Tracing the Liquidity Effects on Bank Stability in Barbados

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June 2012

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By Kester Guy and Shane Lowe*

Abstract

This paper provides a micro-economic approach to evaluating bank stability in the face of adverse liquidity conditions. Specifically, it examines the potential for systemic risk as a result of liquidity shocks on each bank. According to Nier et al., (2008) systemic risk results when the failure of multiple banks imposes significant costs on the entire economy. This assessment is done by tracing the liquidity effect across institutions based on the degree of exposure among commercial banks. In this study, a bank with an after-shock capital adequacy ratio (CAR) less than 8 percent is assumed to require additional capital. In addition, systemic risk rises when the CAR of the entire banking sector converges to the 8 percent threshold.

Overall, the results suggest that banks in Barbados are well capitalised and are able to withstand significant liquidity shocks. In addition, the study found that banks can be ranked in terms of systemic importance. Consequently, the second-round effects that result from systemically important banks tend to have large impacts with significant implications for bank stability.

Keywords: Liquidity, Stress Test, Bank Stability

JEL: G17, G21, G32

Introduction

Bank liquidity has always been a major concern for policymakers. On the one hand, excess liquidity may be a significant contributor to inflation and can hamper the ability of monetary policy (Agénor and El Aynaoui, 2010) while, on the other, liquidity shortages have been associated with failed institutions and can trigger systemic instability. Managing these two extremes is by no means a simple or straight forward task, as several factors, both macro and idiosyncratic, can influence banks' liquidity. In recent years, this subject has received increased attention as policymakers and researchers alike examined and re-examined the dynamics of bank liquidity and its relationship both to macro and micro economic factors. For example, Agénor and El Aynaoui (2010) looked at excess liquidity,

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bank pricing rules, and monetary policy; Khwaja and Mian (2008) studied the impact of bank liquidity shocks in an emerging market; Khemraj (2010) addressed the question, 'what does excess bank liquidity say about the loan market in less developed countries?' and Moore and Maynard (2006) looked at commercial banks' demand for excess liquid assets. These studies represent a small sample of the investigations undertaken in recent times and provide useful insights in addressing some of the critical issues relating to bank liquidity.

A widely used definition of excess liquidity is the involuntary accumulation of liquid reserves. That is, the amounts of reserves in excess of the statutory requirements, and in some cases, beyond what banks hold for precautionary purposes. In managing liquidity risks, banks are not constrained only by the cash on hand and other liquid assets, but are also aware that they can access the interbank market or borrow from the central bank (Agénor et al., 2004). Accordingly, Agénor and El Aynaoui (2010) argued that liquidity determinants may be either structural or cyclical. Understanding the nature of the liquidity constraint and the factors that drive it will aid the policymaker in crafting the appropriate responses.

Liquidity risk is one of the critical issues facing policymakers, as this has the potential to trigger institutional failures through bank runs, the drying up of market liquidity or counterparty speculations about another bank's liquidity conditions. Furthermore, knock-on effects (transmitted through direct bilateral exposures between institutions and in other ways), can generate systemic failures (De Bandt and Hartmann, 2000). While several studies in recent times have included stress test analysis and contagion effects, Willem van den End (2010) maintains liquidity risk scenarios have not been sufficiently addressed. A framework that monitors changes in bank liquidity and assesses the potential for destabilising the financial system is therefore a vital element in the modern-day supervisory toolkit.

This study establishes a framework that is useful in identifying the impact of liquidity on individual banks while tracing the effects across the banking system. Both macro and bank-specific variables were used in an econometric model to determine the drivers of bank liquidity. Extending the model into a forecasting structure and applying simulated shocks to specific explanatory variables provide guidance on the likely path of the liquidity variable under stress for each bank. Further, the liquidity effects based on bank responses were traced through the banking system using interbank network analysis. This analysis provides an early warning system for assessing the systemic risk arising out of liquidity shocks.

The empirical approach seen in Moore and Maynard (2006) was adopted to determine the factors that help to explain liquidity conditions while the resilience to liquidity shocks was determined by the capital ratios of each institution. The CAR serves as an indicator of the bank's ability to absorb losses resulting from either direct liquidity shocks or through interbank contagion. In this study a failed bank was identified as one in which the after-shock CAR is less than the internationally accepted 8 percent benchmark. Furthermore,

systemic risk rises when the CAR of the entire banking sector converges to the 8 percent threshold.

Overall, the results suggest that banks in Barbados are well capitalised and are able to withstand significant liquidity shocks. Moreover, the study found that there is a ranking among banks in terms of systemic importance. Consequently, the second-round effects that result from systemically important banks tend to have large impacts with significant implications for bank stability.

According to the authors' knowledge, literature on the inter-bank exposures for the Caribbean region has been non-existent. By combining the liquidity forecasting approach, a novel framework for assessing the impact of liquidity risk on bank stability was established. The study continues with a discussion on the liquidity observations in Barbados, followed by a brief literature review in section 2. Section 3 discusses the data and methodological approach used, and section 4 discusses the results. Finally, we conclude in section 5 with a summary of our main findings and recommendations.

1. Stylised Facts

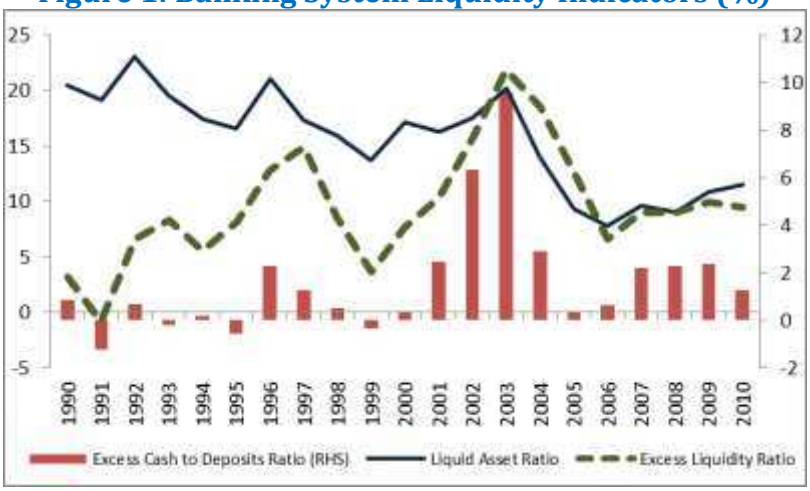
There are several metrics that can be used as a liquidity indicator. Among the commonly used ones in Barbados are the liquid assets ratio, the excess liquidity ratio and the excess cash-to-deposit ratio, each of which provide a unique guide to the policymaker[1]. For example, a high or growing excess cash-to-deposit ratio may indicate that banks are likely to adopt aggressive lending policies in the future. At the same time, the policymaker may consider the indicator when pricing short-term treasury instruments. As seen in Figure 1, the liquidity measures appear to show a stronger correlation since 2002, largely reflecting the swings in excess cash. This convergence was also observed during the 2000-01 period when a series of policy adjustments were implemented – for example, downward adjustments on the cash and security requirements for commercial banks. The liquid assets ratio showed very little co-movement with the other liquidity measures prior to 2002-03, but was over 85 percent with each of the variables subsequently. The correlation between excess cash and excess liquidity averaged 70 percent over the entire period.

Historically, commercial banks' liquid assets ratios have been relatively high compared to the other two liquidity measures. Nevertheless, they are all influenced by elements in the real economy and direct policy intervention by the monetary authority. Of particular note is the build-up in deposit growth during the 1994-96 period, fuelled by an expansion in economic activity and large foreign capital inflows. As credit remained sluggish, the

[1] The liquid assets ratio is measured as local currency, deposits with the Central Bank of Barbados and other local commercial banks, plus domestic treasury bills, divided by total assets. The excess liquidity ratio is measured as the excess cash and securities held by commercial banks beyond that required by law, divided by average deposits, while the excess cash ratio represents that excess cash divided by average depsits.

monetary authority adjusted its policy[2] in order to ease the stringent requirements that stymied credit growth (Samuel and Valderrama, 2006). Excess liquidity eased over the next three years and bottomed out at the end of 1999 aided by further policy intervention. Sustained credit growth had led to immense pressure on the foreign reserves, and upward adjustments to the cash reserve requirement and discount rate were among the strategies implemented to limit the amount of lending in the economy.

Figure 1: Banking System Liquidity Indicators (%)



Source: Central Bank of Barbados

The restrictive policy measures of 1999 were short-lived as the authorities responded to the contractions in economic activity associated with the 9/11 incident. Notwithstanding, liquidity levels grew steadily in the early 2000s on the strength of Government's increased discretionary spending as well as large capital inflows associated with mergers and acquisitions. As interest rates remained low and the overall economy gained momentum, a resurgence in credit demand was evident, and this remained strong through the mid-2000s. At the onset of the financial meltdown, the authorities eased the policy stance on several occasions during the 2007 to 2009 period to encourage economic activity. Subsequently, liquidity across the system edged up slightly, but remained relatively steady over the last two years, even as deposits and credit alike remained flat.

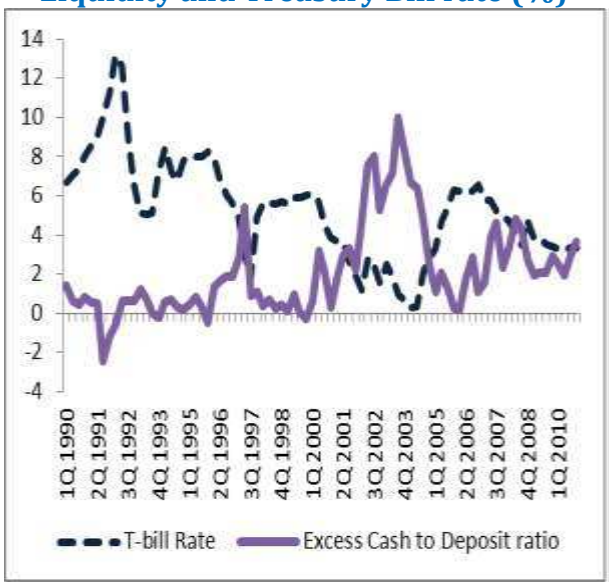
In terms of the association of liquidity with interest rates[3], Figure 2 shows a stable negative association between the variables over the past three decades. The association as defined by correlation coefficient is in the region of -75 percent. This relation is consistent with mainstream arguments which suggest that high liquidity should drive down interest rates as institutions compete to earn a return on their excess funds. Inflation, on the other hand, does not show any significant association with liquidity, and many authors agree with

[2] In May 1997, the Central Bank of Barbados reduced the minimum deposit rate and cash reserve requirements by 1 percentage point and cut the proportion of securities held required by commercial banks from 23 percent to 20 percent. In addition, the Bank withdrew $85 million of its deposits from the banking system.

[3] The T-bill rate was used as it is the best representation of an auction market in Barbados.

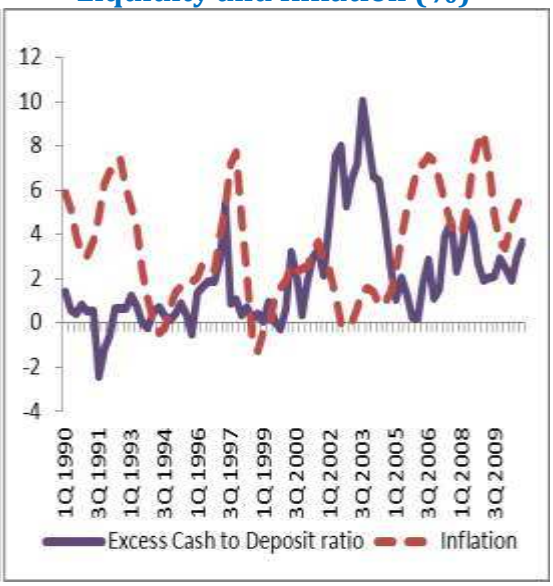
Craigwell and Moore (2010) that inflation in Barbados is largely imported. Despite this finding, some periods of high inflation and low excess liquidity were observed.

Figure 2:
Liquidity and Treasury Bill rate (%)



Source: Central Bank of Barbados

Figure 3:
Liquidity and Inflation (%)



Source: Central Bank of Barbados

2. Literature Review

The literature on modelling banks' liquidity is somewhat extensive, but relatively few studies have focused on small developing countries. Conventional theories of liquidity management and demand have focused on views such as the portfolio management theory where liquid assets are seen as a risk-free component of a bank's portfolio; the concept of liquid assets may be seen as a residual, that is, the sources of funding less credit and investments. Further, liquid assets act as a buffer for banks, guarding against the unpredictability of deposit withdrawals (Alger and Alger, 1999) and helps to explain why banks hold relatively risk-free and low-yielding assets instead of investing in higher yielding securities or credit. The reasons behind this seemingly non-profit making behaviour have implications for policymakers with respect to the effectiveness of monetary and fiscal policy and the overall supply of credit to the economy.

Agenor et al. (2004) provided the starting block for much of the recent literature on modelling excess liquidity. The authors derived a theoretical framework by explicitly modelling banks' excess liquid assets as a function of itself lagged, the reserve requirement, the volatility in the cash-to-deposit ratio and output gap (to capture the precautionary motives of banks), as well as the GDP output gap. Saxegaard (2006) investigated the issue of precautionary versus involuntary build-up in liquid assets due to undeveloped financial markets, and the consequences for the effectiveness of monetary policy.

In many lesser developed countries (LDCs), banks tend to hold large quantities of excess liquidity in their asset portfolios (see also Khemraj 2006 and 2010), explained partially by these two motives. The researcher extended the model used by Agenor et al.(2004) to decompose these two motives of cash accumulation, applying it to banks operating in sub-Saharan African (SSA) countries. Using a non-linear structural VAR model, they augment Agenor's framework with additional explanatory variables, including the volatility of private sector credit and government deposits, as well as further variables to track the flows of funds into and out of the banking system. Saxegaard opted to include the central bank's discount rate as the cost of liquidity and their findings suggest that the build-up in excess liquid assets by banks in their sample was primarily due to the involuntary build-up of funds. The author also made a key observation, that the liquidity build-up represents a structural problem within banking systems. The involuntary build-up of reserves on the other hand, can lead to increased inflationary pressures when the demand for credit picks up and these funds are disbursed. There then is a need for central bank intervention to remove this liquidity, but this may prove futile if monetary transmission is weak.

Maynard and Moore (2006) in modelling excess liquidity in Barbados also augment Agenor et al.'s (2004) demand for liquidity model with a measure of money creation, central bank's net domestic assets, excess cash and excess securities. Khemraj (2006 and 2009) investigated liquidity preferences and determinants in LDCs, focusing primarily on the Caribbean, and Guyana in particular. In his 2006 publication he finds that commercial banks in LDCs view excess liquidity and credit as close substitutes at very high minimum loan rates. Further, he proposes that excess liquidity is a structural result of oligopolistic banking systems and that any monetary policy impact on commercial banks would only be effective at high loan rates. His 2009 article explored why banks would prefer to hold excess funds instead of investing in a profitable foreign asset, finding that for Guyana, commercial banks are less focused on holding cash for precautionary purposes, and are faced by a foreign currency constraint imposed by the Central Bank's desire to accumulate foreign reserves.

Another instructive finding from Agenor et al. (2004) was that in times of stress, banks prefer to ramp-up their precautionary balances rather than lending on the interbank market. Such a practice can exacerbate strains in the financial system and was cited as a factor in the credit crunch of the late 1990s in Eastern Asia. Banks' exposures to each other are also exacerbated in times of stress. Contagion occurs via a number of channels, including common shocks and investor behaviour (Jokipii and Lucey, 2006). Adverse news or events which are perceived to impact directly on commercial banks may lead to runs on banks, presenting challenges for these institutions to meet withdrawals for deposits with available liquid assets. The cost of liquidity would vary from the rate on the interbank market, or the discount rate, or the discounted value associated with having to sell illiquid assets. The ripple effect throughout the banking systems is dependent on the degree of interbank exposures among banks.

Several authors including Allen and Gale (2000), Čihák et al. (2011) and Nier et al. (2008) have illustrated the importance of the structure of a system's interbank linkages in determining the extent of its fragility to shocks. The simple transmission of a shock to one

bank is absorbed, in order of priority, by its capital, creditors (other commercial banks) and finally, if there is any residual, its depositors. In the event that capital is not sufficient to fully absorb any losses, the other commercial banks' holdings are affected, and this initiates the ripple effect of losses on these institutions. Nier et al. found that by varying the size of capital, the size of the interbank market, the degree of connectivity and the concentration within the banking system have significant impacts on the likelihood of a systemic crash. Moreover, limited liquidity and greater discounts on fire sales also increase the chances of a systemic breakdown. Studies such as Espinosa-Vega and Solé (2010), Degryse et al. (2010) and Chan-Lau (2010) also applied these models to cross-border banking risks.

3. Data and Methodology

The econometric approach adopted allowed for evaluating various types of effects across the variables as well as providing for possible heterogeneity in the cross-sections. Such a framework allowed the authors to derive a robust liquidity demand function and assess the accuracy of the model to forecast bank liquidity. Further, the network analysis provided insight into the degree of interbank exposures among banks and identifies the institutions which are systemically significant. Monthly data from 1993 to 2011 was used to estimate and evaluate the model, while balance sheet data as at year-end 2011 was used to simulate the liquidity effects across the sector. The methodology employs three phases: the estimation, the forecasting and evaluation and the network analysis.

3.1. Estimation

A pooled framework was chosen to derive the econometric relationship between the three chosen liquidity measures and eight key macro- and micro-economic variables. The selected regressors and functional relationship was adapted from Agernor et al. (2004), Maynard and Moore (2006) and Khemraj (2009) who all investigated this issue using time series methods. Each liquidity indicator is expressed in general form as:

$$Liquidity_{it} = \beta_1 Liquidity_{it-k} + \beta_2 rr_{t-k} + \beta_3 VolCD_{it-k} + \beta_4 tb_{t-k} + \beta_5 NDA_{t-k} + \beta_6 YYT_{t-k} + \beta_7 VolYYT_{t-k} + \beta_8 VolPSC_{it-k} + \alpha + \varepsilon_{it},$$

representing the pooled homogeneous equation, with the subscripts *i*, *t* and *k* denoting, individual, time and lag length (6 months are chosen initially) respectively. The above equation is also estimated within a pooled heterogeneous framework, in which the coefficient on each variable and the constant α are allowed to vary over time. These two frameworks are then used to forecast the system and bank-specific liquidity ratios, respectively.

The variables included for consideration are defined as follows: Liquidity represents the relevant liquidity indicator used in each equation, while rr is the reserve requirement existing at the time and is expected to have a negative impact on excess liquidity and excess

cash, but a positive impact on the liquid assets ratio as banks are coerced into holding more liquid assets[4]. VolCD and VolPSC capture the volatility in the cash-deposit ratio and private sector credit, respectively as measured by the 3-month rolling standard deviation in the cash-deposit ratio and private sector credit. Increases in these volatilities are expected to push banks to hold more liquid assets as a precautionary motive to meet unpredictable withdrawals in deposits while also satisfing the demand for private sector funding. The Treasury Bill rate (tb) and the central bank's net domestic assets (NDA) are each expected to have positive impacts on the excess liquidity and liquid asset ratios, as higher interest rates should induce banks to hold more short-term securities, while increases in the NDA should lead to money creation and more cash in the vaults of commercial banks. These two variables may have opposite impacts on the excess cash holdings of banks however, as the NDA will again lead to money creation while higher interest rates should lead banks to divert cash to higher-yielding assets. YYT is the deviation of GDP away from its long-term trend while VolYYT is the volatility of this deviation, respectively. It is anticipated that as aggregate demand increases in magnitude and volatility, there will be a greater demand for cash in the economy.

3.2. Forecasting Liquidity

Having estimated the dynamic relationships between the liquidity indicators and the eight explanatory variables, in-sample (1993 – 2010) and out-of-sample (2011m1 – 2011m8) forecasts are carried out to ascertain the predictive nature of each model. The p-values of Mincer-Zarnowitz Regressions (Mincer and Zarnowitz, 1969) and mean percentage errors (MPEs) are calculated for the system models for both forecasts, and the heterogeneous model. Since we are more concerned with the policy implications arising from the system's liquidity as opposed to any one bank, we evaluate the p-values of the Mincer-Zarnowitz Regression and the MPEs for the in-sample forecasts in order to test of the model's ability to track each series.

3.3. Network Model for Contagion Analysis

This paper traces the potential risks to Barbadian commercial banks arising from their exposures with other banks within the domestic, regional and global banking system traced. Shocks to one or more banks can lead to contagious effects being felt throughout a system if at least one institution fails. Here we will describe the approach derived from the body of literature on network models which we use to track the transmission of various shocks, derived from the body of literature on network models.

Our model is built on a network of banks, each of which is connected to the others via interbank holdings, whether deposits or loans. The framework we use assumes that a shock to one bank is fed through as losses to the regulatory capital and risk-weighted assets of that institution and a check is made to ascertain whether that bank has failed (breached its 8 percent prudential capital adequacy ratio limit) or been able to fully absorb

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[4] This variable changes to the local cash reserve requirement ratio when estimating the excess cash function.

the shock [5]. In the event that the former has occurred and the size of the shock is sufficient to eliminate the affected bank's entire capital, all other banks which would have held funds with that institution will lose these holdings in proportion to the size of the residual shock. This translates into losses to these institutions, generating a second round effect where the banks may or may not be able to absorb these losses within their capital. The process continues until the shocks are fully absorbed by the remaining banks, or all banks have failed.

The model also has with it a number of additional parameters which may be adjusted to alter the severity of a shock and provide alternative stress scenarios. The loss-given-default on any shock is initially set at 100 percent, while there are assumptions made about additional contagion effects through investor panic. After a bank fails, depositors may run to withdraw deposits from the remaining institutions, at a rate specified within the model. Initially it is arbitrarily assumed that banks lose 30 percent, 10 percent and 6 percent, respectively of demand, savings and time deposits after the first round of failures, and 20 percent, 8 percent and 4 percent respectively in each subsequent round. To combat this run on deposits, banks pay depositors out of available liquid assets and initially 35 percent of their funds held at head office. However, in the event that this is insufficient to meet the demand, they must begin to sell off non-liquid assets, presumably at a discount in a stressed environment, and this discount is initially assumed to be 50 percent of book value. The discount feeds through as an additional loss to capital and may further intensify the problems faced by banks.

Two main scenarios are used to stress the banking system, namely individual defaults on each commercial bank's three largest exposures [6] and secondly, shocks leading to the failure of European, Canadian, American, Caribbean-affiliated and non-affiliated banks with which domestic commercial banks hold deposits. Scenario one represents a situation in which some banks could find themselves given the large exposure which some have to the domestic private sector. This has manifested itself over the past two years as one particular bank has experienced a substantial rise in its gross classified debt on account of loans to just two groups being classified as substandard. Scenario two is particularly relevant given the current uncertainty surrounding a number of banks operating in the USA and Europe in particular as well as the presence of mostly Canadian banks in the domestic sector. This scenario allows us to evaluate the potential impact of failures arising in these countries, as well as problems which may arise that are similar to those initiated by the failure of CL Financial Holdings in Trinidad & Tobago in 2009.

Under each set of scenarios, the assumptions are then twice varied to reflect first 5, and then 10 percentage point increases in the proportion of deposits withdrawn at each stage of the shock transmission.

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[5] Since only 5 of the 6 banks used in the sample submit regulatory capital to their regulator, the Central Bank of Barbados, an estimation of this value was made for the 6th bank, based on its ratio of calculated risk-weighted assets to those of its parent.
[6] Even though some of these assets are secured by various forms of collateral, we the authors assume a full stress scenario where these securities become impaired.

Table 1 gives a matrix of the interbank holdings of Barbadian commercial banks as at the second quarter of 2011. From the matrix, one can see that only two banks, Banks 2 and 6, hold deposits from other domestic commercial banks. Bank 2 is the most connected within the network, with Bank 6 holding the largest share of deposits, albeit from just one bank. The commercial banks are much more exposed to regional and international institutions, with Canadian and Caribbean affiliated banks holding the largest share of deposits. This finding is not surprising, given that all domestic banks are ultimately owned by Canadian and Caribbean parents.

Table 1: Matrix of Barbadian Commercial Bank Assets Held at Other Banks

	Bank 1	Bank 2	Bank 3	Bank 4	Bank 5	Bank 6
Holding Banks: (BDS$ '000)						
Bank 1	-	-	-	-	-	-
Bank 2	831	-	15	209	781	-
Bank 3	-	-	-	-	-	-
Bank 4	-	-	-	-	-	-
Bank 5	-	-	-	-	-	-
Bank 6	-	-	-	2184	-	-
Canadian	28164	1148	118696	39807	331092	72
US	39472	16190	55	72457	66509	2542
European	871	857	3358	8324	2332	1814
Caribbean affiliates	7483	1112	215	233102	1483	1209
Caribbean non-affiliates	1938	178	-	648	-	-

Source(s): Central Bank of Barbados and Commercial Banks

4. Results and Analysis

4.1. Estimation results and forecasts

Tests to determine the poolability of the data suggest that any individual fixed effects are likely to be redundant. Thus, the estimation results of our pooled homogeneous equations are shown in Table 2. Results of the heterogeneous estimation are not displayed, because of the cumbersome nature of presentation but can be acquired from the authors upon request. Table 3 shows the relative performance of each forecast.

Table 2: Results Pooled Homogeneous Estimations

Liquid Assets		Excess Liquidity		Excess Cash	
Variable	**Coefficient**	**Variable**	**Coefficient**	**Variable**	**Coefficient**
Constant	9.432**	Constant	12.630**	Constant	13.024**
Liquidity(-1)	0.730**	Liquidity(-1)	0.652**	Liquidity(-1)	0.362**
Liquidity(-2)	0.132**	Liquidity(-2)	0.188**	Liquidity(-4)	0.137**
Dummy#	9.715**	D(RR)	-0.954**	VolCD	0.811**
VolCD(-3)	-0.076*	VolCD	0.465**	NDA(-1)	-0.007**
VolCD	0.245**	VolCD(-1)	-0.374**	NDA	0.006**
VolYYT(-3)	51.489**	Liquidity(-3)	0.052*	Liquidity(-2)	0.145**
VolPSC	-10.924**	VolYYT(-3)	126.721**	VolCD(-1)	-0.582**
Liquidity(-3)	0.072**	YYT(-6)	-24.343**	YYT(-6)	-13.252**
YYT(-6)	-8.994**	VolPSC	-12.643**	VolYYT(-3)	72.990**
VolPSC(-5)	6.394**	D(TB(-5))	0.415**	Liquidity(-3)	0.129**
VolCD(-1)	-0.135**	D(TB(-1))	-0.309*		
VolCD(-5)	-0.139**	YYT	11.733**		
D(TB(-5))	0.255**	NDA(-1)	-0.005**		
Liquidity(-6)	0.040**	NDA	0.004**		
		Liquidity(-4)	0.058**		
R-squared	0.9038	R-squared	0.8994	R-squared	0.6385
Jarque-Bera	11.96**	Jarque-Bera	5.20*	Jarque-Bera	14.13**
Q-Stat (1 lag)	0.236	Q-Stat (1 lag)	0.468	Q-Stat (1 lag)	0.004
Q-Stat (2 lags)	0.615	Q-Stat (2 lags)	0.91	Q-Stat (2 lags)	0.639

** and * represent significance at 5 percent and 10 percent levels, respectively
# added to bring distribution closer to normality

Source(s): Author's calculations

After conducting panel unit root tests and differencing the appropriate variables to achieve the stationarity conditions for each series, our pooled estimations suggest that the selected variables explain a higher proportion of variations in the monthly liquid assets ratio, than in excess liquidity and excess cash ratios. The reserve requirement ratio appears in only the excess liquidity equation and carries the correct sign, suggesting an almost one to one relationship between required reserve and excess reserve ratios. Our precautionary motive variables VolCD and VolPSC give varying results across the three equations. The primarily negative sign on the latter variable across equations suggests that as the demand for credit becomes more volatile, banks' liquidity positions decrease in response to at times higher than expected loan demand. The VolCD variable appears with both negative and positive lags in each equation, although the strongest effect appears to be that of a positive one. This result seems quite plausible as frequent up and downturns in cash will be reflected in liquidity positions and banks will be pushed to increase their general holdings of cash in order to meet any unexpected demands. The Treasury Bill rate appears in the first two equations with primarily positive coefficients, suggesting that banks respond to increases

in this rate by purchasing more securities with maturities one year or less. The coefficients on the NDA suggest that money creation initially increases excess cash and securities holdings of commercial banks and this is met by a subsequent decrease one month later, presumably through increased lending or foreign investment. VolYYT carries its a priori sign under each equation, while YYT's dual coefficients suggest that as aggregate demand picks up in the economy, banks become more liquid, possibly through higher deposits. However, as credit growth catches up with deposits, commercial banks' liquidity positions are reversed as more funds are lent back to the economy.

Turning attention to Table 3, the model diagnostics reveal that for the liquid assets and excess cash regressions, there may be some issues of non-normality, but in all three cases, the models do not suffer from 1st or 2nd order serial correlation. [7]

Table 3: Results of Forecast Evaluations

	Liquid Assets		Excess Liquidity		Excess Cash	
	P-value F-stat from Mincer-Zarnowitz Regression	MPE	P-value F-stat from Mincer-Zarnowitz Regression	MPE	P-value F-stat from Mincer-Zarnowitz Regression	MPE
System (in-sample)	0.0203	1.56%	0	6.69%	0.0069	-0.32%
System (out-of-sample)	0.2546	1.67%	0.8491	-0.33%	0.0602	-23.39%
Bank 1	0.8695	4.03%	0.9776	4.40%	0.978	32.46%
Bank 2	0	1.72%	0.0666	-111.26%	0.9767	-291.74%
Bank 3	0.0248	1.96%	0.962	28.30%	0.9819	-473.44%
Bank 4	0.0967	0.68%	0.1329	12.66%	0	-32.67%
Bank 5	0.5954	2.09%	0.8558	6.80%	0.9188	-16.92%
Bank 6	0.0053	7.87%	0.164	-179.78%	0.1249	103.56%

Source(s): Author's calculations

Forecast evaluations of the three liquidity indicators show that, as shown by the R-squared in the three equations, forecasting the liquid assets ratio is considerably more accurate than the other two forecasts, both for the system and the individual banks. At most, the forecasts overpredict the liquid assets ratio by at most 7.87 percent in the case of Bank 6, whose liquidity, on inspection of all other forecast performance indicators, appears to be less easy to predict in general. The excess cash ratio's forecasting performance appears to be worst of all, reflecting the volatile nature of this ratio and comparatively low R-squared, as excess liquidity performs much better in all but few cases. Overall, Banks 2 and 6 appear to exhibit the more difficult ratios to predict, with Bank 2's performance potentially suffering from a constant ratio over much of late 1991 and the entire period of 1992. Despite this performance, however, the p-values from the Mincer-Zarnowitz regressions indicate that all in-sample forecasts of aggregate liquidity measures are biased and

[7] Tests at further lags were done and a similar result was found.

inefficient at the 5 percent level of significance, but out-of-sample forecasts are unbiased and efficient. It is also interesting to note that despite the relatively good performance of the liquid assets forecasts, forecasts for this measure appear to be biased and inefficient for 3 out of the 6 banks.

4.2. Network Stress Analysis

Tables 4 and 5 display the results for the two sets of shocks applied to the Barbadian commercial banking system as at 2011 Q2. As is clear, a shock that produces a default in the three largest exposures of each bank always leads to the failure of the affected bank, highlighting both the risks of large exposures as well as the necessity for holding collateral against large credits and investments. However, these shocks, while reducing the capital of the other banks within the system, have very little effect on the remainder of the system because of the relatively small value of interbank holdings among the six institutions, and because the shocks are absorbed after one round. Nevertheless, as we increase the proportion of deposits withdrawn from banks in the other two scenarios of shocks, we see many more failures, with all banks failing in three out of six shocks under a 5 percentage point increase in withdrawals, and all but one under a 10 percentage point increase in deposit outflows. Finally, Banks 2, 3 and 6 appear to be the most systemically important banks in terms of triggering an overall system collapse.

Table 4: Results of Default of Banks' Three Largest Exposures

Shocks	Minimum CAR % of Remaining Banks	Maximum CAR %	Sector CAR %	Number of Banks with CAR < 8%
Baseline	15.35	23.42	18.33	0
Bank 1	10.96	23.42	17.89	1
Bank 2	10.88	23.42	17.51	1
Bank 3	10.96	20.87	15.71	1
Bank 4	10.96	23.42	18.65	1
Bank 5	15.41	23.42	18.83	1
Bank 6	10.96	23.42	17.49	1
Bank 1 (+5%)	10.35	12.42	11.84	3
Bank 2 (+5%)	-	5.79	-	6
Bank 3 (+5%)	-	5.28	-	6
Bank 4 (+5%)	10.52	17.94	14.62	2
Bank 5 (+5%)	12.85	21.77	17.46	1
Bank 6 (+5%)	-	5.79	-	6
Bank 1 (+10%)	-	7.99	-	6
Bank 2 (+10%)	-	7.99	-	6
Bank 3 (+10%)	-	5.73	-	6
Bank 4 (+10%)	-	7.99	-	6
Bank 5 (+10%)	9.28	20.87	15.06	1
Bank 6 (+10%)	-	7.99	-	6

Source(s): Central Bank of Barbados and authors' simulations

With respect to the failure of regional and international banking systems, there appears to be much fewer defaults in the system than in the previous stress scenario, particularly given that the size of banks' domestic large exposures are much more than their funds held in overseas institutions. However, a similar story does present itself as an increase in the rate of withdrawal of deposits during a crisis significantly increases the number of banks failing domestically, with two banks out of five failing under the most extreme assumption of withdrawals. Overall, failures in Canada and failures by the regional affiliates of domestic banks are the two main triggers of systemic risk in Barbados. This is not surprising given the relatively large exposures which our banks have to their parents and affiliates throughout the western hemisphere.

Table 5: Results of Failure of Individual Banking Systems

Shocks	Minimum CAR % of Remaining Banks	Maximum CAR %	Sector CAR %	Number of Banks with CAR < 8%
Baseline	15.35	23.42	18.33	0
Europe	15.04	23.27	18.12	0
Canada	13.64	20.76	16.07	1
USA	9.07	23.42	15.84	0
Caribbean affiliates	10.82	23.41	18.45	1
Caribbean non-affiliates	15.35	23.42	18.3	0
Europe (+5%)	15.04	23.27	18.12	0
Canada (+5%)	11.04	20.76	14.66	1
USA (+5%)	9.07	23.42	15.84	0
Caribbean affiliates (+5%)	10.03	17.66	14.39	2
Caribbean non-affiliates (+5%)	15.35	23.42	18.3	0
Europe (+10%)	15.04	23.27	18.12	0
Canada (+10%)	-	7.39	-	6
USA (+10%)	9.07	23.42	15.84	0
Caribbean affiliates (+10%)	-	7.98	-	6
Caribbean non-affiliates (+10%)	15.35	23.42	18.3	0

Source(s): Central Bank of Barbados and authors' simulations

A number of key findings are suggested. Firstly, investor behaviour and panic can play a key role in magnifying a banking system's problems (a key result reported by Nier et al., 2008) as increases in the proportion of deposits withdrawn placed much greater strain on banks' liquidity positions, which under previous scenarios had appeared much sounder. In fact, because the size of interbank holdings among domestic entities is relatively small, this exposure played little part in prolonging the crisis at hand. Hence, maintaining adequate liquidity, and subsequently preventing unprofitable fire sales can be essential to mitigating a prolonged crisis.

This relates to our second finding, namely that a prolonged crisis, as witnessed by numerous rounds of defaults, increases the probability of a major failure of the entire

banking system. As the number of rounds of defaults increases from just one or two, the chances of all six banks' capital falling below their prudential limit increases exponentially.

In addition, the model is very beneficial in allowing researchers and policymakers to track the transmission of a shock from its trigger until it is finally absorbed. The results from our simulations have revealed that although Banks 2, 3 and 6 are systemically most important in triggering a crisis, due to their holdings of other banks' deposits, Bank 5 is actually the most likely to trigger additional rounds of default under both sets of scenarios. This is partially explained by the Bank 5's slightly lower capital adequacy and liquid assets ratios. This bank is also heavily exposed to the Canadian banking system and all this combines to increase its probability of default relative to its competitors. Nevertheless, it must be noted that the scenarios used are all extremely stressful and all of the banks investigated appear to be sufficiently liquid and very well capitalised against major shocks to the system, including failures to the US and European banking systems and severe investor panic.

5. Conclusion

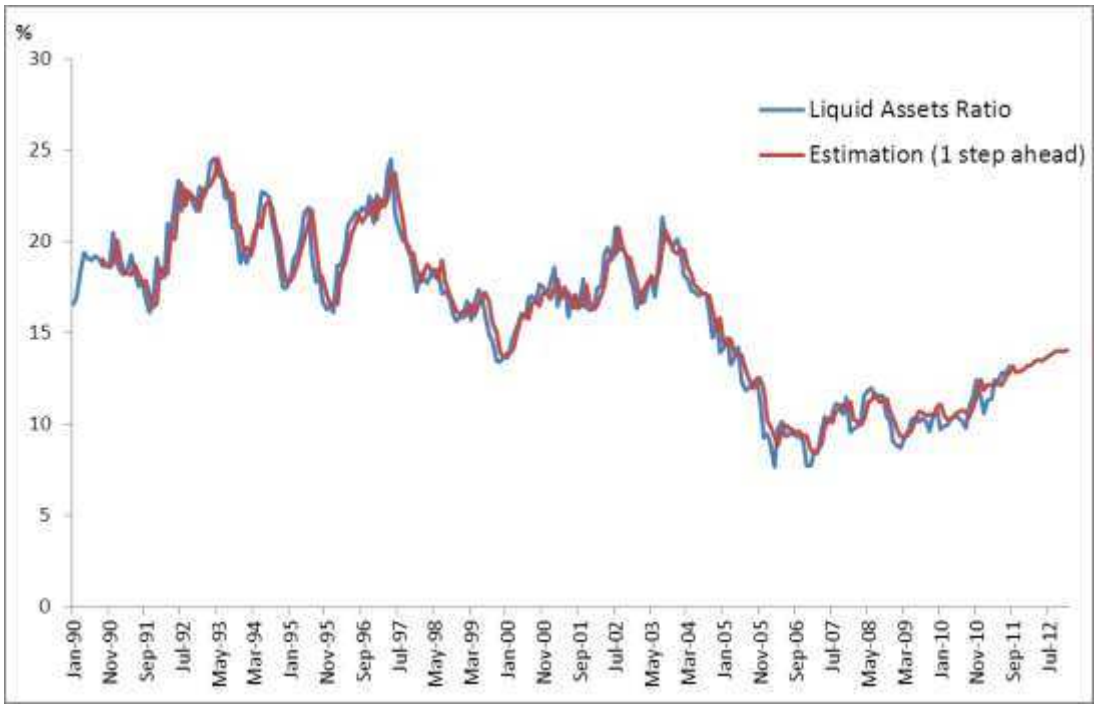
This study provides a useful framework for monitoring systemic as well as individual bank liquidity. We adopted a simple macroeconomic model that allows a formal analytical exploration of the implications of liquidity shocks across institutions and traces the impact on banks' capital. This stress test framework assesses the risks to the Barbadian banking system based on the inter-bank exposures among institutions.

The results suggest that a high level of persistence exists across the liquidity measures. Volatility in cash-to-deposit and changes in the business cycle are also important factors among the three measures of liquidity. Volatility in private sector credit appears to impact the liquid asset ratio and excess liquidity variables only, while the net domestic asset variable is an important factor for excess liquidity and excess cash variables. In addition, the predictive capacity of the model is stable and satisfactory.

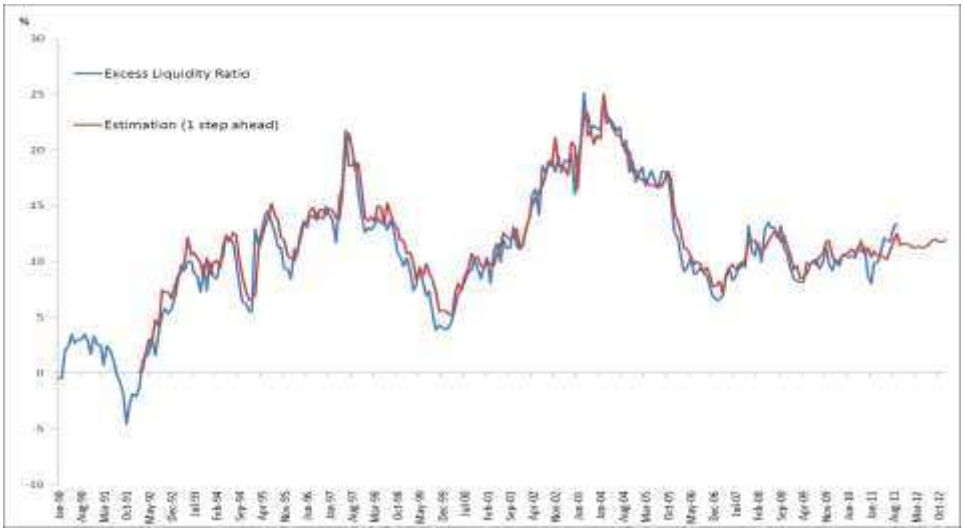
Commercial banks in Barbados are currently well capitalised and are able to withstand significant shocks. According to the stress test analysis, a sizeable credit default would only compromise the capital of the institution in which it occurred. Other institutions are able to absorb losses that may arise through contagion. However, by compounding the stress test simulations with runs on deposits we observe that there are three banks of great systemic importance, each of which has the potential to trigger a collapse in the system. Further, exposures to Canadian banks and Caribbean affiliates are the only exposures which, if compromised in conjuncture with a severe run on banks' domestic deposits, would lead to a failure of the local banking system. This study reveals that Barbadian banks are sufficiently insulated from the current financial crises of Europe and the USA, but are closely connected to their parents, all of whom are either Canadian or Caribbean.

Appendices

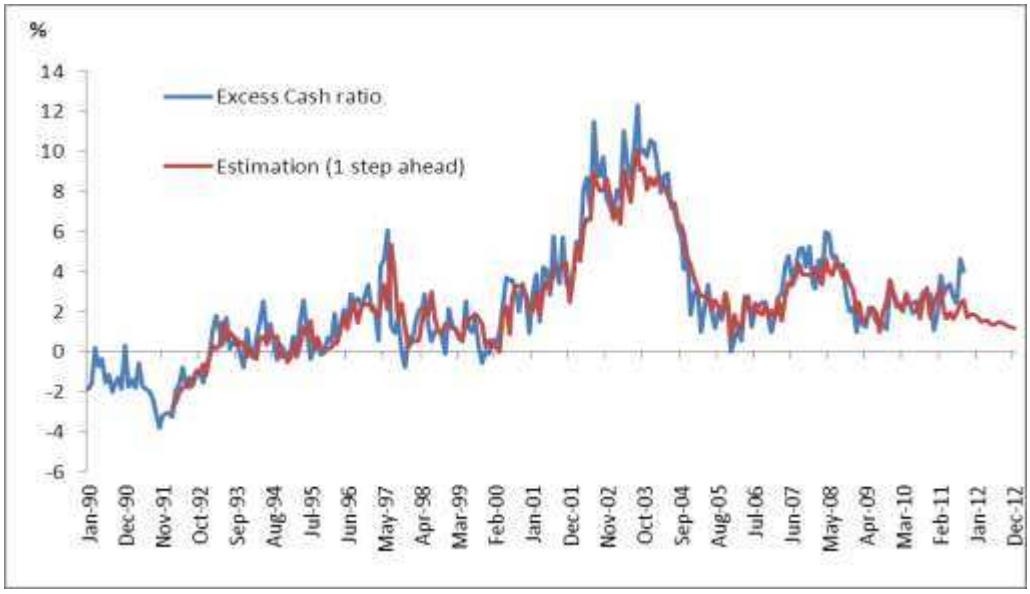
Appendix 1: Liquid Assets Ratio In-Sample, Out-of-Sample and Ex-post Forecasts



Appendix 2: Excess Liquidity Ratio In-Sample, Out-of-Sample and Ex-post Forecasts



Appendix 3: Excess Cash Ratio In-Sample, Out-of-Sample and Ex-post Forecasts



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