The role of macroprudential policy in reducing liquidity risk in Egypt

دور السياسة الاحترازية الكلية في الحد من مخاطر السيولة في مصر

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Abstract

Macroprudential policy is a relatively new approach to stabilize the financial system and reduce systemic risk that could arise over the business cycle due to credit and liquidity risk. The appropriate instruments of the macroprudential policy to be adopted by policymakers depend upon the source of the systemic risk and the country under study. This paper is the first attempt to identify appropriate financial indicators that could be utilized as effective instruments to lessen liquidity risk, measured by loans-to-deposit ratio, in the Egyptian financial system. The financial indicators that are included in our analysis are loan-to-value ratio, debt-to-income ratio, foreign-currency-lending ratio, currency mismatch, and required reserve ratio. We empirically accomplish this via estimating a Vector Autoregressive (VAR) Model using time series data from 2004Q3 to 2021Q1. The findings of this paper suggest the following. An increase in the debt-to-income ratio or currency mismatch ratio will temporarily increase liquidity risk in the Egyptian banking system. Also, an increase in the foreign-currency-lending ratio will permanently increase liquidity risk. These findings suggest to policymakers that caps on loan-to-value, currency mismatch, and foreign-currency lending ratios could be effective in reducing liquidity risk in the Egyptian financial system.

Keywords: liquidity risk, macroprudential policy, systemic risk, financial stability
JEL classification: E58, G32

المستخلص:

السياسة الاحترازية الكلية هي نهج جديد نسبيًا لتحقيق الاستقرار في النظام المالي وتقليل المخاطر النظامية التي قد تنشأ خلال دورة الأعمال بسبب مخاطر الائتمان والسيولة. تعتمد الأدوات المناسبة لسياسة التحوط الكلي التي يتعين على صانعي السياسات اعتمادها على مصدر المخاطر النظامية والبلد قيد الدراسة. هذه الورقة هي المحاولة الأولى لتحديد المؤشرات المالية المناسبة التي يمكن استخدامها كأدوات فعالة لتقليل مخاطر السيولة ، مقاسة بنسبة القروض إلى الودائع ، في النظام المالي المصري. المؤشرات المالية التي تم تضمينها في تحليلنا هي نسبة القرض إلى القيمة ، ونسبة الدين إلى الدخل ، ونسبة الإقراض بالعملة الأجنبية ، وعدم تطابق العملة ، ونسبة الاحتياطي المطلوبة. نحقق ذلك بشكل تجريبي من خلال تقدير نموذج Vector Autoregressive (VAR) باستخدام بيانات السلاسل الزمنية من Q3٢٠٠٤ إلى Q1٢٠٢١. نتائج هذه الورقة تشير إلى ما يلي. ستؤدي الزيادة في نسبة الدين إلى الدخل أو نسبة عدم تطابق العملة إلى زيادة مخاطر السيولة في النظام المصرفي المصري مؤقتًا. كما أن الزيادة في نسبة الإقراض بالعملات الأجنبية ستزيد بشكل دائم من مخاطر السيولة. تشير هذه النتائج إلى صانعي السياسات بأن وضع حد أقصى للقرض إلى القيمة ، وعدم تطابق العملة ، ومعدلات الإقراض بالعملات الأجنبية يمكن أن تكون فعالة في الحد من مخاطر السيولة في النظام المالي المصري.

الكلمات المفتاحية: مخاطر السيولة ، السياسة الاحترازية الكلية ، المخاطر النظامية ، الاستقرار المالي تصنيف JEL: E58، G32

1. Introduction

Financial system plays a major role in promoting economic efficiency by reallocating capital from savers, who lack productive abilities, to borrowers who can make the best use of funds. Therefore, the stability of the financial system is crucial in ensuring this capital reallocation process, which in turn promotes economic growth. However, there is no clear definition of financial stability (Dumičić, 2017). Financial stability can be defined as the absence of financial disturbance or crisis episodes (Gadanecz & Jayaram, 2008). This narrow definition, however, does not capture the importance of the financial system in the economy. Houben et al. (2004) propose that a stable financial system is one that functions efficiently, can withstand shocks, and minimizes the disturbance in the capital allocation process. Therefore, alleviating systemic risk in the financial system is crucial to maintain its stability (Legacies, 2011).

Systemic risk is the risk of occurrence of threats in a systematic pattern which could affect the entire financial system adversely and lead to its collapse. That is, systemic risk refers to the risk of a breakdown of an entire system rather than simply the failure of an individual institution. The recent liberalization and integration of the financial system globally have aggravated the potential effects of systemic risk on the world financial system (Ozgöde, 2011). Two major sources of systemic risk are credit risk and liquidity risk. Credit risk arises when a borrower fails to repay a loan or meet contractual obligations. The amount of loss due to credit risk depends on the value of the collateral, if any. Liquidity risk occurs when a financial institution cannot meet its short-term debt obligations or roll them over. The at-risk financial institution might be unable to convert some of its assets into cash which could derive market value of these assets down (de Bandt & Hartmann, 2000).

Prior to the financial crisis, there was a general consensus in central banks about the conduct and strategy of monetary policy where supervision of banks took place at a micro level. That is, central banks focused on the safety and soundness of individual financial institutions, not the financial system as whole, which is known as microprudential policies. Alan Greenspan, former Chairman of the Federal Reserve has described the financial crisis of 2007 as a "once-in-a-century credit tsunami". Not only the financial crisis called into question the conduct of traditional monetary policy, but it also has led to a new approach to regulation and supervision of the financial system that focuses on system-wide risk, rather than just the riskiness of individual financial institutions (Hahm et al., 2012).

To promote financial stability and limit systemic risks, macroprudential policy has become very popular, especially after the financial crisis in 2007. Macroprudential policies are financial policies aimed at ensuring the stability of the financial system as a whole and prevent systemic risk in credit, liquidity, and other vital financial services necessary for stable economic growth (Borio, 2011). That is, macroprudential policy aims to reduce the financial system's vulnerabilities to shocks, whether these shocks are endogenous to the financial system (e.g. credit risk, liquidity risk, market risk) or exogenous to the financial system (e.g. macroeconomic shocks, political unrest). In a nutshell, while microprudential policies follow a bottom-up approach, macroprudential policy follows a top-down approach (Schou-Zibell et al., 2010). Therefore, macroprudential policy are designed to achieve the objective of financial stability and limiting systemic risk in the financial system (Dumičić, 2017).

There are some similarities and discrepancies between macroprudential policy and monetary policy. On the one hand, they can be seen as complementary to each other and have common objective of financial stability. That is, monetary policy aims to achieve price stability and promote economic growth which in turn provide a stable environment for the financial system. Also, macroprudential policy helps in identifying risks and assessing the vulnerability of the whole financial system, which in turn is a prerequisite to a successful implementation of monetary policy (Borio & Shim, 2007; Caruana, 2011). On the other hand, conflicts could arise between macroprudential policy and monetary policy. For example, a loose monetary policy could encourage credit growth and risk-taking behavior which could pave the road for an upcoming financial crisis (Dell'Ariccia et al., 2017).

The main objective of this paper is to examine the role of macroprudential policy in reducing liquidity risk in Egypt. This is an important and timely research topic since the recent 2022 Nobel Prize in Economics was awarded to Ben Bernanke, Douglas Diamond, and Philip Dybvig for their work on the role of the banking system in the economy and financial crises. The former Federal Reserve Chair Ben Bernanke showed how bank runs could have devastating consequences on the economic functioning by blocking credit. Diamond & Dybvig (1983) demonstrated the fundamental role banks play in the economy as an intermediary between savers, who want instant access to their money, and borrowers, who need long-term financing. Therefore, banks are inherently vulnerable especially when savers are about to withdraw money more than the bank can cope with.

The results of our paper could have profound policy implications since the Central Bank of Egypt has recently added a Macroprudential Unit to its Banking Supervision Department to better understand the banking sector via monitoring financial soundness indicators and assessing systemic risks that may arise. The current available instruments at the Macroprudential Unit are: 1) Financial Soundness Indicators to monitor asset quality, liquidity, and profitability of the Banking Sector, and 2) Stress Testing exercises to evaluate the soundness of the banking sector to absorb any shocks the sector might be exposed to. Therefore, the results of our paper on identifying macroprudential instruments that could dampen liquidity risk and avoid bank runs scenarios in Egypt will be of tremendous help to policymakers at the Central Bank of Egypt.

This paper is organized as follows. Section 2 presents a brief review of relevant literature. Section 3 and 4 present model specification and data, respectively. The empirical results are presented in section 5. Section 6 concludes and provides some policy implications.

2. Literature review

Grace et al. (2015) classified instruments of macroprudential policy into three categories. The first one is the capital-based instruments category which includes instruments such as leverage ratio and capital requirements which can be used to increase the resilience of banks to shocks. The second category is the liquidity-based instruments category which includes instruments such as loan-to-deposit ratio which can be used to address funding risks. The third category is the credit-based instruments category which includes instruments such as loan-to-income and loan-to-value ratios which can be used to constrain a buildup of borrowing risks.

Lim et al. (2011) studied the effectiveness of macroprudential instruments on reducing systemic risk using data that cover 49 countries. They found that most of the macroprudential instruments, in general, are effective in reducing systemic risk. Their effectiveness differs according to the type of underlying risk, though. That is, credit-based instruments are mostly effective if the source of the systemic risk is credit shock. Similarly, liquidity-based instruments and capital-based instruments are mostly effective if the source of the systemic risk is liquidity shock and capital shock, respectively. The main policy implications of their study is that identifying the source of the systemic risk is crucial in designing the appropriate policy response.

Borio (2011) at the Bank for International Settlements posed that systemic risk is driven by collective behavior of financial institutions – not by factors outside these institutions' control. Therefore, to eliminate systemic risk, a top-to-the-bottom approach is needed. This top-to-the-bottom approach could be maintained by macroprudential policy which, in essence, is a supervision approach across the entire financial system, not just the stability of an individual institution. He emphasized the existence of a gap between the idealism of developing a macroprudential framework to deal with any anticipated risk, and the realism of lacking the knowledge of the transmission mechanism of the macroprudential instruments.

Salah & Souissi (2016) have emphasized the importance of using a macroprudential approach to deal with systemic risk in the Tunisian financial system instead of the microprudential approach which only limits the risk of each financial institution in isolation. Their study employed several macroeconomic variables and balance sheet indicators to assess the degree of vulnerability of the Tunisian banking sector to liquidity, capital, and credit shocks. They found that the financial sector suffers from the weak performance of public banks, and that represents a major challenge to the ameliorate the resilience of the Tunisian banking sector. They proposed some recommendations to establish an adequate prudential framework such as restructuring the balance sheets of state-owned banks to improve their governance, enforce stricter regulatory and reporting requirements, and introduce an exit strategy to resolve large liquidity problems.

To the best of our knowledge, only one study has looked at the effect of macroprudential policies on credit risk in Egypt. This study was conducted by Abdelkader & Ashour (2021) and emphasized the role of macroprudential policy in reducing credit shocks. The authors used a VAR and a VECM approach to examine the response of credit risk to different financial indicators. The author recommended the use of a variety of instruments in dealing with systemic risk and emphasized the role that debt-to-income and currency mismatch ratios play in reducing credit risks.

We are not aware of any previous literature that examined liquidity risk at a macro-economic level in Egypt. All previous research on liquidity risk that faces Egyptian banks was conducted at a micro level. We present two selected studies that looked at banking liquidity risk in Egypt at the micro level. Azzam & Almaleeh (2022) examined the effect of liquidity risk on banking performance measures, such as return on assets, return on equity, and earnings per share, in Egypt over the period 2009 to 2019. Their study used data for 9 banks listed on the Egyptian Stock Market. They found that proper liquidity management can have a positive effect on profitability of banks. Although this study is considered one of the few studies that looked at liquidity risk in the banking system in Egypt, it dealt with the research question from a microprudential approach using individual banks data. Another study by ElMoslemany et al. (2021) examined the relationship between liquidity risk and bank profitability in Egypt. Using data from 38 Egyptian banks and panel data regression approach, the study found mixed results about this relationship. Similar to Azzam & Almaleeh (2022) study, ElMoslemany et al. (2021) study followed a microprudential approach instead of studying liquidity risk that faces the whole Egyptian banking sector. To do so, a macroprudential approach is needed. That is exactly what our paper is trying to accomplish.

3. Model specification

This paper is an attempt to analyze the effects of selected macroprudential instruments in reducing systemic liquidity risk in Egypt. The outcome variable is the loan-to-deposit (LTD) ratio. The candidate instruments that will be included in my analysis are the loan-to-value (LTV) ratio, debt-to-income (DTI) ratio, foreign-currency-lending (FCL) ratio, currency mismatch (CMM), and required reserve ratio (RRR). A Vector Autoregression (VAR) model is employed to empirically investigate this research question. More formally, the main equation of interest in our model is specified as follow:

$$\begin{aligned} LTD_t = \alpha_0 &+ \sum_j^n \beta_j\, LTD_{t-j} + \sum_j^n \gamma_j\, LTV_{t-j} + \sum_j^n \lambda_j\, DTI_{t-j} + \sum_j^n \delta_j\, DTI_{t-j} \\ &+ \sum_j^n \theta_j\, DTI_{t-j} + \psi\, RRR_t + \epsilon_t \end{aligned} \quad (1)$$

where n is the optimal lag length, and ϵ_t is a white-noise error. I will discuss the outcome variable and each of the included instruments next.

Liquidity is defined in broad terms as the ability of a financial institution to fulfill its short-term obligations given its liquid assets. One common indicator of liquidity that is used to assess whether a bank has stable funding is loan-to-deposit (LTD) ratio in a given period. The LTD ratio is computed by dividing domestic credit to total deposits. The loan-to-deposit ratio is used to ensure that the bank has adequate liquidity to meet withdrawals by its customers and avoid a bank run in the event of an economic downturn. The loan-to-deposit ratio shows how properly the bank is managed in its usage of funds and its ability to attract new customers. A very low loan-to-deposit ratio casts doubt on the bank ability to use its fund while a very high loan-to-deposit ratio jeopardizes the bank’s liquidity. A loan-to-deposit ratio that exceeds one suggests that the bank borrowed money which it reloaned at a higher rate, rather than relying on its own deposits. If a substantial share of banks operates with a funding gap between its loans and deposits, the banking system as a whole will be vulnerable to adverse shocks to market funding. Hence, the LTD ratio is core indicator for liquidity risk (Van den End, 2016).

The loan-to-value (LTV) ratio is used by financial institutions to assess the risk of extending a loan, such as a mortgage loan, to a borrower. The LTV ratio is obtained by dividing the amount of loan by the value of the collateral property. Therefore, the LTV ratio represents a constraint on borrowers. The LTV ratio is positively associated with the risk level. That is, a loan with a high LTV ratio is considered a risky one, and vice versa. On the macro-level, the LTV ratio is obtained by dividing the value of domestic credit by the value of the counterpart assets. Caps on LTV ratio can be used an effective macroprudential tool to reduce systemic risk resulting from the boom-and-bust cycle of property markets (Wong et al., 2011). An LTV ratio above 100% indicates that the loan is greater than the market value of the collateral, and the borrower is said to be “underwater” on his/her loan.

The debt-to-income (DTI) ratio is defined as the percentage of the credit extended to households relative to their income (seasonally adjusted). The DTI ratio can be used to capture borrowing risk (Krznar et al., 2014). A low DTI ratio indicates that borrowers are likely to meet their debt obligations. Conversely, a high DTI ratio signals that the borrower is overburdened, and hence may be at a high risk of default which, in turn, could lead to a liquidity risk in the financial system. Limits on DTI ratio is considered a macroprudential instrument since it adds a constraint on the ability of household to borrow more than what they can afford to pay back (Shin, 2011).

The foreign-currency-lending (FCL) ratio is the ratio of domestic credit in foreign currency relative to total domestic credit. A high FCL ratio could a source of systemic risk in the financial system. That is, a substantial devaluation of the domestic currency will increase the domestic-currency value of outstanding foreign debt. This will make it more difficult for domestic borrowers to fulfil their debt-service obligations, which, in turn, will pose a threat to the stability of the financial system. A cap on FCL ratio could prevent such a systemic risk.

The inability of developing countries to issue debt in their own currency has become known in the literature as the "original sin" (Eichengreen & Hausmann, 1999). If a country experienced a large domestic currency devaluation, this would increase the value of its foreign-currency denominated liabilities. A currency mismatch captures the sensitivity of the value of financial assets and liabilities dominated in foreign currency to fluctuations in exchange rate. A currency mismatch (CMM) ratio is computed by dividing foreign-currency denominated liabilities by foreign-currency denominated assets. A high ratio of currency mismatch indicates the banking system may be highly vulnerable to foreign currency risks (Ranciere et al., 2010).

The required reserve ratio (RRR) is the fraction of a commercial bank's deposits that the central bank requires commercial banks to hold in reserves and not to loan out. The RRR is used as a shield against mass customer withdrawals. The RRR is used as one of the key monetary policy tools. That is, with a lower RRR, banks have more funds to lend which in turn increases money supply. The RRR can be used as a macroprudential tool where a higher RRR ensures that banks hold enough liquidity as a buffer (Lim et al., 2011).

4. Data and Descriptive Statistics

This paper used quarterly data from 2004Q3 to 2021Q1 outsourced from the Banking Survey which is conducted by Central Bank of Egypt. A description of the evolution of each series over our study period is presented next.

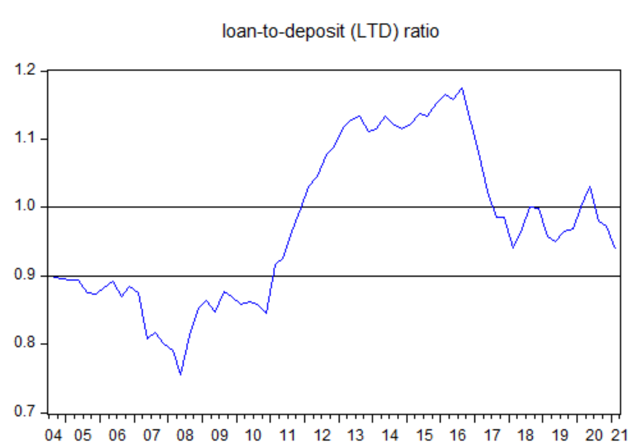

Figure (1): Loan-to-deposit (LTD) ratio in Egypt (authors' calculation).

Figure (1) depicts the evolution of loan-to-deposit (LTD) ratio in Egypt. It has been accepted among practitioners that an 80% to 90% loan-to-deposit ratio is ideal. The LTD ratio in Egypt had remained below 90% till the events of January 25th, 2011. Then, it skyrocketed above 100% afterwards till 2017Q3 where it returned to acceptable, below 100%, ratios and remained at these levels except for 2020Q2 due to the Covid-19 outbreak. Although this may indicate that the banking system in Egypt usually keeps a reasonable liquidity during normal times, it poses a question about the ability of the banking system to maintain the same liquidity levels during financial-distress times.

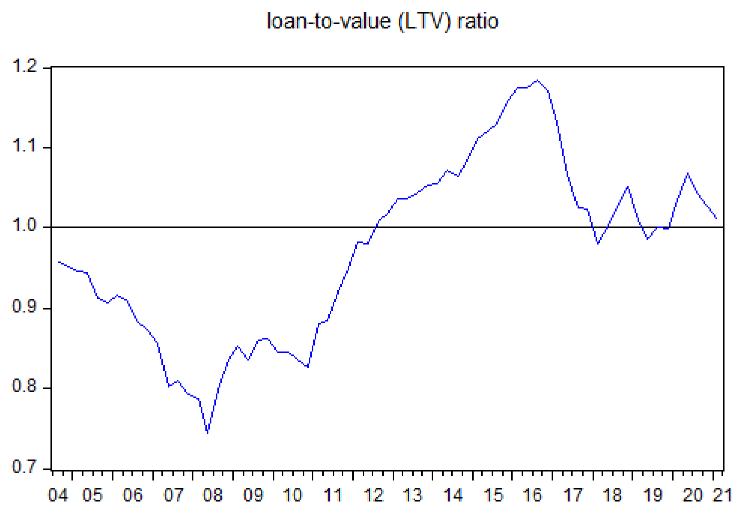

Figure (2): Loan-to-value (LTV) ratio in Egypt (authors' calculation).

Figure (2) presents the evolution of loan-to-value (LTV) ratio in Egypt. With the exception of two data points, the LTV ratio in Egypt has been above 100% since 2012. Although this may indicate a high level of risk in the financial system, caps on LTV ratio could be a potential tool for macroprudential policy would bring this potential risk down.

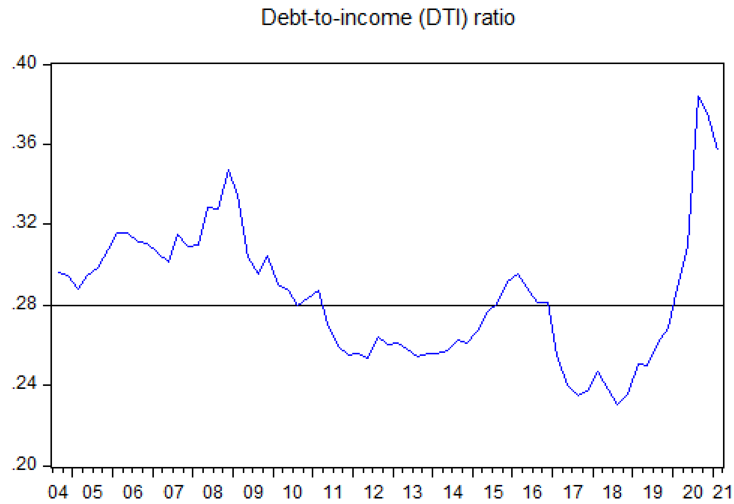

Figure (3): Debt-to-income (DTI) ratio in Egypt (authors' calculation). The horizontal line depicts the historical mean of the series.

Figure (3) depicts the evolution of debt-to-income (DTI) ratio in Egypt. The DTI ratio in Egypt has been historically around 28%. This ratio rose by 10 percentage points following the outbreak of Covid-19, but it started to decline again towards the mean by the end of 2020. Maintaining an average around 30% as a cap on DTI ratio is achievable as a macroprudential instrument and reduces liquidity risk during times of financial distress.

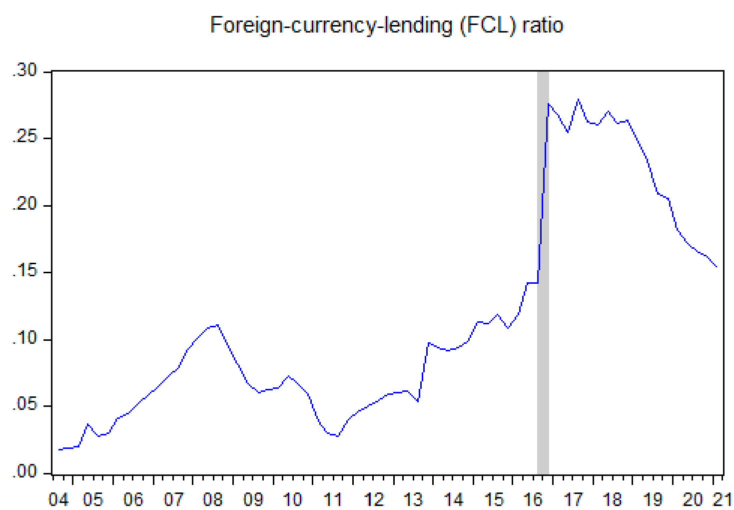

Figure (4): Foreign-currency-lending (FCL) ratio in Egypt (author's calculation). Vertical shading denotes the large devaluation of the Egyptian pound in 2016Q4.

Figure (4) depicts the evolution of foreign-currency-lending (FCL) ratio in Egypt. The large devaluation of the Egyptian pound in end of 2016 has increased the value of domestic credit in foreign currency where the FCL ratio almost doubled. A macroprudential policymaker could prevent the occurrence of a similar situation by placing a cap on the FCL ratio.

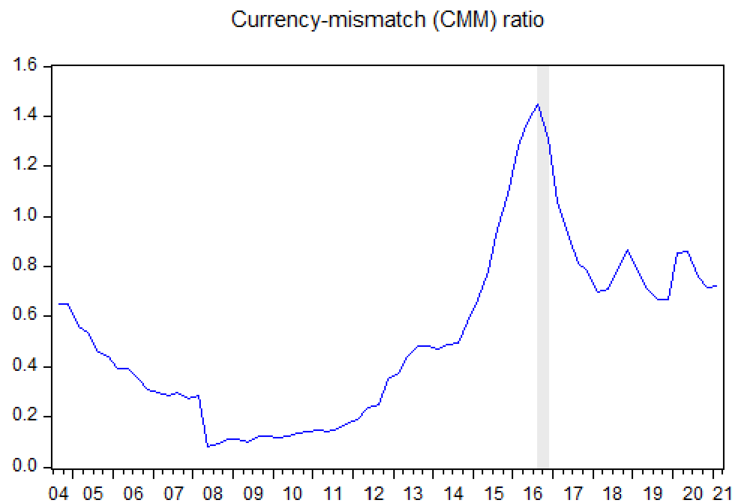

Figure (5): Currency-mismatch (CMM) ratio in Egypt (author's calculation). Vertical shading denotes the large devaluation of the Egyptian pound in 2016Q4.

Figure (5) depicts the evolution of currency mismatch (CMM) ratio in Egypt. The pressures on the Egyptian pound prior to the 2016 devaluation has drastically increased CMM to very risky levels (145% in 2016Q3). The devaluation of the Egyptian pound in 2016 has helped to bring this ratio back to acceptable levels, around 65%. Figures (4) and (5) suggest that macroprudential instruments are very sensitive to fluctuations in exchange rates. Therefore, policymakers should pay serious attention to the effects of shocks to exchange rates on the stability of the financial system.

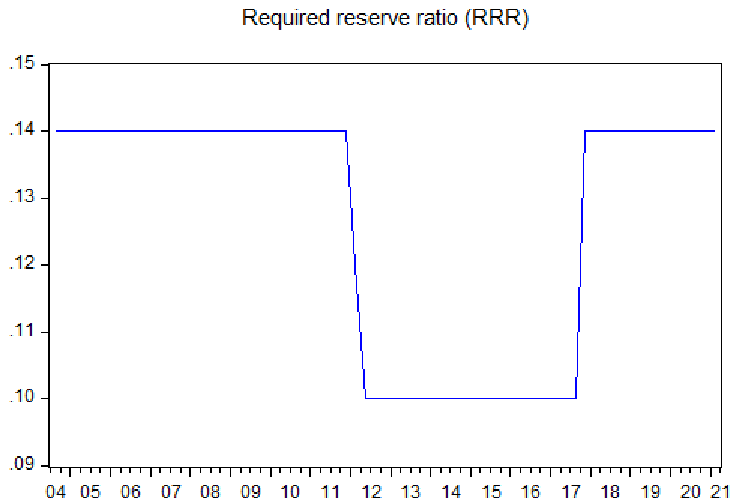

Figure (6): Required reserve ratio (RRR) in Egypt.

As shown in figure (6), the RRR has been 14% prior to the events of January 25th, 2011, where the Central Bank of Egypt decreased it to 10%. Then, in the fourth quarter of 2017, the Central Bank of Egypt has increased it again to 14% and remained there till the third quarter of 2022, not shown in figure 6, where the Central Bank of Egypt increased it to 18%. Since the RRR takes only two values during the period of my analysis, we will recode the RRR to be a dummy variable that takes the value of 0 when RRR is 14% and 1 when the RRR was decreased to 10%. The benefits of doing so are that the new recoded variable will be treated in our regression as dummy with no need to account for its lags, which in turn reduces the dimensionality of my estimated model. Moreover, the coefficient of the new dummy variable will capture the effect of decreasing the RRR on liquidity, my dependent variable.

5. Empirical results

The first step in estimating a VAR model is to assess whether the underlying variables are stationary or not. To do so, we test each series for the existence of a unit root using the augmented Dickey & Fuller (1981) (ADF) and Phillips & Perron (1988) tests. The null hypothesis of both the ADF and PP tests is that the series has a unit root. Both ADF and PP tests are very sensitive to specifications of the series, i.e., whether we include a constant, a constant and trend, or neither. We follow a unified approach for testing the included series by testing the series first without including a constant or a trend. If the test statistic suggests the existence of a unit root, we run the test again with a constant. If the test statistic is not large enough to reject the null hypothesis of a unit root, we run the test with the inclusion of a constant and a trend. If we fail to reject the null hypothesis, we conclude that the series is not stationary at level, then we repeat the process at the first difference of the series.

Table (1) reports the results of these tests for all series at levels and using the first difference. We fail to reject the null hypothesis at level for all series, except FCL ratio, using either ADF or PP test and under different specifications. For the FCL ratio, and given its evolution in figure (4), we suspect that the series could be stationary after accounting for a structural break. We run the (Bai & Perron, 2003) test and we rejected the null hypothesis that the series has a unit root after accounting for a break in 2016Q3. The drawback of this latter result it would put a constraint on our ability of using a Vector Error Correction Model (VECM) since one of the series is stationary at level, with a structural break.

Table (1): Results of the ADF and PP unit-root tests

	H_0: series has a unit root							
	ADF				PP			
Variable	None	c	c and t	1st diff.	None	c	c and t	1st diff.
LTD	-0.02	-1.24	-0.95	-6.38***	-0.01	-1.30	-1.11	-6.48***
LTV	0.064	-1.19	-1.71	-5.99***	0.06	-1.19	-1.77	-6.01***
DTI	0.22	-1.78	-1.47	-6.24***	0.33	-1.46	-0.92	-6.24***
CMM	-0.85	-1.64	-2.62	-4.42***	-0.68	-1.35	-2.16	-4.48***
FCL	-0.08	-1.32	-2.22		-0.22	-1.42	-1.69	
FCL (Breakpoint)			-7.15*** (2016Q3)					

Note: *, **, and *** denote significance at 10%, 5%, and 1%, respectively. The number of lags included were selected based on the Akaike Information Criterion. The letters c and c, t indicate whether the test specification includes a constant or a constant and a trend.

The second step in estimating a VAR model is to determine the optimal lag length to be included in the estimated model. Both the Akaike Information Criterion (AIC) and the LR test statistic suggest the inclusion of 1 lag, while the Schwarz Information Criterion (SIC) and the Hannan-Quinn (HQ) Information Criterion suggest the inclusion of no lags. Although the selection of the latter criteria produces a more parsimonious model, which increases the estimates precision, we would follow the AIC and LR test statistic and include one lag to avoid underfitting our estimated model.

The next step is to examine the stability of the estimated VAR model. If all inverse roots of the AR characteristic polynomial have modulus less than 1 and lie inside the unit circle, then the estimated VAR model is stable. As shown in figure (7), we can conclude that our estimated VAR model is stable.

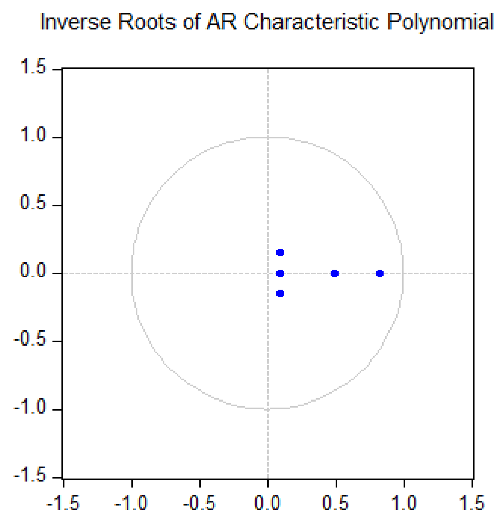

Figure (7): Inverse roots of the AR characteristic polynomial of the estimated VAR model (authors' calculations)

After we checked for the stability of our estimated VAR model, we need to check whether our estimated VAR model is correctly specified. To do so, we run a few residuals diagnostic checks to make sure that our residuals are white noise: 1) plotting the residuals of each equation, 2) checking the residuals variance-covariance matrix, 3) plotting the residuals correlogram, and 4) testing formally for serial correlation among residuals using the LM test. Figure (8) shows the residuals of the estimated 5 VAR equations. Although the residuals seem to be stationary, there are a few spikes that correspond mainly to major economic or political events such as January 25th revolution, the major devaluation of the EGP in 2016 and the outbreak of Covid 19. Table (2) displays the residuals variance-covariance matrix. Since the off diagonals elements are nearly zero, we can conclude that there is no contemporaneous correlation among errors of different equations within our estimated model. The correlogram of the residuals is presented in figure (9). There is no evidence of autocorrelation among residuals since all residuals lie within 2 standard errors. A formal LM test of the absence of autocorrelation at lag h and up to lag h is presented in table (3) where it shows that there no evidence of residuals autocorrelation.

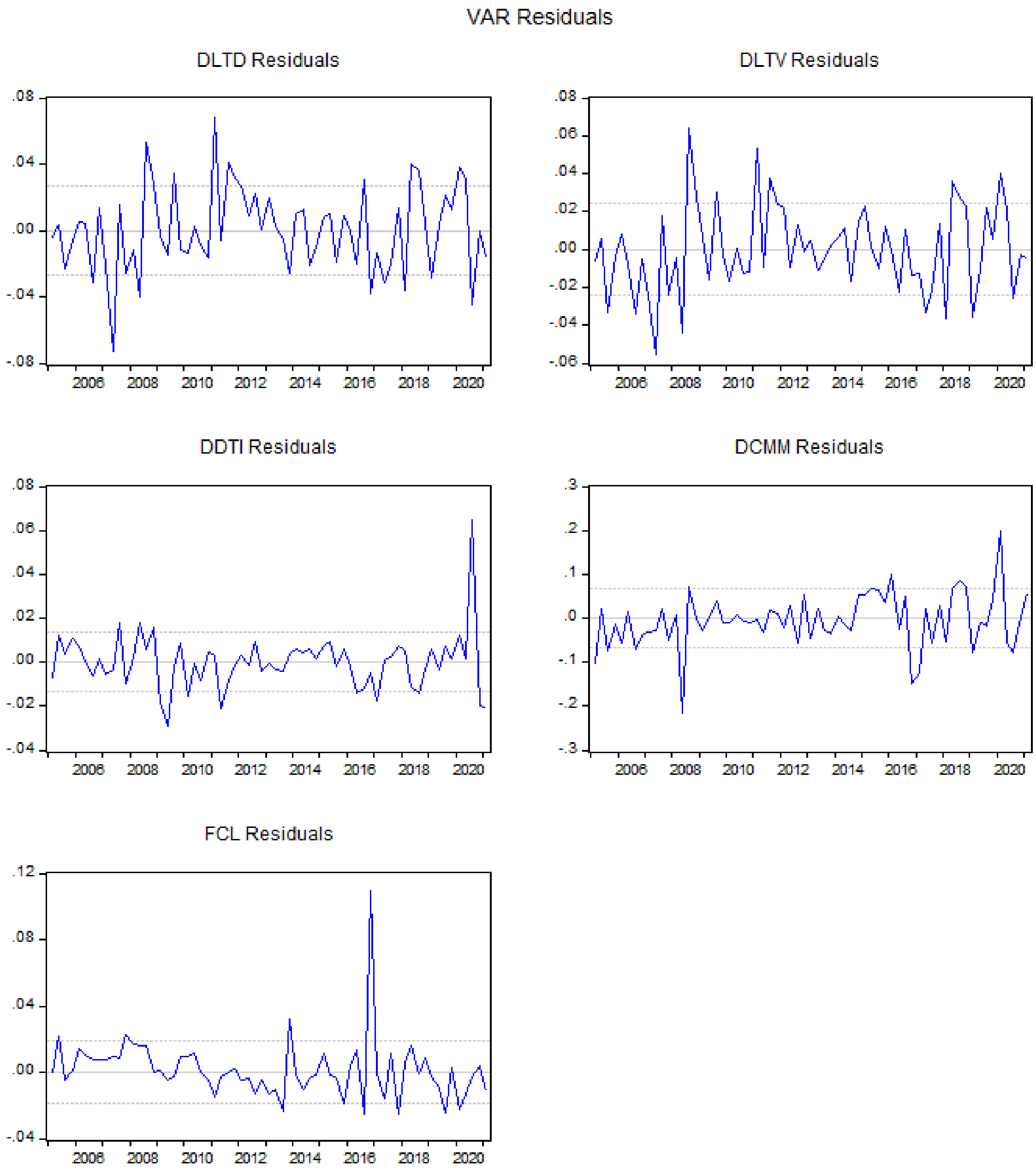

Figure (8): residuals of the estimated 5 VAR equations (authors' calculations)

Table (2): residuals variance-covariance matrix

	DLTD	DLTV	DDTI	DCMM	FCL
DLTD	0.000723	0.000598	-1.45E-05	0.000875	-0.000175
DLTV	0.000598	0.000588	1.17E-05	0.000876	-8.19E-05
DDTI	-1.45E-05	1.17E-05	0.000179	-9.18E-05	-9.18E-06
DCMM	0.000875	0.000876	-9.18E-05	0.004349	-0.000443
FCL	-0.000175	-8.19E-05	-9.18E-06	-0.000443	0.000372

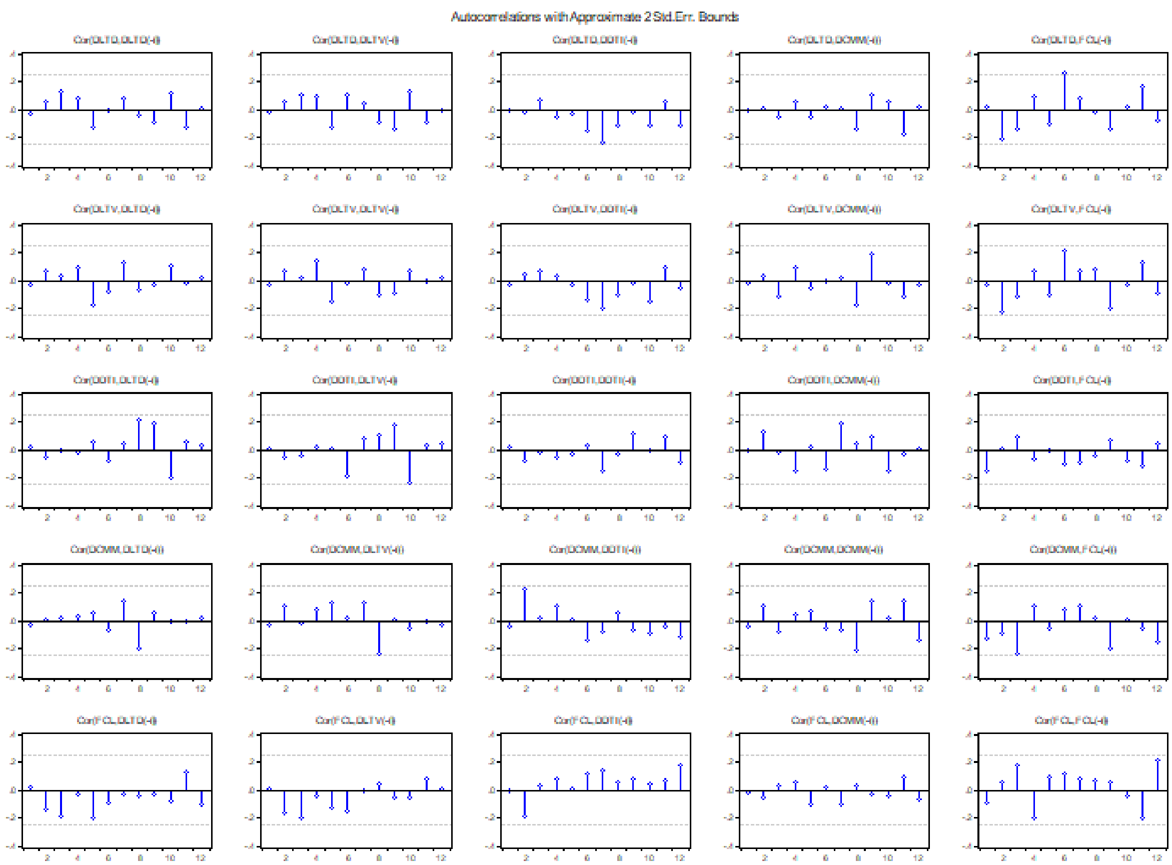

Figure (9): residuals correlogram

Table (3): VAR Residual Serial Correlation LM Tests

Null hypothesis: No serial correlation at lag h						
Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	18.63640	25	0.8142	0.736110	(25, 183.5)	0.8152
2	22.19490	25	0.6245	0.884841	(25, 183.5)	0.6261

Null hypothesis: No serial correlation at lags 1 to h						
Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	18.63640	25	0.8142	0.736110	(25, 183.5)	0.8152
2	47.91013	50	0.5576	0.954073	(50, 204.0)	0.5651

Sample size: 65

The impulse response function (IRF) allows us to trace out the time path of the liquidity risk, captured by LTD ratio, to a Cholesky one standard deviation in the innovations of each included variable in the estimated VAR system. Figure (10) presents the estimated IRFs with confidence bands in red dots for 8 periods, i.e., 2 years. The estimated IRFs come consistent with our prior expectations, with the exception of the response of LTD to LTV. A one standard deviation shock to LTV will decrease liquidity risk at the beginning, but it will return to its steady state level within a year. The other three estimated IRFs provide useful insights to policymakers as follows. A one standard deviation shock to DTI will increase liquidity risk during the following three quarters, then it will return to its steady state level. Therefore, a cap on the DTI ratio could reduces liquidity risk. Also, a one standard deviation shock to CMM will increase liquidity risk which comes consistent with our prior expectations since CMM ratio measures the domestic liabilities in foreign currency to domestic assets in foreign currency. Any increase in this ratio will put a pressure on domestic liquidity. Finally, a one standard deviation shock to FCL will increase liquidity risk and keep it at a higher steady state level. This is an alarming result to policymakers because it suggests that an increase in foreign-currency lending ratio by the Egyptian banking system will increase liquidity risk in the banking system and this risk will not return to its initial steady state.

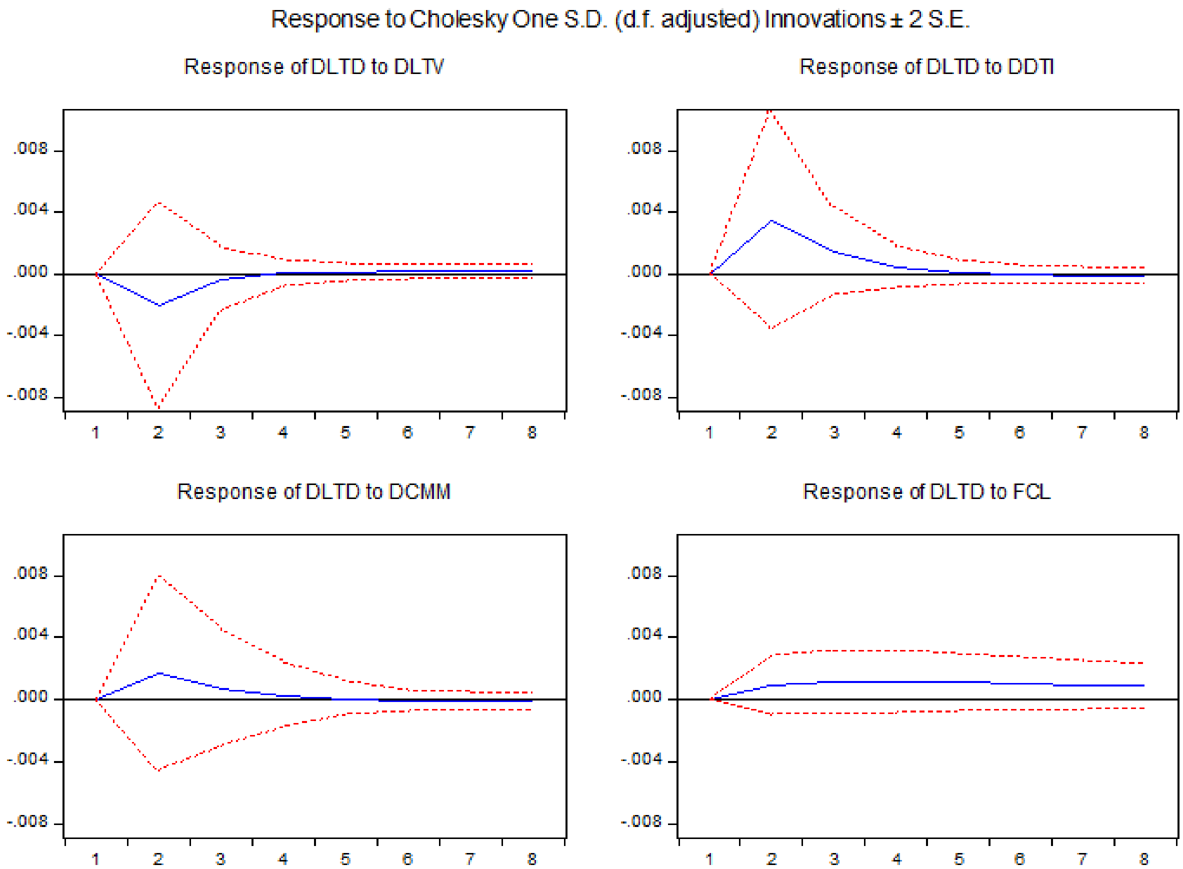

Figure (10): The estimated Impulse Response Functions

The variance decomposition shows how much of the variability in the dependent variable, LTD ratio, can be explained by its own shocks vs shocks to other variables in the system, i.e., LTV, DTI, CMM, and FCL ratios. Table (4) presents the Cholesky variance decomposition of LTD ratio for up to three years. By Cholesky identification strategy, LTV, DTI, CMM, and FCL have no contemporaneous effect on LTD ratio. After one year, 82% of variations in LTD ratio is explained by shocks to itself, while 6.4%, 5.9%, 4.1%, and 1% of variations in LTD ratio are explained by FCL, DTI, LTV, and CMM, respectively. After three years, shocks to LTD ratio explains 68% of its own variations. DTI, FCL, LTV, and CMM explain 15.8%, 8.5%, 3.9%, and 3.8% of variations in LTD, respectively. As a sum up, in the very short run, policymakers should pay close attention to FCL and DTI ratios since they have the largest magnitude in explaining variations in liquidity risk. In the long run, caps on DTI would be the most appropriate procedure to limit liquidity risk.

Table (4): Variance Decomposition of DLTD

Period	S.E.	DLTD	DLTV	DDTI	DCMM	FCL
1	0.027624	100.0000	0.000000	0.000000	0.000000	0.000000
2	0.028370	94.83504	3.752138	1.115227	0.005884	0.291708
3	0.029664	87.26750	4.292245	1.338435	0.637650	6.464174
4	0.030521	82.76921	4.059703	5.892740	0.914995	6.363352
5	0.032066	75.67288	3.826388	11.21768	0.833749	8.449304
6	0.032541	73.48237	3.719179	12.15055	2.256238	8.391666
7	0.033191	70.63198	3.881783	13.77325	3.296491	8.416497
8	0.033372	69.90637	3.841164	14.32758	3.491859	8.433028
9	0.033648	68.97009	3.939297	15.21839	3.435477	8.436752
10	0.033806	68.48036	3.936171	15.63402	3.483514	8.465933
11	0.033895	68.19897	3.922928	15.77977	3.625409	8.472919
12	0.033945	68.03454	3.920184	15.81441	3.773389	8.457471

6. Conclusion and Policy Recommendations

A stable financial system is essential to ensure a smooth transfer of funds between savers and borrowers and to promote economic growth. The stability of the financial system requires minimizing systemic risk that affects the financial system as a whole. The main sources of systemic risk to the financial system are credit risk and liquidity risk. Macroprudential policy is a relatively new set of instruments that are meant to handle these sources of risk. Our paper is the first attempt to identify effective instruments of macroprudential policy that could be used to reduce liquidity risk in Egypt.

Using data from 2004Q3 to 2021Q1, we build a VAR model to investigate the response of loans-to-deposit (LTD) ratio, a common measure of liquidity risk, to selected different financial indicators, which could serve as potential instruments for reducing liquidity risk. These financial indicators are loan-to-value (LTV) ratio, debt-to-income (DTI) ratio, foreign-currency-lending (FCL) ratio, currency mismatch (CMM), and required reserve ratio (RRR). Using both the augmented Dickey & Fuller (1981) (ADF) and Phillips & Perron (1988) tests, we conclude that none of the series is stationary at level, except the FCL ratio. After taking the first difference of the non-stationary variables, we used the Akaike Information Criterion (AIC) to determine the optimal lag length to be included in the estimated model. We then run a few diagnostic checks to assess the stability and the correct specifications of our estimated VAR model.

The estimated impulse response functions suggest the following. While the response of liquidity risk to LTV ratio is inconsistent with our prior expectations, we find that a one standard deviation shock to DTI or CMM will temporarily increase liquidity risk. We also find an alarming result that a one standard deviation shock to FCL will *permanently* increase liquidity risk. Our variance decomposition analysis suggests that liquidity risk in Egypt is largely explained by DTI and FCL ratios.

We can draw the following policy recommendations. Liquidity risk in the Egyptian financial system could be reduced by setting caps on debt-to-income ratio, currency mismatch ratio, and foreign-currency lending ratio. Also, policymakers in Egypt should pay a close attention to fluctuations in the exchange rate since a depreciation of the Egyptian pound leads to an increase in FCL ratio which in turn will pose a permanent threat to the financial system liquidity.

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