (0.0028)
D(CAR_FX(-2))			-0.0018*** (0.0005)
D(CAR_FX(-3))			0.0052 (0.0054)
Macroeconomic Variables			
D(D_CPI)	-0.0036*** (0.0009)	-0.0113*** (0.0033)	-0.0163*** (0.0025)
D(D_CPI(-1))		-0.0087*** (0.0026)	-0.0140*** (0.0024)
D(D_CPI(-2))			-0.0062*** (0.0014)
D(D_CPI(-3))			-0.0103*** (0.0014)
D(LN_GDP)	0.0941 (0.0796)	0.1179** (0.0467)	0.0659 (0.0937)
D(LN_GDP(-1))		0.2595*** (0.0083)	0.2494* (0.1393)
D(LN_GDP(-2))			0.1786 (0.1252)
D(LN_GDP(-3))			-0.2214 (0.1664)
D(D_LN_GOVTEXP)	-0.0526*** (0.0091)	-0.0145 (0.0152)	-0.2121*** (0.0424)
D(D_LN_GOVTEXP(-1))		0.0069 (0.0124)	-0.1729*** (0.0393)
D(D_LN_GOVTEXP(-2))			-0.1519*** (0.0331)
D(D_LN_GOVTEXP(-3))			-0.0842*** (0.0137)

Note: *(1)* MLR means funding liquidity risk – a sub-index of the ASLRI *(2)* Robust standard errors in parentheses; *** $p<0.01$, ** $p<0.05$, * $p<0.1$ indicate significance at 1%, 5% and 10% respectively; (2) L = 0 lags representing the short-run; L = 2 lags representing the medium term; L = 4 lags representing the long-run.

Table 10a: Results of Model 1A: ASLRI Estimation – Commercial Banks

VARIABLES	Short term ($L = 0$)	Medium term ($L = 2$)	Long term ($L = 4$)
Idiosyncratic Variables			
ASLRI(-1)	0.6933*** (0.0841)	0.6116*** (0.1385)	0.6188*** (0.1544)
ASLRI(-2)		0.1062 (0.1381)	0.0058 (0.1562)
D_CAR_FX	-0.0015 (0.0124)	-0.0034 (0.0140)	0.0004 (0.0159)
D_CAR_FX(-1)		-0.0094 (0.0138)	-0.0038 (0.0158)
D_CAR_FX(-2)		-0.0143 (0.0132)	-0.0180 (0.0165)
D_CAR_FX(-3)			-0.0126 (0.0161)
D_CAR_FX(-4)			-0.0086 (0.0154)
Macroeconomic Variables			
D_CPI	0.0049 (0.0080)	0.0091 (0.0082)	0.0036 (0.0097)
D_CPI(-1)		0.0092 (0.0085)	0.0102 (0.0096)
D_CPI(-2)		0.0205** (0.0085)	0.0241** (0.0094)
D_CPI(-3)			0.0062 (0.0102)
D_CPI(-4)			0.0190* (0.0102)
LN_GDP	0.0518 (0.0501)	0.0827 (0.0648)	0.1129 (0.0825)
LN_GOVTEXP	0.0311 (0.0421)	0.0233 (0.0462)	-0.0130 (0.0567)
LN_GOVTEXP(-1)		0.0101 (0.0432)	-0.0026 (0.0502)
LN_GOVTEXP(-2)		-0.0130 (0.0453)	-0.0308 (0.0503)
LN_GOVTEXP(-3)			0.0039 (0.0495)
LN_GOVTEXP(-4)			0.0734 (0.0557)

Note: *(1)* Robust standard errors in parentheses; *** $p<0.01$, ** $p<0.05$, * $p<0.1$ indicate significance at 1%, 5% and 10% respectively; *(2)* L = 0 lags representing the short-run; L = 2 lags representing the medium term; L = 4 lags representing the long-run.

Table 10b: Results of Model 1C: MLR Estimation – Commercial Banks

VARIABLES	Short term ($L = 0$)	Medium term ($L = 2$)	Long term ($L = 4$)
Idiosyncratic Variables			
MLR(-1)	0.4234*** (0.1030)	0.4675*** (0.1336)	0.5040*** (0.1545)
MLR(-2)		-0.1086 (0.1354)	-0.2384 (0.1833)
MLR(-3)			-0.0913 (0.1744)
MLR(-4)			0.0183 (0.1574)
D_CAR_FX	0.0066 (0.0093)	0.0088 (0.0106)	0.0151 (0.0119)
D_CAR_FX(-1)		-0.0016 (0.0104)	0.0066 (0.0113)
D_CAR_FX(-2)		0.0001 (0.0099)	-0.0041 (0.0118)
D_CAR_FX(-3)			0.0005 (0.0118)
D_CAR_FX(-4)			0.0065 (0.0112)
Macroeconomic Variables			
D_CPI	-0.0021 (0.0060)	0.0004 (0.0061)	-0.0046 (0.0076)
D_CPI(-1)		0.0036 (0.0064)	0.0031 (0.0071)
D_CPI(-2)		0.0146** (0.0063)	0.0140** (0.0065)
D_CPI(-3)			-0.0029 (0.0071)
D_CPI(-4)			0.0149** (0.0073)
LN_GDP	-0.0338 (0.0320)	0.0188 (0.0437)	0.0161 (0.0508)
LN_GOVTEXP	0.0351 (0.0318)	0.0417 (0.0349)	0.0139 (0.0419)
LN_GOVTEXP(-1)		-0.0200 (0.0331)	-0.0467 (0.0371)
LN_GOVTEXP(-2)		-0.0371 (0.0349)	-0.0554 (0.0382)
LN_GOVTEXP(-3)			-0.0125 (0.0366)
LN_GOVTEXP(-4)			0.0732* (0.0411)

Note: *(1)* Robust standard errors in parentheses; *** $p<0.01$, ** $p<0.05$, * $p<0.1$ indicate significance at 1%, 5% and 10% respectively; *(2)* L = 0 lags representing the short-run; L = 2 lags representing the medium term; L = 4 lags representing the long-run.

Table 11a: Results of Model 2A: ASLRI Estimation – Building Societies

VARIABLES	Short term ($L = 0$)	Medium term ($L = 2$)	Long term ($L = 4$)
Idiosyncratic Variables			
D_ASLRI(-1)	-0.1792 (0.1350)	-0.3639** (0.1464)	-0.3890** (0.1664)
D_ASLRI(-2)		-0.2222 (0.1364)	-0.1847 (0.1848)
D_ASLRI(-3)			0.1188 (0.1970)
D_ASLRI(-4)			0.2284 (0.1496)
CAR_FX	0.0006 (0.0042)	0.0058 (0.0063)	-0.0073 (0.0084)
CAR_FX(-1)		-0.0104 (0.0074)	-0.0071 (0.0097)
CAR_FX(-2)		-0.0018 (0.0058)	-0.0094 (0.0077)
CAR_FX(-3)			0.0076 (0.0077)
CAR_FX(-4)			-0.0052 (0.0063)
Macroeconomic Variables			
D_CPI	0.0034 (0.0103)	0.0015 (0.0101)	-0.0024 (0.0113)
D_CPI(-1)		0.0058 (0.0101)	-0.0033 (0.0106)
D_CPI(-2)		0.0129 (0.0101)	0.0124 (0.0101)
D_CPI(-3)			-0.0084 (0.0101)
D_CPI(-4)			0.0096 (0.0104)
LN_GDP	-0.0124 (0.0570)	-0.0012 (0.0685)	-0.0010 (0.0801)
LN_GOVTEXP	0.0335 (0.0560)	0.0705 (0.0563)	0.0288 (0.0723)
LN_GOVTEXP(-1)		-0.0368 (0.0506)	-0.0369 (0.0549)
LN_GOVTEXP(-2)		-0.0061 (0.0532)	-0.0521 (0.0544)
LN_GOVTEXP(-3)			0.0220 (0.0531)
LN_GOVTEXP(-4)			0.0725 (0.0611)

Note: *(1)* Robust standard errors in parentheses; *** $p<0.01$, ** $p<0.05$, * $p<0.1$ indicate significance at 1%, 5% and 10% respectively; *(2)* L = 0 lags representing the short-run; L = 2 lags representing the medium term; L = 4 lags representing the long-run.

Table 11b: Results of Model 2B: FLR Estimation – Building Societies

VARIABLES	Short term ($L = 0$)	Medium term ($L = 2$)	Long term ($L = 4$)
Idiosyncratic Variables			
D_FLR(-1)	-0.0989 (0.1321)	-0.0119 (0.1486)	-0.0786 (0.1233)
D_FLR(-2)		0.0057 (0.1437)	0.0643 (0.1354)
D_FLR(-3)			0.3332** (0.1361)
D_FLR(-4)			0.0812 (0.1434)
CAR_FX	0.0007 (0.0031)	0.0107** (0.0051)	
CAR_FX(-1)		-0.0193*** (0.0060)	
CAR_FX(-2)		0.0050 (0.0048)	
Macroeconomic Variables			
D_CPI	0.0086 (0.0078)	-0.0005 (0.0078)	0.0014 (0.0074)
D_CPI(-1)		-0.0017 (0.0078)	-0.0010 (0.0071)
D_CPI(-2)		0.0040 (0.0078)	0.0015 (0.0070)
D_CPI(-3)			-0.0060 (0.0071)
D_CPI(-4)			-0.0022 (0.0075)
LN_GDP	0.0104 (0.0433)	-0.0042 (0.0519)	
LN_GOVTEXP	0.0206 (0.0425)	0.0136 (0.0440)	0.0015 (0.0018)
LN_GOVTEXP(-1)		-0.0359 (0.0387)	
LN_GOVTEXP(-2)		0.0454 (0.0407)	

Note: *(1)* Robust standard errors in parentheses; *** $p<0.01$, ** $p<0.05$, * $p<0.1$ indicate significance at 1%, 5% and 10% respectively; *(2)* L = 0 lags representing the short-run; L = 2 lags representing the medium term; L = 4 lags representing the long-run.

Table 11c: Results of Model 2C: MLR Estimation – Building Societies

VARIABLES	Short term ($L = 0$)	Medium term ($L = 2$)	Long term ($L = 4$)
Idiosyncratic Variables			
MLR(-1)	0.6521*** (0.0947)	0.5928*** (0.1414)	0.6335*** (0.1577)
MLR(-2)		0.0857 (0.1437)	-0.0945 (0.1895)

MLR(-3)			0.0236 (0.1924)
MLR(-4)			0.1428 (0.1729)
D_CAR_FX	0.0003 (0.0024)	-0.0020 (0.0042)	-0.0044 (0.0060)
D_CAR_FX(-1)		0.0017 (0.0046)	0.0075 (0.0067)
D_CAR_FX(-2)		-0.0008 (0.0035)	-0.0049 (0.0052)
D_CAR_FX(-3)			0.0033 (0.0051)
D_CAR_FX(-4)			-0.0002 (0.0041)
Macroeconomic Variables			
D_CPI	-0.0017 (0.0062)	0.0012 (0.0066)	-0.0005 (0.0077)
D_CPI(-1)		0.0080 (0.0067)	0.0070 (0.0074)
D_CPI(-2)		0.0111 (0.0067)	0.0118 (0.0073)
D_CPI(-3)			-0.0034 (0.0075)
D_CPI(-4)			0.0159** (0.0074)
LN_GDP	-0.0280 (0.0339)	0.0380 (0.0441)	0.0302 (0.0566)
LN_GOVTEXP	0.0126 (0.0340)	0.0194 (0.0374)	0.0236 (0.0474)
LN_GOVTEXP(-1)		-0.0204 (0.0330)	-0.0226 (0.0385)
LN_GOVTEXP(-2)		-0.0482 (0.0348)	-0.0514 (0.0378)
LN_GOVTEXP(-3)			-0.0059 (0.0382)
LN_GOVTEXP(-4)			0.0154 (0.0415)

Note: *(1)* Robust standard errors in parentheses; **** p<0.01, ** p<0.05, * p<0.1* indicate significance at 1%, 5% and 10% respectively; *(2)* L = 0 lags representing the short-run; L = 2 lags representing the medium term; L = 4 lags representing the long-run.

Table 12a: Results of Model 3A: ASLRI Estimation – Merchant Banks

VARIABLES	Short term ($L = 0$)	Medium term ($L = 2$)	Long term ($L = 4$)
Idiosyncratic Variables			
ASLRI(-1)	0.6594*** (0.0974)	0.6331*** (0.1427)	0.6223*** (0.1469)
ASLRI(-2)		-0.0203 (0.1327)	0.0640 (0.1598)

ASLRI(-3)			-0.3560** (0.1732)
ASLRI(-4)			0.0259 (0.1632)
D_CAR_FX	-0.0009 (0.0008)	0.0001 (0.0009)	-0.0007 (0.0011)
D_CAR_FX(-1)		0.0032*** (0.0010)	0.0037*** (0.0011)
D_CAR_FX(-2)		0.0015 (0.0009)	0.0015 (0.0012)
D_CAR_FX(-3)			-0.0011 (0.0015)
D_CAR_FX(-4)			0.0019 (0.0022)
Macroeconomic Variables			
D_CPI	-0.0084 (0.0109)	-0.0087 (0.0108)	-0.0022 (0.0116)
D_CPI(-1)		-0.0114 (0.0110)	-0.0068 (0.0112)
D_CPI(-2)		0.0065 (0.0115)	0.0060 (0.0113)
D_CPI(-3)			-0.0261** (0.0113)
D_CPI(-4)			-0.0053 (0.0123)
LN_GDP	-0.0854 (0.0639)	-0.1437 (0.0923)	-0.3563 (0.5813)
LN_GDP(-1)			-0.7585 (0.5549)
LN_GDP(-2)			0.9514 (0.5943)
LN_GDP(-3)			-1.0470 (0.6940)
LN_GDP(-4)			0.9084 (0.6430)
LN_GOVTEXP	0.0543 (0.0603)	0.0429 (0.0621)	0.1261* (0.0655)
LN_GOVTEXP(-1)		0.0780 (0.0567)	0.0684 (0.0636)
LN_GOVTEXP(-2)		-0.0366 (0.0585)	-0.0311 (0.0635)
LN_GOVTEXP(-3)			0.0278 (0.0634)
LN_GOVTEXP(-4)			0.0019 (0.0667)

Note: *(1)* Robust standard errors in parentheses; *** $p<0.01$, ** $p<0.05$, * $p<0.1$ indicate significance at 1%, 5% and 10% respectively; *(2)* L = 0 lags representing the short-run; L = 2 lags representing the medium term; L = 4 lags representing the long-run.

Table 12b: Results of Model 3B: FLR Estimation – Merchant Banks

VARIABLES	Short term ($L = 0$)	Medium term ($L = 2$)	Long term ($L = 4$)
Idiosyncratic Variables			
FLR(-1)	0.7180*** (0.0927)	0.6896*** (0.1441)	0.6393*** (0.1487)
FLR(-2)		-0.0169 (0.1400)	0.1746 (0.1781)
FLR(-3)			-0.2746 (0.1779)
FLR(-4)			-0.0154 (0.1581)
D_CAR_FX	-0.0007 (0.0007)	-0.0004 (0.0008)	-0.0009 (0.0009)
D_CAR_FX(-1)		0.0015* (0.0008)	0.0007 (0.0009)
D_CAR_FX(-2)		0.0012 (0.0008)	0.0011 (0.0008)
D_CAR_FX(-3)			0.0002 (0.0009)
D_CAR_FX(-4)			0.0002 (0.0013)
Macroeconomic Variables			
D_CPI	-0.0065 (0.0088)	-0.0088 (0.0095)	-0.0022 (0.0106)
D_CPI(-1)		-0.0110 (0.0096)	-0.0050 (0.0099)
D_CPI(-2)		-0.0021 (0.0101)	-0.0063 (0.0102)
D_CPI(-3)			-0.0151 (0.0102)
D_CPI(-4)			-0.0086 (0.0107)
LN_GDP	0.0083 (0.0479)	-0.0383 (0.0663)	-0.0818 (0.0773)
LN_GOVTEXP	-0.0060 (0.0473)	-0.0240 (0.0532)	0.0141 (0.0579)
LN_GOVTEXP(-1)		0.0542 (0.0480)	0.0661 (0.0528)
LN_GOVTEXP(-2)		0.0032 (0.0506)	0.0151 (0.0526)
LN_GOVTEXP(-3)			-0.0238 (0.0529)
LN_GOVTEXP(-4)			0.0367 (0.0558)

Note: *(1)* Robust standard errors in parentheses; *** $p<0.01$, ** $p<0.05$, * $p<0.1$ indicate significance at 1%, 5% and 10% respectively; *(2)* L = 0 lags representing the short-run; L = 2 lags representing the medium term; L = 4 lags representing the long-run.

Table 12c: Results of Model 3C: MLR Estimation – Merchant Banks

VARIABLES	Short term ($L = 0$)	Medium term ($L = 2$)	Long term ($L = 4$)
Idiosyncratic Variables			
D_MLR(-1)		-0.1638 (0.1396)	-0.0426 (0.1465)
D_MLR(-2)		-0.0961 (0.1330)	-0.0211 (0.1488)
D_MLR(-3)			-0.2693 (0.1706)
D_MLR(-4)			-0.0991 (0.1608)
D_CAR_FX		0.0004 (0.0005)	0.0007 (0.0006)
D_CAR_FX(-1)		0.0015*** (0.0005)	0.0017** (0.0006)
D_CAR_FX(-2)		0.0002 (0.0005)	-0.0005 (0.0006)
D_CAR_FX(-3)			-0.0004 (0.0006)
D_CAR_FX(-4)			0.0013 (0.0008)
Macroeconomic Variables			
D_CPI		-0.0022 (0.0062)	-0.0033 (0.0070)
D_CPI(-1)		-0.0025 (0.0062)	-0.0020 (0.0066)
D_CPI(-2)		0.0084 (0.0064)	0.0113 (0.0069)
D_CPI(-3)			-0.0085 (0.0071)
D_CPI(-4)			0.0028 (0.0066)
LN_GDP		0.0304 (0.0421)	
LN_GOVTEXP		0.0375 (0.0343)	0.0781* (0.0390)
LN_GOVTEXP(-1)		-0.0127 (0.0308)	-0.0260 (0.0346)
LN_GOVTEXP(-2)		-0.0670** (0.0323)	-0.0506 (0.0330)
LN_GOVTEXP(-3)			0.0191 (0.0323)
LN_GOVTEXP(-4)			-0.0294 (0.0360)

Note: *(1)* Robust standard errors in parentheses; *** $p<0.01$, ** $p<0.05$, * $p<0.1$ indicate significance at 1%, 5% and 10% respectively; *(2)* L = 0 lags representing the short-run; L = 2 lags representing the medium term; L = 4 lags representing the long-run.

Table 13a: Results of Model 5A: Customer Deposits Estimation – DTI Sector

VARIABLES	Short term ($L = 0$)	Medium term ($L = 2$)	Long term ($L = 4$)
Idiosyncratic Variables			
D_LN_DEPOSITS_DTIS(-1)	-0.0878 (0.1288)	-0.1883 (0.1375)	-0.1464 (0.1658)
D_LN_DEPOSITS_DTIS(-2)		-0.0567 (0.1398)	0.0133 (0.1791)
D_LN_DEPOSITS_DTIS(-3)			0.1406 (0.1668)
D_LN_DEPOSITS_DTIS(-4)			0.1682 (0.1525)
D_CAR_FX_DTIS	-0.0049 (0.0040)	-0.0015 (0.0054)	-0.0004 (0.0060)
D_CAR_FX_DTIS(-1)		0.0013 (0.0047)	0.0003 (0.0060)
D_CAR_FX_DTIS(-2)		0.0003 (0.0043)	-0.0060 (0.0065)
D_CAR_FX_DTIS(-3)			-0.0024 (0.0052)
D_CAR_FX_DTIS(-4)			-0.0014 (0.0047)
Macroeconomic Variables			
D_CPI	-0.0012 (0.0027)	-0.0003 (0.0027)	-0.0001 (0.0032)
D_CPI(-1)		-0.0058** (0.0028)	-0.0033 (0.0032)
D_CPI(-2)		-0.0076** (0.0028)	-0.0068** (0.0032)
D_CPI(-3)			0.0041 (0.0036)
D_CPI(-4)			0.0023 (0.0034)
LN_GDP	-0.0185 (0.0146)	-0.0046 (0.0186)	-0.0008 (0.0228)
LN_GOVTEXP	0.0265* (0.0142)	0.0438*** (0.0150)	0.0270 (0.0182)
LN_GOVTEXP(-1)		-0.0114 (0.0152)	-0.0101 (0.0182)
LN_GOVTEXP(-2)		-0.0250 (0.0158)	-0.0260 (0.0183)
LN_GOVTEXP(-3)			-0.0086 (0.0180)
LN_GOVTEXP(-4)			0.0299 (0.0203)

Note: *(1)* Robust standard errors in parentheses; *** *p<0.01*, ** *p<0.05*, * *p<0.1* indicate significance at 1%, 5% and 10% respectively; *(2)* L = 0 lags representing the short-run; L = 2 lags representing the medium term; L = 4 lags representing the long-run.

Table 13b: Results of Model 5B: Customer Deposits Estimation – Commercial Banks

VARIABLES	Coefficient	Std. Error	t-Statistic	Prob.*
Idiosyncratic Variables				
D_LN_DEPOSITS_CB(-1)	-0.075379	0.139467	-0.540476	0.5914
D_LN_DEPOSITS_CB(-2)	0.046350	0.138673	0.334237	0.7397
D_CAR_FX_CB	-0.002530	0.006925	-0.365397	0.7164
D_CAR_FX_CB(-1)	0.006553	0.006751	0.970622	0.3366
D_CAR_FX_CB(-2)	0.004541	0.006523	0.696106	0.4897
Macroeconomic Variables				
D_CPI	-0.001469	0.004025	-0.365120	0.7166
D_CPI(-1)	-0.008352**	0.004121	-2.026710	0.0483
D_CPI(-2)	-0.008101*	0.004150	-1.951753	0.0568
LN_GDP_	0.021591	0.028233	0.764735	0.4482
LN_GOVTEXP_	0.037834*	0.022247	1.700631	0.0955
LN_GOVTEXP_(-1)	-0.019032	0.021494	-0.885458	0.3803
LN_GOVTEXP_(-2)	-0.033540	0.022594	-1.484468	0.1442
C	-0.072936	0.161940	-0.450388	0.6545

Note: *(1)* Robust standard errors; *** *p<0.01*, ** *p<0.05*, * *p<0.1* indicate significance at 1%, 5% and 10% respectively; *(2)* Results represent only the medium term (L = 2 lags)

Table 13c: Results of Model 5C: Customer Deposits Estimation – Building Societies

VARIABLES	Short term ($L = 0$)	Medium term ($L = 2$)	Long term ($L = 4$)
Idiosyncratic Variables			
D_LN_DEPOSITS_BS(-1)	0.0297 (0.0188)	0.0249 (0.0185)	0.0268 (0.0198)
D_LN_DEPOSITS_BS(-2)		-0.0207 (0.0185)	-0.0188 (0.0197)
D_LN_DEPOSITS_BS(-3)			0.0129 (0.0196)
D_LN_DEPOSITS_BS(-4)			-0.0002 (0.0202)
CAR_FX_BS	0.0011*** (0.0002)	0.0014*** (0.0002)	0.0013*** (0.0003)
Macroeconomic Variables			
D_CPI	-0.0003 (0.0019)	-0.0014 (0.0019)	-0.0013 (0.0021)
D_CPI(-1)		-0.0011 (0.0020)	-0.0011 (0.0021)
D_CPI(-2)		-0.0017 (0.0020)	-0.0016 (0.0021)
DUM_BS	-0.0021 (0.0046)	-0.0064 (0.0048)	-0.0047 (0.0055)

Note: *(1)* Robust standard errors in parentheses; *** *p<0.01*, ** *p<0.05*, * *p<0.1* indicate significance at 1%, 5% and 10% respectively; *(2)* L = 0 lags representing the short-run; L = 2 lags representing the medium term; L = 4 lags representing the long-run.

Table 14: Existence of unknown factors and Robustness check for commercial banks estimations

VARIABLES	Short term $(L = 0)$	Medium term $(L = 2)$	Long term $(L = 4)$
RESIDUALS: Model 1A			
Coefficient	1.00	1.00	1.00
Std. Error	0.03	0.05	0.07
t-Statistic	31.10	19.71	15.18
Prob.	0.00***	0.00***	0.00***
Observations	63	61	59
R-squared	1.0	1.0	1.0
Adjusted R-squared	1.0	1.0	1.0
RESIDUALS: Model 1B			
Coefficient	1.00	1.00	1.00
Std. Error	0.01	0.01	0.03
t-Statistic	192.33	123.68	30.38
Prob.	0.00***	0.00***	0.00***
Observations	63	61	59
R-squared	1.0	1.0	1.0
Adjusted R-squared	1.0	1.0	1.0
Coefficient	1.00	1.00	1.00
Std. Error	0.02	0.00	0.02
t-Statistic	61.78	238.90	43.80
Prob.	0.00***	0.00***	0.00***
Observations	63	61	59
R-squared	1.0	1.0	1.0
Adjusted R-squared	1.0	1.0	1.0

Note: *(1)* Regression models correspond to Tables 10a-c with the addition of the residuals into the regression; only the residuals are reported *(2)* *** *p<0.01*, ** *p<0.05*, * *p<0.1* indicate significance at 1%, 5% and 10% respectively; *(3)* L = 0 lags representing the short-run; L = 2 lags representing the medium term; L = 4 lags representing the long-run.

Table 15: Existence of unknown factors and Robustness check for building societies estimations

VARIABLES	Short term $(L = 0)$	Medium term $(L = 2)$	Long term $(L = 4)$
RESIDUALS: Model 2A			
Coefficient	1.00	1.00	1.00
Std. Error	0.01	-	-
t-Statistic	120.49	-	-
Prob.	0.00***	0.00***	0.00***
Observations	62	61	59
R-squared	1.0	1.0	1.0
Adjusted R-squared	1.0	1.0	1.0
RESIDUALS: Model 2B			
Coefficient	1.00	1.00	1.00
Std. Error	0.02	0.01	6.26E-17

t-Statistic	50.62	152.10	1.60E+16
Prob.	0.00***	0.00***	0.00***
Observations	63	61	59
R-squared	1.0	1.0	1.0
Adjusted R-squared	1.0	1.0	1.0
RESIDUALS: Model 2C			
Coefficient	1.00	1.00	1.00
Std. Error	0.02	0.01	0.00
t-Statistic	50.07	142.08	311.57
Prob.	0.00***	0.00***	0.00***
Observations	63	61	59
R-squared	1.0	1.0	1.0
Adjusted R-squared	1.0	1.0	1.0

Note: *(1)* Regression models correspond to Tables 11a-c with the addition of the residuals into the regression; only the residuals are reported *(2)* *** *p<0.01*, ** *p<0.05*, * *p<0.1* indicate significance at 1%, 5% and 10% respectively; *(3)* L = 0 lags representing the short-run; L = 2 lags representing the medium term; L = 4 lags representing the long-run.

Table 16: Existence of unknown factors and Robustness check for merchant banks estimations

VARIABLES	Short term $(L = 0)$	Medium term $(L = 2)$	Long term $(L = 4)$
RESIDUALS: Model 3A			
Coefficient	1.00	1.00	1.00
Std. Error	0.03	0.05	0.07
t-Statistic	33.63	21.97	14.07
Prob.	0.00***	0.00***	0.00***
Observations	62	61	59
R-squared	1.0	1.0	1.0
Adjusted R-squared	1.0	1.0	1.0
RESIDUALS: Model 3B			
Coefficient	1.00	1.00	1.00
Std. Error	0.01	0.02	0.01
t-Statistic	176.14	58.08	103.53
Prob.	0.00***	0.00***	0.00***
Observations	63	61	59
R-squared	1.0	1.0	1.0
Adjusted R-squared	1.0	1.0	1.0
RESIDUALS: Model 3C l 1C			
Coefficient	-	1.00	1.00
Std. Error	-	0.00	0.01
t-Statistic	-	275.11	120.22
Prob.	-	0.00***	0.00***
Observations	-	61	59
R-squared	-	1.0	1.0
Adjusted R-squared	-	1.0	1.0

Note: *(1)* Regression models correspond to Tables 12a-c with the addition of the residuals into the regression; only the residuals are reported *(2)* *** *p<0.01*, ** *p<0.05*, * *p<0.1* indicate significance at 1%, 5% and 10% respectively; *(3)* L = 0 lags representing the short-run; L = 2 lags representing the medium term; L = 4 lags representing the long-run.

Appendix B – Figures

Figure 1a: Detecting liquidity procyclicality in the Jamaican banking system

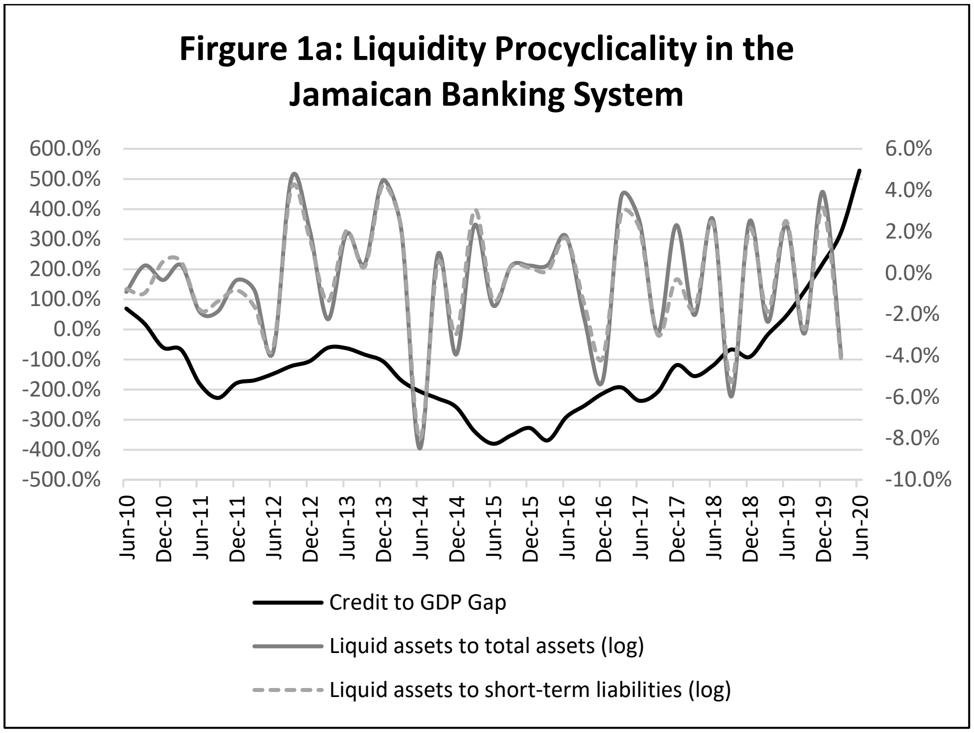

Figure 1b: Detecting liquidity procyclicality in the Jamaican banking system

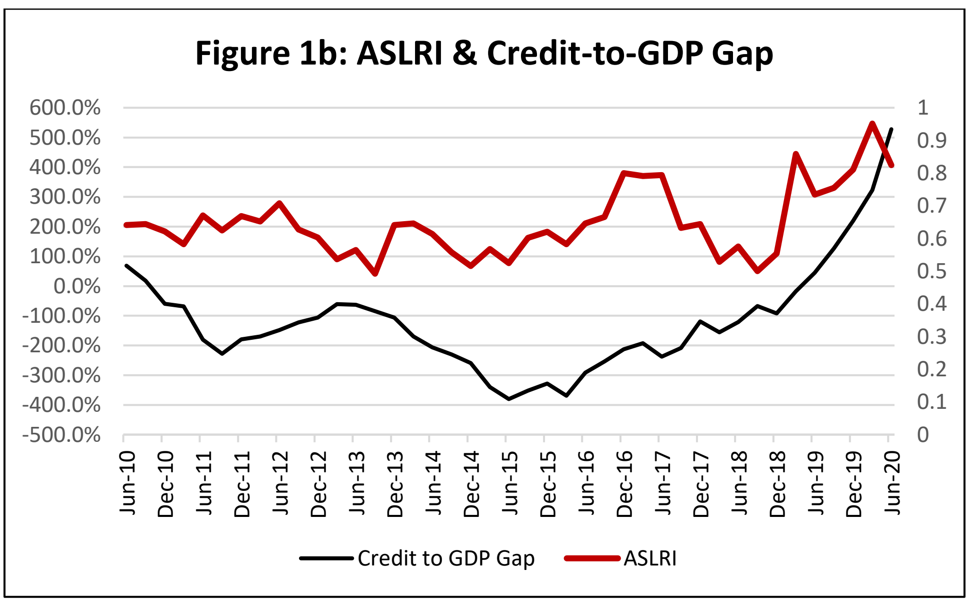

Figure 2: Showing the relationship between the ASLRI and its sub-indices

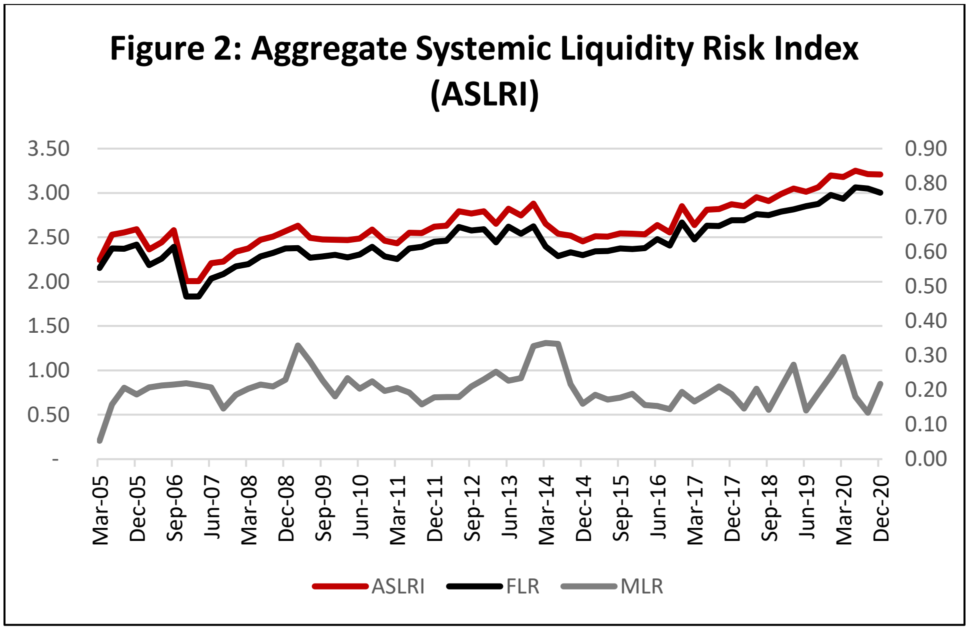

Figure 3: Showing the relationship between the ASLRI and liquidity ratios