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ARAŞTIRMA MAKALESİ / RESEARCH ARTICLE

A LIQUIDITY STRESS-TESTING METHODOLOGY AS A COMPLEMENT TO THE BASEL III REGULATION: AN APPLICATION TO TURKEY

BASEL III REGÜLASYONUNU TAMAMLAYICI BİR LİKİDİTE STRES TESTİ METODOLOJİSİ: TÜRKİYE UYGULAMASI

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Abstract

Basel III liquidity regulation introduced two new metrics with a focus on time horizons up to 30 days (LCR: Liquidity Coverage Ratio) and beyond one year (NSFR: Net Stable Funding Ratio) respectively. This paper bridges the horizon gap by applying a yearlong liquidity stress test to the implied cash flow data of the seven biggest Turkish banks to gauge the extent (from 1 to 365 days) to which they can withstand a country-specific liquidity crisis. At the same time, this is the first study that has revealed the survival horizons of banks after a liquidity stress test at the institutional level. Results show that all banks fail each of the eight Turkey-specific liquidity stress scenarios (with a single exception) even under various Central Bank of the Republic of Turkey (CBRT) supports while complying with both LCR and NSFR ex-ante. As such, regulators would be better off employing the framework as a complementary local tool to the global Basel III liquidity regulation in order to account for medium-term liquidity risks between 30 days and one year. And therewithal, central banks could also use the results to draw up a contingency funding plan by reconsidering their hypothetical reactions to a liquidity crisis.

Keywords: bank regulation, bank liquidity, stress testing, Basel III

JEL Codes: G17, G21, G32

Öz

Basel III likidite regülasyonu, odaklandığı vade ufku sırasıyla 30 güne kadar (LCR: Likidite Karşılama Oranı) ve bir yıldan ötesi (NSFR: Net İstikrarlı Fonlama Oranı) olan iki yeni oran düzenlemiştir. Bu çalışma aradaki vade boşluğunu, yedi büyük Türk bankasının nakit akımı projeksiyonlarına bir yıl süreli likidite stress testi uygulayıp ülkeye özgü bir likidite krizine ne kadar dayanabileceklerini (1 ila 365 gün arasında) ölçerek

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doldurmaktadır. Aynı zamanda, bir likidite stres testi sonucunda hayatta kalma süresini banka bazında açıklayan ilk çalışmadır. Sonuçlar göstermektedir ki bankalar, test uygulanmadan önce LCR ve NSFR yükümlülüklerini karşılamalarına ragmen Türkiye Cumhuriyet Merkez Bankası'ndan destek sağladıkları durumlarda dahi Türkiye'ye özgü sekiz likidite stres testi senaryosunun hiçbirini (tek bir istisna hariç) geçememektedir. Bu nedenle regülatörler, çalışmada önerilen yöntemi 30 gün ila bir yıl arası orta vadeli likidite risklerini gözetmek üzere, global Basel III likidite regülasyonunu tamamlayıcı yerel bir enstrüman olarak kullanabilirler. Bununla birlikte merkez bankaları da bir likidite krizine yönelik varsayımsal reaksiyonlarını gözden geçirip bir acil durum fonlama planı hazırlamak üzere sonuçları kullanabilirler.

Anahtar Kelimeler: bankacılık regülasyonu, banka likiditesi, stres testi, Basel III

JEL Kodları: G17, G21, G32

Introduction

Banks are typically maturity transformers as they borrow on far shorter maturities than they lend. This results in a fundamental liquidity gap which might cause a liquidity crisis if short-term liabilities are not rolled over (funding liquidity risk). Besides, their liquid assets are vulnerable to market price fluctuations and even worse the markets might be fully or partly frozen when these assets are needed to be monetized (market liquidity risk). As such, banks are constantly subject to both funding and market liquidity risk at the same time that puts its management at jeopardy. Last but not the least, since banks (as highly leveraged institutions) operate on the foundations of a qualitative ingredient which is nothing but the confidence of all other economic units; these liquidity risks may swiftly arise not only due to a common systematic risk or a bank-specific problem but also because of the difficulty of other banks (contagion effect) or even rumours. Most of that swiftness owes to the comparative fact that while it might take years for a solvency risk building up, an extremely severe liquidity crisis could make a bank go bust in a few weeks or months. As such, a bank may fail due to liquidity risk even though it's still solvent. However, "as a result of focussing so unrelentingly on bank capital adequacy, central banks have, to some considerable extent, taken their eye off liquidity" (Goodhart, 2006, 3421). These liquidity risks most recently materialized in its all aforementioned features over the course of the 2007-2008 global financial crisis (GFC) due to poor risk management and excessive risk appetite of the banks not counterbalanced by adequate regulation. "The greater use of short-term wholesale funding was key to the build-up of vulnerabilities in the system, including excess leverage and maturity mismatch." (Gobat et al., 2010, 68) One of the biggest lessons learned from the GFC was that "a crisis is amplified by amplification mechanisms (run on banks, fire sales, and liquidity spirals, bank funding fragility)" (Kok, 2013, 29). The Basel III agreements introduced in the aftermath of the GFC are considered to be stemming from four different facts as insufficient capitalization, excessive maturity mismatch, the insufficient holding of high-quality liquid assets of the banks and materialization of unforeseen systemic risks (Cizel, 2016, 4) whereas liquidity risk prevails. They encourage and force monetary policy authorities to have a clear interest in conducting Systemic Liquidity Stress Tests next to the otherwise regularly conducted system-wide solvency stress tests (Halaj and Henry, 2017, 3).

When we look at the history of stress testing, we see that banks began small-scale stress tests of their trading activities in the early 1990s and Basel II introduced the requirement for credit risk stress testing by banks in 2004 (Dent et al., 2016, 132). However, it's not crystal clear since when exactly banks have been voluntarily and compulsorily performing liquidity stress tests. A liquidity stress test is defined by Bank for International Settlements (BIS) as "A liquidity stress test is the process of assessing the impact of an adverse scenario on institution's cash flow as well as on the availability of funding sources, and on market prices of liquid assets." (BIS, 2017, 60) EU banks have implemented liquidity stress testing as a mandatory tool as of 1 January 2007 as required by the Capital Requirements Directive which inter alia includes the requirement to have in place stress testing techniques and contingency funding plans. The Basel Committee on Banking Supervision (BCBS) only five months later in September 2008 published 17 principles for sound liquidity risk management and supervision in response to the GFC. Its 10th principle sets out why and how banks should apply liquidity stress tests with respect to governance, measurement and management of the liquidity risk as well as its public disclosure and the role of the supervisors: "A bank should conduct stress tests on a regular basis for a variety of short-term and protracted institution-specific and market-wide stress scenarios to identify sources of potential liquidity strain…" (BIS, 2008, 4) This is why nowadays we can read in bank's publicly available reports how they manage their liquidity risk and the current level of their LCR (or more) provided at the same time that they submit the results of a liquidity stress test to their supervisor aimed at ensuring liquidity adequacy in adverse circumstances as a part of their periodic internal liquidity adequacy assessment process – ILAAP – (ECB, 2018, 25). Context of the regulatory framework for the liquidity risk management in Turkish banks mimics the BCBS's after the GFC. However, it's only International Monetary Fund's (IMF) Financial System Stability Assessment (FSSA) on Turkey that publishes the results of the liquidity stress tests of major banks but on aggregate (IMF, 2017, 35). In addition, unlike to its EU and USA peers who announced bank stress test results at the institution level after GFC, Turkish regulators never disclosed any stress test result even at the industry level even though BRSA uses ECB's macro stress test model and shares its results with the relevant authorities twice a year (Türker, 2015, 112). Therefore, this paper will attempt to shed light on the aforementioned topics by applying a deterministic liquidity stress test to the balance sheet data of the seven biggest Turkish banks under country-specific extreme but plausible scenarios.

I seek to test the following hypothesis: "If the banks fail in a country-specific yearlong liquidity stress test while meeting both of LCR and NSFR, then the stress framework is a complementary local tool to the global Basel III liquidity measures." If the hypothesis is proven, then we could conclude the banks and their regulator in Turkey should implement it. The underlying rationale is there might be some vulnerability in Turkey at the bank and/or country level which cannot be captured by globally uniform Basel III regulation such that only tailor-made liquidity stress tests could address them if constructed accordingly. It's a fact that stress tests aren't predictive and their baseline worst-case scenarios are tail events; yet, they help to identify vulnerabilities provided that their set up is prudent. I'll take Basel III liquidity metrics as given and skip the discussion about their adequacy or necessity. In a nutshell, LCR and NSFR compare the stock of high quality liquid assets and available stable funds to the expected net cash outflows (over the next 30 calendar days) and required stable funds respectively under fixed assumptions. However, this liquidity stress test framework is based on contractual (fixed) and behavioral (expected) cumulative cash flows simultaneously during which the scenario assumptions could be changed as well. One year horizon of the test allows for (i) a double dynamic approach whereby it relies on the cumulative implied cash flows of the banks whilst the stress evolves in time, (ii) designing a prolonged stress just as long as necessary required by the anecdotal assumption that the banks in fact may still benefit from a highly likely regulatory forbearance for solvency after a year of trouble but liquidity risk already builds up to its peak in the meantime (for example, banks can somehow delay solvency by postponing the acknowledgment of their non-performing loans which might also be the case for liquidity regulation under forbearance but in case of the latter they can't avoid insolvency if all cash or cash generating capacity is consumed), and (iii) complementariness to the Basel III liquidity metrics. Even if we fail to reject the hypothesis, such a dynamic liquidity stress test could still be complementary for one more reason given the static nature of Basel III liquidity ratios; however, that discussion is beyond this paper. The concept of calculating a survival horizon as the output of a yearlong liquidity stress test is already being applied by the Dutch Central Bank (DNB) since June 2017 whereas this measure is expected to be not shorter than 180 days for less significant institutions. (DNB, 2017, 1) The Bank of Canada also suggests a similar approach whereas the stress horizon is six months (BIS, 2013, 26). According to (Matz, 2011, 532), "for a worst-case forecast for a sudden idiosyncratic funding disruption that evolved over time, banks should have a minimum survival horizon of nine months from the inception of the disruption."

The rest of the paper is organized as follows: Chapter 1 reviews the literature for liquidity stress testing. Chapter 2 sets out the financial data of the seven biggest Turkish banks stressed by the framework. Chapter 3 introduces the methodology deployed for the design of eight liquidity stress test scenarios. Chapter 4 presents the results at the institutional level and the last chapter concludes including limitations of the study, comparison with the existing literature and strategic recommendations.

1. Literature Review

Although liquidity is largely discussed for ages in the financial and economic literature in different contexts including (albeit later) its risk management in banks (e.g., ECB, 2002); since liquidity stress testing has only recently been a key element of the banks' risk management following the lessons learned from the GFC, relevant literature for this novel topic is immature. The adolescence and paucity of this kind of research are more obvious when compared to the solvency stress test. This shortage also derives from the fact that liquidity based disruptions are more complex, low-frequency and high magnitude events which makes it very difficult to design a stress test per se. In addition to that, the common approach for a long time (for instance during the set-up of Basel I and Basel II Accords) was such that controlling for solvency would have automatically mitigated the liquidity risk until it was proven otherwise lately. Regulative measures and banks' own internal risk management practices are indeed raw for liquidity (including its stress testing) in comparison to solvency (including its stress testing) albeit improving lately. The state of affairs is similar in Turkey and therefore research for stress testing the Turkish banking industry is very limited in terms of liquidity as opposed to solvency.

As already adhered to its relevant publications in the previous chapter, it's primarily BIS who points out the necessity of performing a liquidity stress test and details guidelines from a regulatory point of view. One of those remarkable BIS paper is co-written by a long list of bankers from various regulators and institutions and it not only conducts a survey of the theory and the empirics but also links them to the market practices. It gives examples of liquidity stress testing methods employed by different authorities across the globe. As it's chiefly adopted in this paper "the most common method used by banks to measure liquidity risk is the cash flow maturity mismatch approach". Nevertheless, "The liquidity stock approach and the balance sheet maturity mismatch approach are, although not uncommon, used less often" as they're indeed complementary tools (via stressed LCR and NSFR proxy) hereby. Time horizon of these tests was relatively short prior to the GFC but "Banks have started to consider longer stress periods, typically six to 12 months" (BIS, 2013, 31&32) as one year is preferred in my scenario. Not surprisingly, IMF and central banks are the primary sources of various liquidity stress testing frameworks and their implementation, given their policy mandates. Some large banks and vendor model providers also produce such methodologies but their work is not public. IMF publishes working papers mostly accompanied by a suite of analytical tools of liquidity stress testing frameworks which have been developed by their staff over the past few years. It starts with (Čihák, 2007) whereas liquidity risk is a part of a comprehensive stress test that is introduced through an Excel spreadsheet calculating the survival horizon of an individual bank under a given distress scenario using balance sheet data. Even though it accounts for a maximum of 30 days, it's very alike with this paper for being based on an implied cash flow test and being supplemented by LCR and NSFR recalculations under stress. Scenario design is based on assumptions for rollover and haircut ratios of different liabilities and assets respectively to measure the extent to which the counterbalancing capacity of the bank (via selling liquid unencumbered assets if necessary) could withstand the net cash outflow. As such, it sets out the first version of the "Next Generation System-Wide Liquidity Stress Testing" template of IMF which will soon be enhanced by (Schmieder et al., 2012) and (Jobst et al., 2017). We see that last two papers (i) solely focus on the liquidity risk, (ii) benefit from previous ones, (iii) enhance the aforementioned Excel tool and thus the methodology, (iv) attempt to link liquidity and solvency risks. Tailor-made versions of the template is being used for assessing the liquidity risk in a given banking industry whenever IMF conducts an FSSA in that country whose results are disclosed on aggregate or at single bank level (without naming banks explicitly in the latter case due to confidentiality). See, for example (IMF, 2017) for Turkey. Central banks also contribute to this area significantly given their function of watchdog of the banking industry and the crucial role of lender of last resort thereto. Their working papers on some occasions introduce a new method but mostly apply commonly accepted ones to the banking industry under their supervision. The first attempt came from the Austrian National Bank when it adopted a highly severe cash flow based liquidity stress test during IMF's FSSA in 2007 (OeNB, 2008) "whose work has heavily influenced the European approach as well (see, e.g., ECB, 2008)" (Schmieder et al., 2012, 11). A well-known integrated model accounting for the liquidity risk (The Risk Assessment Model of Systemic Institutions-RAMSI) is introduced by the Bank of England (BOE) initially in 2009. The striking feature of RAMSI which is also the core assumption of my stress scenario is that banks similar to a failed bank are more vulnerable to being shut out of funding markets. This is captured by modeling a danger zone "in which a range of indicators determine whether a bank suffers stress so severe that it is shut out of unsecured funding markets" (Aikman et al., 2009, 3). Its further developed version takes fire sales losses and closure of funding markets into account when it comes to stress testing the liquidity risk (Burrows et al., 2012). Nevertheless, my scenario takes the closure of funding markets as given and doesn't calculate a similar likelihood. A top-down liquidity stress framework developed by ECB staff (as a part of a broader analytical tool named as "Stress Test Analytics for Macroprudential Purposes in the euro area – STAMP€) is similar to the IMF template, yet (i) time horizon is three months, (ii) there're three scenarios increasing in severity and four models for asset encumbrance calculation, (iii) counterbalancing capacity is controlled for the credit quality of the asset, (iv) a new indicator namely "distance to liquidity stress" is introduced which measures the magnitude of the stress required to make a bank illiquid, (v) second-round effects of fire sales and interconnectedness of the banks are taken into account, (vi) impact of the stress on funding cost is considered to incorporate the solvency and the liquidity risks, (vii) results derived from the test applied to 94 Single Supervisory Mechanism banks are presented on aggregate (Halaj and Laliotis, 2017). This framework (introduced in February 2017) seems to be the most advanced deterministic liquidity stress test for the time being given its comprehensiveness. However, an Excel tool is not provided and components of the framework are not detailed as opposed to the IMF's methodology. Interestingly, one following paper was co-written by one of the authors provides an excessive guideline for designing a systemic liquidity stress test (SLST) after having perfectly described what an SLST should look like: "SLST should be a tool to assess banks' capacity to withstand extreme liquidity shocks… This requires looking at banks' liquidity positions far beyond the LCR and NFSR perspective…" (Halaj and Henry, 2017, 9). Without excluding a purely statistical approach as an alternative, it mainly recommends a framework similar to the IMF's by focusing on cash-flow modeling under stress, albeit with a stronger emphasis on the feedback effects and a link to the solvency risk. Leonard Matz who has been writing over bank liquidity risk management since 1985 explains in his fifth and last relevant book that stochastic methods aren't useful for stress testing the liquidity risk which is a low-frequency, high magnitude and non-normally distributed event. He suggests "deterministic, scenario-based stress tests are the least-worst solution" and presents a framework very alike to the IMF's (Matz 2011). There's also a liquidity measure (Liquidity mismatch index-LMI)) in the literature that can be expressed in terms of dollars which could be aggregated across various institutions in a meaningful way unlike to survival horizon measure in common (Brunnermeier et al., 2012) This index can be used as a liquidity stress test since it measures the mismatch between the market liquidity of assets and the funding liquidity of liabilities of a bank at any future point in time but determining their liquidity weights in the formula remains as an empirical question. Despite this entire prevailing tendency to prefer determinant structures, there's a very remarkable model (Dutch Central Bank's Liquidity Stress-Tester) based on a stochastic approach as well. It simulates the probability of a liquidity shortfall by a Monte Carlo approach (Van den End 2008).

When we have a look at a bank's liquidity risk disclosure with respect to stress testing, we could for instance read from Deutsche Bank's 2017 annual report that "On a daily basis, we run the liquidity stress test over an eight-week horizon, which we consider the most critical time span in a liquidity crisis, and apply the relevant stress assumptions to risk drivers from on-balance sheet and off-balance sheet products. Beyond the eight week time horizon, we analyze the impact of a more prolonged stress period, extending to twelve months. This stress testing analysis is performed on a daily basis" (Deutsche Bank, 2018, 77). However, when it comes to details, for example about modeling the actions the bank would take to counterbalance the outflows incurred, we're given only a generic explanation and for sure not the specifications nor the exact figures. These are most probably provided to the regulator only through ILAAP. Nevertheless, the reporting tables show the results of the bank's internal global liquidity stress test under the various different scenarios. Prior to switching to the Turkish context in the next paragraph, I want to recall that there's a vast literature keeps growing about liquidity measures of Basel III, namely LCR and the NSFR but this is not the interest of this paper. By definition, these are two deterministic liquidity stress tests of those assumptions are given (and thus cannot be tailor-made anymore) with respect to banks' short-term and long-term liquidity, respectively. As the BIS survey reveals "banks aim at ensuring compatibility with Basel III liquidity standards" and "many banks consider the LCR and the NSFR as specific scenarios in their internal liquidity stress tests" but not the mainstream (BIS, 2013, 31&32). On the contrary, Turkish banks mostly prefer to further stress their LCR as their main liquidity stress testing framework. When we look at 2019Q3 financial statements of seven biggest Turkish banks, and in particular, to the "liquidity risk management" chapter to follow the credentials for liquidity stress testing, it's only Garantibank that obviously elucidates the usage of a dynamic implied cash flow methodology to calculate a survival horizon under stress (Garantibank, 2020, 58). However, neither the results (unlike Deutsche Bank's disclosure above) nor the framework details (alike with Deutsche Bank) are presented. Other Turkish banks either follow a static approach whereas LCR is further stressed or leave it to blur. Nonetheless, they all disclose their LCR and liquidity gap table. Unfortunately, BRSA doesn't apply ILAAP but rather replaces it with a liquidity section in the internal capital adequacy assessment process (ICAAP) which seems to be inadequate and contradictory to the international practices.

Another strand of literature relevant for this paper solely focuses on the liquidity risks of a given banking industry by applying a stress test. See, for example; (Balás and Móré, 2007) for Hungarian and (Geršl et al., 2016) for Czech banks. Their focus on cash flow analysis is akin to this paper yet they only disclose the extent to which banks lost their initial liquidity buffers on aggregate post-stress and not the specific survival horizons at the institutional level. Previously mentioned report on FSSA on Turkey includes a banking stress test for liquidity that covered the 10 largest deposit-taking banks (by assets) based on 2015 year-end data by employing two methodologies: LCR per currency and cash flow using maturity buckets. A severely adverse scenario assumes a prolonged loss of market access by Turkey which could "lower liquidity coverage capacity by half (TL) or more (fx) reflecting the potentially large negative cash-flow positions up to 12 months" (IMF, 2017, 14) whereas the cumulative net liquidity after counterbalancing turns positive only after a year for TL and remains negative at all times for fx. This report is by far the most advanced and comprehensive liquidity stress test publicly available for the Turkish banking industry with a brilliant link to the solvency risk and rest of the economy albeit it's a bit outdated. As usual with most supervisory stress tests, results are not shown at single bank level and steps of the methodology are missing. A staff of BRSA expects cross border borrowing of the banking sector to help to reduce its maturity gap at the cost of a deteriorating loan-to-deposit (LTD) ratio (Sakarya, 2016). The conclusion is that liquidity of the TBI is robust given its LCR meeting the regulatory requirement. Another study (Delikanlı et al., 2013) provides a liquidity stress testing framework for the TBI based on (Van den End, 2008). Its conclusion is the same: TBI is robust for the liquidity risk only because it meets the LCR. A CBRT working paper introducing a liquidity stress test framework again based on (Van den End, 2008) derives precautionary conclusions from the level of non-core liabilities to M2 money supply ratio of the TBI (Akdoğan and Yıldırım, 2014). How the liquidity measures of Basel III would affect the TBI is discussed in (Gülhan and Küçükkocaoğlu, 2018). It's fully a review of the relevant legislation except that it calculates the NSFR (which is still not disclosed by the banks) proxy as 100,05% for the TBI by using aggregated sector data from 2016 year-end and calls attention to the fact that it barely meets the requirement. (Gümüş and Nalbantoğlu, 2015) analyze how LCR of different banking groups might be stressed on aggregate by using 2014 year-end balance sheet data. Based on the assumption that deposits are suddenly withdrawn by 5 to 30%, LCR is recalculated only via deducting the total withdrawal from the cash in the numerator. In the most severe scenario, LCR drops from 113% to 72% on average for the entire TBI. Foreign banks perform better than other three banking groups (state-owned, domestic private and participation banks) yet all fall short of 100%. Türküner (2016) simulates a model in order to design the hypothetical balance sheet of a Turkish bank which could meet all requirements of Basel III. Scaling the available Tier-1 at 100 units, the model follows the leverage and capital adequacy ratios at the minimum to determine the size of each balance sheet item of an average Turkish bank. Eventually, a sensitivity test is applied to the ultimate balance sheet by Monte Carlo simulations which show that LCR is most sensitive to the credit risk. Another liquidity risk metric calculation is the liquidity transformation gap (LTG) performed by the TBI (Akkaya and Azimli, 2018). LTG indicates the net amount of liquidity transformation a bank performs as a fraction of total assets that it holds and calculated as 0.20 for the average bank in (Deep and Schaefer, 2004). Using their methodology over panel data of 28 Turkish commercial banks between 2005-2015, it finds out that LTG is bigger for large banks (0.33) than it is for medium (0.20) and small (-0.35) banks with an average of 0.15. In other words, for every dollar of assets that the average bank holds, it converts only 15 cents of liquid deposits into illiquid assets. This gap widens further during the GFC. According to the regression results, banks with a higher return on their assets tend to have a larger metric such that these banks transform more liquidity.

Returning to the question posed at the beginning of this study, it is now possible to state that this paper is the first one revealing the survival horizons of banks after a liquidity stress test at the institutional level. It also introduces a new approach to liquidity stress testing not only because the stress parameters are assigned according to a combination of regression analysis, historical figures and narrative verdicts but also because they're applied to the total outstanding balances of cash (in/out) flows and not to their maturing amounts (except the counterbalancing capacity).

2. Data

The liquidity stress test framework in this paper is applied to the seven biggest Turkish banks which altogether account for 80% of the TBI in terms of total consolidated assets as of September 30, 2019. The framework uses two types of financial data:

Firstly, real GDP figures and fx rates are provided from the Turkish Statistical Institute and the CBRT respectively. Together with aggregated balance sheets of the TBI (deposit banks only) obtained from Banks Association of Turkey, these three quarterly data altogether help to model how a shock to the first two would affect main items of the third.

Secondly, fundamental data at the institutional level to which aforementioned and other shocks would be applied is derived from "Presentation of assets and liabilities according to their (contractual) remaining maturities" table as disclosed under "Explanations on Consolidated Liquidity Risk and Consolidated Liquidity Coverage Ratio" subsection of the "Information on the financial position and risk management of the group" chapter of each individual bank's public consolidated 2019Q3 financial statement in accordance with the Banking Regulation and Supervision of Agency (BRSA) Accounting and Financial Reporting Legislation.

Table-1 gives a brief snapshot of the sample banks as of 2019Q3 end with respect to their total assets and liquidity profile. A proxy for the NSFR is calculated according to its definition in (BIS, 2014, 3) by means of relevant footnotes in each bank's financials.

Table-1: Total Assets and Selected Liquidity Ratios of the Seven Biggest Turkish Banks (as per their 2019Q3 consolidated balance Sheets)

Bank	Total assets	Liquidity Ratios				
		LCR	NSFR proxy	Loan to deposit (LTD)	Cumulative ST [1] Liquidity Gap / ST Liabilities	Unencumbered (Cash+ financial assets) [2] / ST Liabilities
	Billions of TL	%				
Ziraatbank	655	126	113	113	39.7	12.6
İşbank	526	174	127	118	33.8	34.6
Halkbank	454	117	87	118	45.8	13.1
Garantibank	411	233	142	106	23.9	28.7
Vakıfbank	399	133	106	126	55.0	22.7
YKbank	397	176	108	110	27.5	27.6
Akbank	379	188	111	96	25.1	35.4
Mean	***460***	***164***	***113***	***112***	***35.8***	***25.0***
StDev	***99.2***	***41.2***	***17.3***	***9.7***	***11.6***	***9.3***

Table-1 might also be giving some hints about the stress test results should these ratios be a good predictor of the liquidity risk resilience under the stress scenarios as deployed by the framework. It's only;

- YKbank whose all five liquidity ratios fall within one standard deviation of the mean, and
- Halkbank's NSFR within the entire group that can't meet Basel III liquidity requirements.

3. Methodology

I'll employ a top-down regulatory liquidity stress testing framework chiefly drawing on the "implied cash flow analysis" developed at IMF in several working papers with a particular focus

1 ST: Short term (until the end of the yearlong stress).

2 Cash includes the mandatory reserves. Financial assets (excludes the derivatives) are almost only Turkish sovereign debt securities (96% of all) in the TBI.

on (Schmieder et al., 2012, 14) which is more comprehensive among others. In the framework, banks' public financial data (primarily the liquidity gap tables) are used to simulate how contractual cash flows over three time buckets up to one year (as given in Table-2) could be subject to a liquidity gap. The ultimate output is a survival horizon per each bank in number of days (from 1 to 365) identical to the one given in (Matz, 2011, 200) as far as a liquidity shortfall doesn't occur under two different adverse but plausible stress scenarios so called "adverse" and "severely adverse".

All cash flows mature proportionally in time throughout a time bucket period. The maturity for the remaining balance of a balance sheet item at the end of each time bucket (if any) is assumed to be extended to the next bucket (waterfall model) except the counterbalancing capacity items. On the other hand, unencumbered liquid assets of the counterbalancing capacity are either (i) monetized before the maturity at the cost of the given stress coefficient of the corresponding time bucket during which they're monetized, otherwise (ii) monetized without any losses (stress coefficient is then 0%) during the given time bucket, and (iii) there's no new business to purchase additional ones. After all, all non-contractual (behavioral) cash flows of the bank and its customers are implicitly given in the scenarios. Banks don't have control over their secondary sources of the counterbalancing capacity since they're already parameterized via stress coefficients and parameters.

Asset encumbrance data is divided into three categories in the TBI according to the disclosure template. I deduct (if any) the amount of (i) pledged cash (from the cash account), (ii) financial assets pledged/blocked (from the Turkish government debt securities account), and block iii) financial assets pledged for repo at the beginning of the stress but release them at the end of each time bucket proportional to the maturing liabilities of the "Money Market Funds" account. [3]

In general, run-off and rollover rates are assigned to different funding sources (balance sheet liabilities) and assets respectively as well as haircuts both to the liquid assets that constitute the counterbalancing capacity and to the contingent liabilities. This paper will follow the same method for the;

- Negative haircuts concerning the liquid assets of the counterbalancing capacity,
- Positive haircuts concerning the contingent liabilities,
- Rollover rates concerning cash and mandatory reserves.

based on historical figures and narrative verdicts as shown in Table-2.

However, a less conventional approach is adopted for assets and liabilities including a combination of regression analysis, historical figures and narrative verdicts as illustrated in Table-6. To be able to clarify differences among those two sets of liquidity stress rates, I'll name them and their accompanying chapters as "stress coefficients" and "stress parameters" by and by. In short, the latter are nothing but drivers of the stress coefficients of balance sheet items.

3 Asset encumbrance treatments are based on anecdotal evidence in the TBI. Also see footnote 17 under Table-6 for encumbrance of the "Due from banks" balance sheet account.

3.1. Stress coefficients

Table-2 assigns various stress coefficients that are the fractions of (i) two types of assets (cash and mandatory reserves) that are not converted into cash and therefore higher this rate (rollover rate) higher the risk is, (ii) contingent liability that has to be paid in cash and therefore higher this rate (positive haircut) higher the risk is, and (iii) losses suffered by the bank over the face value of an unencumbered liquid asset whenever it's monetized before its maturity in the market and therefore higher this rate (negative haircut) bigger the risk is. For the liquid assets of the counterbalancing capacity, stress coefficients are originated from the August 2018 turmoil experience in the Turkish financial markets. These figures are then multiplied by 1.25 to account for a hypothetical 20% extra loss due to fire sales [4] before they enter into Table-1. If and only if an unencumbered liquid asset is not liquidated before the maturity (conditional on the bank's survival) then this ratio is zero.

Stress test coefficient for all balance sheet items maturing later than a year is zero except securities. Nevertheless, securities maturing later than a year are stressed by the coefficient of the corresponding time bucket during which they're monetized (if needed).

Table-2: Stress Coefficients (rollover, run-off, and haircut assumptions) Assigned to Contractual Cash Inflows/Outflows and Counterbalancing Capacity [5]

%	Fraction of total assets [6]	Stress coefficients		
		Up to 1 month	1-3 Months	3-12 Months
Rollover rates for cash inflows (assets)				
Cash (all except the mandatory reserves)	4.39	0	0	0
Mandatory reserves	4.70	100	100	100
Any other asset	90.91	Implicitly assigned for each and every asset type via an associated stress parameter in Table-6		
Run-off rates for cash outflows (liabilities + contingent claims)				
Any liability	89.55	Implicitly assigned for each and every liability type via an associated stress parameter in Table-6		
Contingent claims [7]	30.93	1.50	4.00	19.95
Haircuts for the counterbalancing capacity (assets)				
Turkish government debt securities	16.17	24.30	34.43	40.83
Other debt securities [8]	1.62	29.16	41.32	49.00

4 For a detailed discussion about fire sale losses, see Cont,R. and Schaanning,E., 2017. They find out (within a stress test for European banks) 20% is the minimum extent of the extra losses over total losses due to fire sales.

5 This template mimics the "Presentation of assets and liabilities according to their (contractual) remaining

6 Fraction of the total outstanding amount of the given cash flow item to the total assets on average for the sample banks prior to the stress. It shows the relative importance of each item in the set up since the stress test results are more sensitive to larger ones. As such, quoted and not-quoted shares can't change the survival horizons even by a single day on average even if their coefficients were jointly increased to 100% given their extremely low fractions.

7 Includes non-cash loans and irrevocable commitments. Stressed by the author's hypothetical expectation.

8 Stressed 20% more than Turkish government debt securities by the author's hypothetical expectation.

Quoted shares	0.05	17.84	25.66	37.93
Not-quoted shares [9]	0.04	26.75	38.50	56.90

3.2. Stress parameters

Stress coefficients of the balance sheet items that were omitted in Table-1 (with a reference to Table-6) will hereby be implicitly assigned by the stress parameters. I made use of two simultaneous approaches to assign a stress parameter to each cash in/out flow deriving from left and right hand sides of the bank balance sheets. In the first approach, I focused on designing liquidity wise consequences of simultaneous GDP and fx shocks by using linear regression analysis. Whenever this approach didn't produce statistically significant results for a given balance sheet item, the second approach used the historical worst realizations without any reference to a specific type of shock. Despite their huge differences, both approaches provided an input to the very same (implied cash flow) methodology. The starting point of the first approach is the following equation:

$$\textbf{(1)}\ \%\Delta(BSi)q = \beta0 + \beta1\ \%\Delta(GDP)q + \beta2\ \%\Delta(FX)q + \beta3\ \%\Delta(L1.BSi)q$$

where $\%\Delta(BSi)q$ is the real percentage change in the balance sheet item i during quarter q, $\%\Delta(GDP)q$ and $\%\Delta(FX)q$ are the percentage changes in seasonally adjusted real GDP of Turkey and the average fx rate respectively in the same quarter [10] and $\%\Delta(L1.BSi)q$ is the first lag of the dependent variable. It's in fact an advanced form of the following equation "$\ln(L)t = \beta0 + \beta1 \ln(GDP)t$" where L is bank liability at date t, GDPt is real GDP at date t, and the estimated value of β1 represents the elasticity of liability i with respective to the current real GDP (Hahm et al., 2012, 38). I used quarterly aggregated balance sheet of the TBI from 2002Q4 [11] to 2019Q3 (depository financial institutions only) to model how a shock to the exchange rate and the real economic growth would affect selected balance sheet items. I adjust the periodical changes for fx rates (affecting fx portions of BSi's) for the sake of real changes. This is why the framework appreciates fx portion of each BSi as much as the fx shock in each time bucket before applying the corresponding stress coefficient assuming that its fraction to the total outstanding balance (TL+fx) at the beginning is uniform through all time buckets. [12]

The purpose hereby is to use the estimated values of β's in order to predict the future percentage changes in the total sum of balance sheet items during q (stress parameters) when a shock is applied to GDP and fx. The implicit assumption is that all sample banks will uniformly respond to the shocks as an average Turkish bank with respect to each and every stress parameter. Thus, each bank's stress

9 Stressed 50% more than quoted shares by the author's hypothetical expectation.

10 Percentage changes are not annualized for any variable. TL hereby depreciates against a basket of 60% USD and 40% EUR which is the case for fx denominated accounts of the aggregated TBI balance sheet on average.

11 Starting right after the end of the 2001 local financial crisis.

12 With one single exemption only for the loans for which the aggregated TBI data by BRSA suggests 84% of fx denominated loans have a maturity longer than one year. Then I made the simplest assumption that 16% of fx denominated loans amortize equally during the first three time buckets (until the end of one year) and so as the remaining 84% in the last two buckets (longer than one year).

coefficient for its any balance sheet item during a time bucket will be just as much as its stress parameter requires (but numerically not the same and even much larger by definition) for that bucket such that the nominal change over the maturing amount during a bucket caused by the coefficient equals the nominal change if the parameter was applied to the sum of all remaining buckets (via parameter). Only if a balance sheet item's total cash in/out flow during a time bucket (including transferring amounts from the previous bucket in the waterfall model) is not large enough (as required by the stress parameter) then it fully materializes and the corresponding stress coefficient takes the value of 0% for assets and 100% for liabilities. Nonetheless, stress coefficient for a given balance sheet item is unique for each bank unlike to others in Table-1 that is uniform for all banks. Fact of the matter is stress parameters are one but the composition of banks' balance sheets and cash flows aren't. When the first equitation is rewritten to estimate the changes in %Δ(BSi)q during two relevant periods of the framework (0-3 months and 3-12 months) separately, I get the following:

$$\textbf{(2)}\ \%\Delta(BSi)_{q1} = \beta0 + \beta1\ \%\Delta(GDP)_{q1} + \beta2\ \%\Delta(FX)_{q1} + \beta3\ \%\Delta(L1.BSi)_{q1}$$

$$\textbf{(3)}\ \%\Delta(BSi)_{q234} = \beta0 + \beta1\ \%\Delta(GDP)_{q234} + \beta2\ \%\Delta(GDP)_{q1} + \beta3\ \%\Delta(FX)_{q234} + \beta4\ \%\Delta(FX)_{q1} + \beta5\ \%\Delta(L1.BSi)_{q234}$$

whereas q1 and q234 stand for the first and the last three quarters of the yearlong stress respectively.

The magnitudes of these shocks to be applied in the regressions are given in Table-3 for q1 and q234 periods. These figures are derived from real data between 2002Q4 and 2019Q3. They're based on the assumption that the biggest quarterly shocks ever will be followed by the worst three quarterly shocks ever.

Table-3: Shocks Applied to GDP and FX (not annualized) in the First Approach

Magnitude of the shock (%)	**↓ During the ↓**		**Cumulative shock in four consecutive quarters**
	first quarter of the stress (q1)	**last three quarters of the stress (q234)**	
GDP	-4.28	-7.22	-11.19
FX rate	+32.53	+58.09	+109.52

Selected balance sheet items are as follows: i=1, BS1= Total loans, i=2, BS2= Total deposits, i=3, BS3= Funds borrowed from other financial institutions, i=4, BS4= Securities issued, i=5, BS5= Due from banks, i=6, BS6= Money market placements, i=7, BS7= Money market funds. Omitted items (e.g. other assets and other liabilities) on both sides of the balance sheet altogether constitute only 6% and 10% of the sample banks' total assets and total liabilities respectively on average and they are not taken into account in the framework.

Table-4 and Table-5 present the base specifications of the second and third equations respectively for three of the BSi's (i=1,2,3) for which GDP and fx explanatory variables are significant at least at 10% level in both tables. Remaining four BSi's that stay out (i=4,5,6,7) will later be subject to the second approach.

Table-4: Quarterly Impact of Changes in the GDP and FX on Turkish Banks' Selected Balance Sheet Items

Table-4 describes the baseline estimations of the impact of GDP and FX rate on Turkish banks' three balance sheet items (BSi, i=1,2,3) as given in the second equation. I denote 1%, 5% and 10% significance levels with ***, ** and *, respectively. The t-statistics are presented in parentheses under the coefficients.

Dependent var.→ Regressors↓	%Δ(BS1)*q1*	%Δ(BS2)*q1*	%Δ(BS3)*q1*
%Δ(GDP)*q1*	0.743*** (3.81)	0.361*** (2.68)	1.443*** (4.16)
%Δ(FX)*q1*	-0.093* (-1.91)	-0.169*** (-4.66)	-0.146 (-1.41)
%Δ(L1.BSi)*q1*	0.561*** (5.44)	0.183 (1.12)	0.362*** (3.71)
Constant	1.520*** (2.76)	3.032*** (5.92)	0.439 (0.55)
N. of Obs.	66	66	66
F-stat	20.87	7.48	14.13
R^2	0.49	0.22	0.34

Table-4 and Table-5 use aggregated quarterly balance sheet data of the TBI derived from data query system of the BAT from 2002Q4 [13] to 2019Q3. Both tables show that a decrease in GDP and an increase in fx are associated with a decline in the balance sheet accounts. This deleveraging impact is indeed in line with the expectations since banks typically deleverage after the shocks.

Table-5: Three Quarterly Impact of Changes in the GDP and FX on Turkish Banks' Selected Balance Sheet Items

Table-5 describes the baseline estimations of the impact of GDP and FX rate on Turkish banks' three balance sheet items (BSi, i=1,2,3) as given in the third equation whereas insignificant %Δ(GDP)*q1* is omitted. "D1" stands for "first difference operator" that remedies non-stationarity. I denote 1%, 5% and 10% significance levels with ***, ** and *, respectively. The t-statistics are presented in parentheses under the coefficients.

Dependent var.→ Regressors↓	%Δ(BS1)*q234*	%Δ(BS2)*q234*	D1.%Δ(BS3)*q234*
%Δ(GDP)*q234*	0.687*** (5.08)	0.282** (2.55)	0.683*** (2.87)
%Δ(FX)*q234*	-0.160*** (-3.18)	-0.163*** (-4.98)	-0.333*** (-4.53)
%Δ(FX)*q1*	-0.219*** (-3.28)	-0.091* (-1.71)	-0.181 (-1.33)
%Δ(L1.BSi)*q234*	0.751*** (9.47)	0.615*** (7.83)	-0.262 (-1.66)
Constant	2.984** (2.08)	4.529*** (3.85)	-0.885 (-0.61)

13 Starting right after the end of the 2001 local crisis.

N. of Obs.	63	63	62
F-stat	57.95	44.26	8.94
R^2	0.88	0.76	0.31

Table-6 shows the estimations of the real percentage changes in the selected balance sheet items (i=1,2,3) for two time buckets (q1 and q234) when the shocks in Table-3 and βs from Table-4 and Table-5 are plugged into the second and third equations. These econometric predicted values at 1% level are then given within the intervals of confidence and prediction separately. The second approach, on the other hand, looks into the min/max real changes (during the same period as the first one) in the remaining balance sheet accounts (i=4,5,6,7) regardless of the search for a link to an underlying shock in the very same table. These min/max values are also given for the first three i's for information only. Table-6 compares the findings per each balance sheet item and ultimately assigns one of them as a stress parameter to each stress scenario (adverse and severely adverse) for both of q1 and q234 periods.

Table-6: Stress Parameters for the Balance Sheet Items (i's) Throughout q1 and q234 Periods

Balance sheet item (i:number, A/L: asset or liability, F: fraction as a percent [14])			**Changes (%) in the outstanding balances of i's during q1 period**							
			Econometric predicted values at 1% level				**Historical real figures**		**Assigned stress parameter**	
			Confidence interval		**Prediction interval**		**Min**	**Max**	**Stress scenario**	
i	**A/L**	**F**	**Low**	**Up**	**Low**	**Up**			**Adverse**	**Severely adverse**
1	A	61	-9.43	1.34	-14.30	6.21	-4.36	18.29	6.21	
2	L	78	-8.60	2.25	-13.49	7.14	-4.21	20.69	-8.60	-13.49
3	L	7	-22.03	-1.94	-31.04	7.06	-11.92	27.20	-22.03	-31.04
4	L	3	n/a	n/a	n/a	n/a	-10.32 [15]	88.16§§§§	-2.90 [16]	-10.32
5	A	7	n/a	n/a	n/a	n/a	-44.20	53.46	-53.80 [17]	
6	A	1	n/a	n/a	n/a	n/a	-75.77	1945	-100	-75.77
7	L	6	n/a	n/a	n/a	n/a	-30.42	80.52	-9.26*****	-30.42
i	**A/L**	**F**	**Changes (%) in the outstanding balances of i's during q234 period**							
1	A	64	-33.07	-14.80	-39.48	-8.40	-7.38	50.80	-8.40	
2	L	69	-19.03	-3.69	-24.20	1.49	-2.33	37.12	-19.03	-24.20

14 Fraction of the total ST amount of the given balance sheet item to the total ST assets or liabilities (first one for A's and the latter for L's) on average for the sample banks at the beginning of each period (q1 and q234). It shows the relative importance of each item in the set up since the stress test results are more sensitive to larger ones in the ST. As such, "money market placements (i=6)" can't change the survival horizons even by a single day on average in the severely adverse scenario even if its parameter in the q234 period was decreased to 100% given its extremely low fraction.

15 This account was too small even at the aggregated level in the TBI before 2006Q4 and therefore fluctuations were huge. Presented figures are those observed since then.

16 12.5% percentile figures.

17 Only Garantibank discloses encumbered amount for this balance sheet item which is 46.2% of the total in 2019Q3 meaning 53.8% of it is available to withdraw at the maximum. Once fully consumed, nothing is left to the next time bucket anymore. These figures are used for all sample banks instead of historical ones.

3	L	8	-70.19	-27.00	-79.84	-25.08	-24.02	75.36	-70.19	-79.84
4	L	3	n/a	n/a	n/a	n/a	-17.84§§§§	347.24§§§§	-8.08*****	-17.84
5	A	5	n/a	n/a	n/a	n/a	– 22.18	110.10	0†††††	
6	A	0.02	n/a	n/a	n/a	n/a	-88.49	1695	-100	-88.49
7	L	5	n/a	n/a	n/a	n/a	-36.91	118.61	-8.23*****	-36.91

From a liquidity stress point of view, historical maximum values should have been preferred for the assets of the second approach (i=5,6) since they could then not generate cash anymore and amplify the stress. However, as mentioned earlier, banks typically deleverage during stress. Therefore, minimum values are preferred instead for the sake of plausibility. It should also be noted that stress parameters of the q1 period address the corresponding stress coefficients of initial two time buckets (up to one month and one to three months) in Table-1. For that reason, these parameters are distributed to those two buckets proportionally. Period q234 of the parameters and third (last) time bucket (3-12 months) of the coefficients exactly match. Additionally, coefficients are common for both stress scenarios applying to the parameters. When Table-2 and Table-6 are jointly taken into account, stressed items of the balance sheet (either directly by the coefficients or implicitly by the parameters) account for;

- 116% and 93% of the sample banks' total short term assets and total short term liabilities, or
- 56% and 78% of the sample banks' total assets and total liabilities.

on average respectively [18]. Any other asset or liability is not stressed and thus they don't originate any cash in/out flow. Given the yearlong horizon of the scenario, aggregated figures for the stressed items (116% and 93%) suggest that both sides of the sample banks' balance sheets are subject to the stress to a very large extent. Besides, contingent claims are stressed, too. Next chapter will show another extent (up to 365 days) to which each bank can survive that stress given its common GDP&fx shocks and coefficients&parameters throughout a year.

4. Results

The framework applies two baseline stress scenarios (adverse and severely adverse) to the sample banks. I also constructed three alternative scenarios to each of them based on hypothetical reactions of the CBRT as lender of last resort which update some coefficients in Table-2. CBRT one by one i) provides unlimited liquidity without any haircut over market prices so that financial assets don't lose extra value due to fire sales anymore, ii) releases all mandatory reserves at the end of the first time bucket, and iii) conducts the first and second reactions simultaneously. I suggest these three reactions are extreme but predictable boundaries of the CBRT given Article 52 of the law on the bank regulating open market operations (CBRT, 2001, 18). Survival horizons with and without any CBRT reactions are shown in Table-7 for each stress scenario separately:

18 Except cash in Table-2 because it's not stressed. All short term assets and liabilities are accounted for. Counterbalancing capacity assets whose original maturity is longer than one year are also included since they're monetized earlier than one year. This also justifies 116%.

Table-7: Survival Horizons (1≤number of days≤365) for the Sample Banks

Adverse stress scenario					
Bank	**Baseline**	**CBRT Reaction-1**	**CBRT Reaction-2**	**CBRT Reaction-3**	***Mean***
Ziraatbank	54	58	88	103	***76***
İşbank	195	216	256	279	***237***
Halkbank	204	234	302	334	***269***
Garantibank	244	265	333	365	***302***
Vakıfbank	161	185	204	229	***195***
YKbank	201	218	256	272	***237***
Akbank	169	189	286	310	***239***
Mean (all)	***175***	***195***	***246***	***270***	***222***
Mean (all except Ziraatbank)	***196***	***218***	***273***	***298***	***246***
Severely adverse stress scenario					
Bank	**Baseline**	**CBRT Reaction-1**	**CBRT Reaction-2**	**CBRT Reaction-3**	***Mean***
Ziraatbank	43	46	66	69	***56***
İşbank	138	155	190	209	***173***
Halkbank	89	157	198	224	***167***
Garantibank	154	170	235	253	***203***
Vakıfbank	90	121	137	159	***127***
YKbank	135	148	188	202	***168***
Akbank	118	133	223	243	***179***
Mean (all)	***110***	***133***	***177***	***194***	***153***
Mean (all except Ziraatbank)	***121***	***147***	***195***	***215***	***170***

As seen in Table-7, there are eight narratives in total including one baseline plus three CBRT reactions for each of two scenarios. The survival periods are 175 and 110 days on average in the adverse and severely adverse baseline scenarios respectively. They increase up to 222 and 153 days when three CBRT reactions are introduced one after one.

Table-8 starts testing the hypothesis of the paper by checking whether each bank meets both of the Basel III ratios prior to the stress or not. If yes, then it controls if the bank passes any of the stress test scenarios including supportive CBRT reactions to the baselines. After all, if a bank cannot pass even a single test while meeting both of LCR and NSFR ex-ante; we could then conclude the failing bank(s) and their regulator in Turkey should implement the framework as a complementary local tool to the global Basel III liquidity metrics.

Table-8: Hypothesis Testing

Bank	**LCR**	**NSFR proxy**	**Meets both ex-stress?**	**Passed any of the eight stress test scenarios including CBRT reactions?**	**Meets both of LCR and NSFR ex-stress but couldn't pass a single stress test scenario?**
	%		**YES or NO**	**YES (scenario name) or NO**	**YES or NO (explain)**
Ziraatbank	126	113	YES	NO	***YES***

İşbank	174	127	YES	NO	***YES***
Halkbank	117		***NO***	NO	NO (fails NSFR ex-stress)
Garantibank	233	142	YES	***YES*** (CBRT reaction-3 to the adverse baseline)	NO (passes a single scenario post-stress)
Vakıfbank	133	106	YES	NO	***YES***
YKbank	176	108	YES	NO	***YES***
Akbank	188	111	YES	NO	***YES***

Table-8 shows that Basel III liquidity metrics compliant banks ex-stress (all except Halkbank) fail under each of the eight scenarios post-stress (except Garantibank in CBRT reaction-3 to the adverse baseline). Higher the number of YES's in the last column more robustly we could confirm the hypothesis. Halkbank's NO stems from the fact that its NSFR was already 13% shy of the threshold ex-stress and therefore we may reasonably assume it doesn't disprove the hypothesis. It's only Garantibank's NO to be able to do so since it manages to pass at least a single scenario post-stress. However, that's nothing but the most favourable of the eight scenarios (CBRT reaction-3 to the adverse baseline) including extremely supportive reactions of the CBRT to the milder baseline scenario.

Conclusion

This paper is the first one that has revealed the survival horizons of banks after a liquidity stress test and, in particular, the results of any stress test in the TBI at the institutional level in both. It gauges the extent (in number of days from 1 to 365) to which seven biggest Turkish banks can settle their obligations with immediacy under a yearlong atrocious turmoil. As such, it bridges the gap between LCR and NSFR that focus on time horizons up to 30 days and beyond one year respectively. It also introduces a new approach to liquidity stress testing based on cash (in/out) flows. Nevertheless, the framework has its own limitations deriving mostly from adherence to selected scenario design and reliance on the public data. Yet, authorities can easily overcome the latter given their continuous access to confidential and granular bank data. For the first one, stress testers can employ various scenarios simultaneously in tandem with expert judgment on the potential determinants of a country-specific yearlong liquidity crisis. By way of alternative, the coefficients and parameters of the framework might be kept in line with the LCR calibration that could stretch the outer scope of LCR from 30 to 365 days.

This study has identified mean survival period for seven biggest Turkish banks (110 days) is somewhat close to that of a random universal bank (almost 90 days) in (Schmieder et al., 2012, 30). Unfortunately, existing literature doesn't provide any other survival horizon benchmarks for comparison neither on sector averages nor at the institutional level. Despite the differences among their underlying stress scenarios, findings of these two studies clearly indicate that the average Turkish bank is not any different than its universal peer when it comes to survival under a medium-term liquidity stress. In connection with the fact that aforementioned survival horizons (110 and 90 days) are somewhere between the outer scopes of short sighted LCR (up to 30 days) and long-term NSFR (beyond one year), a yearlong liquidity stress test would be worthwhile for all stakeholders. It has been actually being applied by the Dutch Central Bank since June 2017 whereas the survival horizon is expected to be not shorter than 180 days. This could also help Turkish banks and regulators give up their over-reliance on LCR in liquidity stress testing. As a matter of fact, results are in tune with all sample banks' Basel III compliant LCR's (LCR>100%) since none of the survival horizons is shorter than 30 days in Table-7. However, it's as short as 43 days for Ziraatbank in the severely adverse baseline scenario providing insights for if not confirming the hypothesis, then partially substantiating it.

The second major finding was that seven biggest Turkish banks are all vulnerable to the given liquidity shocks but to different extents. Ziraatbank's survival horizons are so short that the bank can't keep up even until half way through the stress in any of the eight narratives notwithstanding CBRT reactions. The bank relies on short-term money market funds rather than relatively longer-term funding from other wholesale channels (unlike other sample banks) and its current level of asset encumbrance puts its liquidity metrics at jeopardy. Other six sample banks, on the other hand, survive much longer on average (196 days versus only 54 days for Ziraatbank) in the adverse baseline scenario. However, this measure shrinks to 121 days in the severely adverse one in which private banks outperform their state-owned peers. Given the survival horizons for each bank, only Garantibank manages to survive till the end of the yearlong stress that was achievable only in the third reaction of CBRT to the baseline adverse scenario which is by definition the most favorable one among eight cases. Other than that single exemption, banks cannot see the end of the yearlong stress even benefiting from CBRT reactions. If CBRT was to accept loans as collateral to provide unlimited liquidity in the framework, only then all banks could survive in a hypothetical CBRT reaction-4 case. However, the current legal framework doesn't allow that neither the consequences of such a monetary expansion would be ideal than morally and practically destructive.

If the benchmark for success was defined as meeting the minimum 180 days survival criteria of the DNB and the Bank of Canada, then banks are mostly on the safe side with a modest and strong aid from CBRT in the adverse and severely adverse scenarios respectively (again excluding Ziraatbank) yet none of them succeeds in the severely adverse baseline one which is the toughest even if CBRT reaction-1 is attached. Four banks (İşbank, Halkbank, Garantibank, YKbank) survive 180 days at six of eight times on the good side whereas Vakıfbank can only three times and Ziraatbank fails at all on the other. Although Akbank isn't one of top four above (passes the test five times), it comes in the third place (after Garantibank and Halkbank) in terms of survival periods on average because it benefits the second most (after Halkbank) from CBRT reactions. When the benchmark is further stretched to nine months, then Vakıfbank joins Ziraatbank in failing all eight cases whereas the most successful banks (Garantibank, Akbank, Halkbank) can pass only two of them which are not surprisingly the most favorable two adverse scenario ones.

Turkish banks need to find more stable and longer-term sources of funding to support loan growth and they're better off having some extra arsenal in their cash stocks until then also taking tapering of the quantitative easing policy across the globe into consideration. That being said, sample banks could indeed avoid a liquidity shortfall in the set up if they had preferred; diminishing their ex-stress LTD ratios from 112% on average to 92% and 80% in the adverse and severely adverse scenarios respectively and investing the proceedings rather in cash, or funding themselves at least as much as the liquidity shortfall they meet in each narrative more either by any liability that doesn't mature earlier than a year or equity.

The results also reveal that Turkish banks shouldn't rely solely on their Basel III complaint liquidity metrics, either. Although they have LCR and NSFR ratios well above 100% (except Halkbank's NSFR only 13% shy of the threshold), only a single bank and only for once (Garantibank in CBRT reaction-3 to the adverse baseline) can pass one of the eight stress tests. Thus, this framework could be a complementary local tool to the global Basel III liquidity regulation anywhere (if adapted locally by means of country-specific stress scenarios/parameters/coefficients while keeping the methodology constant) since almost all banks fail (even with aids from the central bank) in the Turkish episode while already complying with both of LCR and NSFR. Last but not least, the dynamic framework contributes to both predicting and understanding the extent of future fragility to a possible liquidity shortfall next to the static liquidity ratios from different perspectives. For instance, Halkbank apparently comes last for its five liquidity ratios prior to the stress yet its survival horizons are the second best in the adverse scenario but not that comfortable anymore in the severely adverse one.

After all, the regulator can ask many helpful questions based on the framework and its results as the following: Are the results satisfactory? If not, what are the common or per se vulnerabilities and how would the banks be incentivized to keep enough liquidity without relying on unorthodox CBRT reactions? Irrespective of the success associated with the results, why is the order of sample banks by survival horizon not exactly the same in two different stress scenarios? Why and how do the CBRT reactions significantly extend the baseline survival horizons but to different extents for each bank? This paper intends to open the door to those questions for both the bank managements and the regulators initially in Turkey but also elsewhere insofar as it could locally be adapted. It is also recommended that further research be undertaken in the following areas:

- Seeking to answers to the research questions above in the last paragraph from different stakeholders' point of view,

- Localising the Turkish portraiture of the framework's stress scenarios at the outset while keeping its universal methodology constant for any other banking industry,

- Replicating the framework by replacing the stress coefficients and parameters by LCR calibration,

- Establishing links between liquidity and solvency risks.

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