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Abstract: *The paper's aim is to contribute to the debate on the impact of stress test on banking system liquidity. Due to the theoretical character of the problem, the used methodology is a set of results from research and theoretical works about how the attempts to increase system solvency could lead into a greater lack of liquidity.*

Introduction

After World War I, Moulton (1918a, pp. 484-508; 1918b, pp. 638-663; 1918c, 705-731) explained his *shiftability* theory, in which, under normal conditions, liquidity is not as much a maturity problem as an assets transfer problem to other banks and 'raise cash'. If a bank with problems can get help from other better off, is not so necessary to meet deadlines-appeal. Thus, banks rely on assets that can be transferred to other banks before maturity to meet its cash requirements (Summers 1975). However, in August 2007, the subprime crisis created serious liquidity problems for the interbank market. Banks, unsure about the depth of the problems on other banks' balance sheets, were simply unwilling to lend to each other without substantial

accommodations for counterparty risks (Brunetti et al. 2011, 2053-2083). So, a set of measures was necessary to establish which banks and how deeply had been damaged by the crisis, and to ensure transparency in the bank data provided.

In this context, supervisors brought stress testing up as the only way out from the confidence crisis that underlies the liquidity crisis consequence of a prior regulatory crisis. The stress test's objectives were laudable: to strengthen the financial system by forcing banks to hold adequate equity and to convince markets about the solvency of banks. Unfortunately, situations such as the Irish banks, which approved the 2010's stress tests and forced the country to be rescued a few months later, and recent banking bailouts (e.g. Dexia, Bankia) led to a criticism in media about the tests rigour (The Financial Times 2011; Finch et al. 2011; Burke 2011). In this sense, half a decade since the crisis started, a lack of confidence over banks information and liquidity crisis in markets there remains. This leads us to wonder whether the stress tests really have favoured or have harmed (by an unwanted feedback effect) the lack of liquidity in the banking market. Furthermore, we wonder whether elements such as setting a minimum reference capital or, even more, the uncertainty about how much this minimum will have to be, is acting as real minimum that prevents money from flowing. Despite the fact that literature on bank regulatory practices is copious, analysts disagree as to whether the imposition of a minimum capital requirement actually reduces risk-taking incentives (Blum 1999). Chortareas et al. (2012, pp. 292-302) provides an investigation of the impact of regulatory and supervisory approaches on bank efficiency in the European Union (EU) during the period 2000-2008. They also point a number of studies (Rochet 1992, pp. 1137-1170; Gorton, Winton 1995; Hovakimian, Kane 2000, pp. 451-468), prior to crisis, which have emphasized the capital standards role in preventing bank failure. Holmstrom and Tirole (1998, pp. 1-40) focus on the lack of sufficient liquidity in the private sector as a rationale for government intervention. Rime (2001, pp. 789-805) claimed that the banks which find themselves close to the minimum regulatory capital requirement tend to increase their ratio of capital to risk-weighted assets.

Therefore, the aim of this paper is to contribute to the existing debate on the impact of stress test on banking system liquidity. Due to the theoretical character of the problem, the used methodology is a set of results from research and theoretical works. The remainder of our article is organized as follows. Section 2 presents the main stress tests done, and their main criticisms. Section 3 shows how banks may obtain liquidity and which trouble they could face in a crisis time; it reopens the old debate about whether regulatory structures and styles of supervision should be adjusted, through question whether regulators and supervisors could react in other way than they

did; it also presents how a liquidity crisis may cause contagion by undermining the confidence in other banks, because under uncertain conditions banks use the most pessimistic probability assessments. Finally, Section 4 offers some concluding remarks, limitations and further lines to work. After that, we show the references used in this paper.

Stress Tests

The Stress testing is an important risk management tool that is used to determine the stability of a given system or entity. This tool implies an evaluation beyond normal operational capacity, and an observation of its results. In the financial literature, the stress tests have traditionally referred only to an entity assets or portfolios, but more recently through the Basel II capital adequacy framework, have also been applied to the banks' overall activity, as well as financial systems in general (BCBS 2009).

Furthermore, stress testing alerts bank management to adverse unexpected outcomes related to a variety of risks and provides an indication of how much capital might be needed to absorb losses should large shocks occur. As noted above, stress testing is a tool that supplements other risk management approaches and measures. It plays a particularly important role in: providing forward-looking assessments of risk; overcoming limitations of models and historical data; supporting internal and external communication; feeding into capital and liquidity planning procedures; informing the setting of a banks' risk tolerance; facilitating the development of risk mitigation or contingency plans across a range of stressed conditions. However, the financial crisis has revealed a weakness in organizational aspects of stress testing programs, because at some banks it was performed mainly as an isolated exercise by the risk function with little interaction with other business areas. So, prior to crisis, most banks did not perform stress tests that took a comprehensive firm wide perspective across risks. Even if they did, the stress tests were insufficient in identifying and aggregating risks. As a result, banks did not have a comprehensive view across credit, market and liquidity risks of their various businesses (BCBS 2009). In this way, during recent years we have attended the presentation and implementation of several stress tests both in the United States (US) and here in Europe. Table 1 shows the main characteristics of the four exercises and highlights the amount of information disclosed to investors.

While the United States stress tests and the first one carried out in Europe in 2010 only released a few key figures for each bank, the 2011 EU test was significantly more comprehensive, as it provided up to 3,400 data items for each bank; this included a breakdown of sovereign bonds and other credit

exposures by country and duration bands (Petrella, Resti 2012). Unfortunately, in Europe there was a lot of criticism about the way in which test had been carried out and its outcomes (Saraiva, Biggadike 2010).

Table 1. Stress Test Exercises in de United States and European Union

Exercise	Announce- ment date	Results date	Banks cov- ered	N. items per bank	Minimum capital tar- get(s)	Capital shortfalls found
2009 Supervi- sory Capital Assessment Program (SCAP) by Federal Re- serve, FDIC, OCC, OTS	Feb.10, 2009	May 7, 2009	19 domestic bank holding companies, covering 2/3 of the assets in the US banking system	17	Common Tier 1 at 4% Tier 1 at 6%	10 banks, USD 75 bn.
2010 EU Su- pervisory Capital Exer- cise by the Committee of European Banking Su- pervisors	Dec.2, 2009	July 23, 2010	91 banks, covering 65% of the assets in the EU banking system and at least 50% for country	27	Tier 1 at 6%	7 banks (+17 “near fail”), €3.5 bn.
2011 EU Stress Test by the European Banking Au- thority	Jan.12, 2011	July 15, 2011	90 banks, covering 65% assets in the EU banking system and at least 50% for country	3,456	Core Tier 1 at 5%	8 banks (+16 “near fail”), €2.5 bn.
2012 Compre- hensive Capital Analysis and Review (CCAR) by Federal Re- serve	Nov.22, 2011	March 13, 2012	19 companies participating in the 2009 SCAP	41	Common Tier 1 at 5% lev- erage at 3-4%	4 (short- fall not disclosed)

Source: Petrella, Resti (2012).

Historical statistical relationships, such as correlations, proved to be unreliable once actual events started to unfold. Even more, there were media suggestions that the authorities preferred a stronger stress test but were constrained by political and banking pressures because bankers argued that given the uncertainty in money markets, a disclosure of detailed information would exacerbate the crisis (Wilson 2011). Based on these contradictions, Cardinali and Nordmark (2011) studied the stock market reaction to the 2010 and 2011 EU stress tests by looking at for tested and untested banks. Their main findings were the following. First, the 2010 results were relatively uninformative to investors. Secondly, the announcement of the methodology to be used in 2011 triggered negative cumulative abnormal returns for stress-tested banks, while non-tested institutions were roughly unaffected. Then, it is possible to question why stress tests did not show properly the real risk on investments that was trying to set. A potential answer would be that the choice and construction of stress tests must apply criteria of reasonableness.

But these criteria are necessarily subjective, since the risks to consider are generally relied on historical precedent and not on a virtually endless host of improbable reasons (Abbink 2011, pp. 421-434).

Facing criticism about the rigour of the tests (The Financial Times 2011; Finch et al. 2011; Burke 2011), the European Banking Authority (EBA) (2011) pointed to the huge financial information disclosed in the last trial done (91 banks and more than 3,200 data points per each). However these data were filled with anomalies, mainly relating to aggregation of data and omissions. Thus, there were risks that were not covered in sufficient detail in those stress tests. For example, in sovereign bonds held in the banks' books a credit rating downgrade of the issuer was specified in the test. For Greek bonds, this translated into a stress scenario of 15% loss, which was below their market prices (21%). Similar problems existed with the Irish and Portuguese bonds, where market prices implied losses around 30-40%; and for Spanish and Italian bonds, where the losses were below the levels seen in trading. So the test results significantly underestimated the losses if Greece, Ireland and Portugal were default and the Spain and Italy experienced a serious financial pressure as they did.

Other stress elements were also insufficiently tested. The modest drop in growth and rise in unemployment contrasted with the sharp contraction in economic activity and employment seen in the peripheral European economies. Given the stated desire of the EU to bring public finances and budget deficits in line with guidelines, the risk of a long period of stagnation (low growth and high unemployment) and its effect on loan losses could not be discounted. The assumption of a 15% fall in stock prices could understate the potential volatility. The 10-17% fall in property prices looked benign due to, for example, Spanish property prices, which were still highly valued.

This overvaluation was exacerbated by unwillingness on the part of lenders to take possession of and sell assets securing loans, which would bring losses (Das 2011).

Furthermore, by a quirk of fate during the 2011's test, Helaba German bank was withdrawn to avoid public failure (BBC 2011). Another good example of how wrong stress testing was could be seen in Allied Irish Banks Plc and Bank of Ireland Plc, which passed the EU's examinations in 2010, while Anglo Irish Bank Corp. wasn't tested. Later that year, a liquidity shortfall prompts EU governments and the International Monetary Fund to agree on an 85 billion euro bailout for the country.

In the same way, Dexia got a clean bill of health in 2011 EU's stress tests and less than three months after that, France and Belgium considered a second bailout. Here, the answer seems obvious. Dexia was able to exclude the paper losses on its sovereign bonds to calculate its capital ratios in that test. Meanwhile, Bankia problem was that its core (Caja Madrid, Bancaja) was drowned by the crisis because the real estate bubble explosion caught squarely.

Bankia has been observed in international markets as the extreme case of a general situation in the Spanish financial system, highly burdened by the exposure to the real estate sector because of reckless loans and investments held for years.

As a consequence, cases such as the Irish banking system, Dexia or Bankia have brought about the accumulation of inaccuracies in the stress tests, as well as influences or pressures suspicion have created a crisis of confidence, hard to restore without sufficient honesty signs from supervisory authorities. Nowadays, the financial sector, affected by that lack of confidence is unable to perform its natural function: to provide credit to the economy.

Liquidity Crisis

Liquidity is a core concept inside current economic problems, which is commonly defined as the ratio between loans and deposits. It shows how much a bank has used its lending capacity. However, this ratio, without further data, could hide doubtful quality assets because, as it is defined, all loans are short-term and self-liquidating. Then, a comprehensive study of bank liquidity should include several ratios, one for each maturity category. Therefore, if banks' debts mature before their credit does, they will not fulfill its obligations unless they obtain money. Hence, it is possible to have a solvent heritage, being in an illiquidity status or economic bankruptcy, since it is also necessary the conversion in cash of the values of its assets

(including receivables). This means that banks are forced to sell their long-term loans to the Central Bank to ‘raise cash’ and meet its short-term debts. Another way for firms to generate liquidity is to sell assets. However, the level of liquidity can affect the value of these assets. Yet banks, once they start this process, are launching a vicious circle, in which falling liquidity reduces asset values, which, in turn, leads to lower liquidity, and so on (Elul 2008, pp. 13-22).

The illiquidity also imposes challenges to risk measurement from lack of correlation data for assets that do not mark frequently to market, that is assets such as real estate or private equity, which are illiquid by nature. So it is implausible that quantitative methods for ascribing an estimated volatility to assets can carry much conviction. It is even more so, when they are applied to assets that seldom mark-to-market at all, particularly when pricing mechanisms has become distorted (Abbink 2011, pp. 421-434).

Aikman et al. (2009) demonstrate how rising funding costs and liquidity concerns can amplify other sources of risk. Thus, in the Van den End’s (2010) liquidity stress-tester model, the second round feedback effects are determined by the number and size of reacting banks and the similarity of reactions. Contagion results from the effects of balance sheet adjustments on prices and volumes in the markets and funding channels where banks are exposed (Van den End 2011).

In conclusion, financial intermediaries serve to provide firms’ and investors’ liquidity needs, but during liquidity crises they fail to function properly. It is so because they accumulate liquidity as a way to avoid selling in the interbank market at fire sale prices. This reaction may cause contagion in cascades by undermining confidence in other banks, as Aikman et al. (2009) set.

Regulatory Crisis

‘Is the theory underlying our banking legislation wrong, or have our banks constantly been in a perilous condition, and is it because of investment loaning that we have had recurring financial disasters?’ This Moulton’s question (1918c, pp. 705-731) was asked nearly a century ago and still remains valid. Thereby, from early 1990’s onwards there has been a debate, both from academic and policy circles, about the ways in which regulatory structures and styles of supervision should be adjusted to face more complex financial institutions, more complicated financial products, and highly adaptive markets which tended to find ways around any given set of rules (Regling, Watson 2010). In this sense, Chortareas et al. (2012, pp. 292-302) allude to how regulation may interfere with the efficient operation of banks.

Thus, whenever regulation is implemented with the aim of restricting or limiting banks' activities, their business conduct and efficiency with which they operate are affected. This is because banks may react to a higher regulatory burden by engaging in more risky activities and invest in ways that circumvent regulation.

Hence, some authors had warned that the architecture for resolving problems within the European single financial market has been deficient. There was concern about the ability to manage liquidity or solvency difficulties. On the liquidity side, the worry focused on the absence of clear guidelines for implementing the EU lender of last resort function in situations when banks would experience problems. On the solvency side, the cares were the lack of clear arrangements and the resolution of cross-border banking crises (Pisani-Ferry, Sapir 2010, pp. 341-372). This debate was not conclusive and some countries decided to set up a separate unified financial regulator, while others preferred formulas that left banking supervision in the hands of the central bank. Thereupon, some countries shifted towards '*principles-based*' regulation which deemphasized specific rules that could be side-stepped; as well as some countries adopted even '*less intrusive*' approaches, sometimes described as '*light touch*' supervision. Then, to say that the EU was institutionally ill-prepared to manage a financial crisis, especially one involving systemic cross-border institutions, would certainly not be an overstatement. Even more, focused on risk analysis terms, regulators and supervisors were not entirely blind to the build-up of possible vulnerabilities. They were aware of risks in exposure to the property sector, if prices should fall steeply. But four key elements, among others, typically combined to dissuade them from taking forceful action to restrain the banks (Regling, Watson 2010):

1. They did not consider it their job to react to the macroeconomic component of the problems that were potentially building up. There was in any case no strong consensus among economists how much of the fall in global interest rates, the decline in risk premia, or the rise in local asset prices should be viewed as unsustainable.
2. Liquidity supervision (as opposed to solvency) had been off the core Basel agenda for decades; and few regulators performed stress tests that combined asset market with funding shocks. In the euro area, financial integration and interdependency were goals of policy, and the side-effects on vulnerability were not strongly emphasized.
3. It was unclear to many supervisors what instruments to use to counter macrofinancial risks. A few acted to limit loan-to-value ratios; increased reserve requirements, or imposed heavier provisioning as risks built up. But in a setting of strong cross-border competition, there was also a concern that such actions might just penalize locally owned banks.

4. Thus, many supervisors – faced with complex assets and operations, and with banks' ability to work around specific rules – moved to rely more on banks' own risk assessment systems and to supervise processes and principles, with some moving very far in the direction not just of '*principles-based*' but of '*light-touch*' supervision.

Finally, in order to understand why and what has been happening, it is necessary to realize that the banks have been historically protected by states against their creditors, basing on the principles of '*too many to fail*' (Acharya, Yorulmazer 2007, pp. 1-31) and '*too big to fail*'¹ (Freixas 1999; Goodhart, Huang 2000).

Under these two doctrines a bank can continue to operate if the State considers it, being outside the bankruptcy law applicable to any person or company. This banks' protection has helped them to ignore the basic principles of safety and liquidity, and has led to a mismatch between the maturities of balance's assets and liabilities. In fact, there were some banks and other financial institutions which engaged in lending practices that were dangerous in an '*old banking*' way. These practices did not require special supervisory imagination or moral courage to penalize. The failure of supervisors to act strongly against such practices is much harder to understand (Regling, Watson 2010).

Thereupon, all these capital adequacy rules might specify how much capital each bank should hold, but if such rules do not truly reflect the risks involved they could unintentionally induce banks to hold either too much or not enough capital. Insufficient capital increases the danger of bank failure while excessive capital imposes unnecessary costs on banks and their customers with adverse implications for the efficiency of the banking system (Chortareas et al. 2012, pp. 292-302).

Confidence Crisis

During any liquidity crises banks experience an investor confidence loss, making it difficult to raise further cash. If a bank has insufficient cash reserves, it could run into a vicious circle, where the bank cannot pay its debts

¹ The Financial Stability Board (2011) released a list of 29 banks worldwide that they considered as "*systemically important financial institutions*". Of the list, 17 are based in Europe, 8 in the U.S., and 4 in Asia: Bank of America, Bank of China, Bank of New York Mellon, Banque Populaire CdE, Barclays, BNP Paribas, Citigroup, Commerzbank, Credit Suisse, Deutsche Bank, Dexia, Goldman Sachs, Group Crédit Agricole, HSBC, ING Bank, JPMorgan Chase, Lloyds Banking Group, Mitsubishi UFJ FG, Mizuho FG, Morgan Stanley, Nordea, Royal Bank of Scotland, Santander, Société Générale, State Street, Sumitomo Mitsui FG, UBS, Unicredit Group, Wells Fargo.

because it has no funds, but cannot raise funds as its financial difficulties result in the downgrading of its debt. Furthermore, the actual vicious spiral between sovereign debt and banking crises has been compounded by the decision, first taken in Ireland and later followed in Spain's Bankia crisis, to shift the burden of rescues onto the public budget. Fears of a repeat of the post-Lehman disaster have been one reason; another has been pressure by creditor countries to spare their banks from any losses on their exposure (Micossi 2012). In this way, in Caballero and Krishnamurthy's model (2008, pp. 2195-2230), a sudden liquidity shock hits some firms in the economy and generates a need for borrowing. But those firms which had not been affected by this first shock grow concerned that they may be hit by the second shock, even though the second shock is very unlikely. The unaffected firms react by preemptively drawing down their own lines of credit. That is, they hoard liquidity. The result is that there is much less available for those firms that actually need liquidity because they have been hit by the first shock. Thus, they assume that market participants are uncertainty averse. In this sense, Ellsberg's paradox (1961, pp. 643-669) demonstrated that ambiguity influences decisions in a way that is incompatible with standard versions of rationality. Greater ambiguity could imply greater variability in outcomes, but variability can have a downside. So, a prudent agent could regard ambiguity as a tell-tale marker of high variability and decide accordingly. That is, when evaluating outcomes about which they are uncertain, they use the most pessimistic probability assessments. In particular, each participant overweights the probability that he will be among those hit by the second shock. This creates a desire to hoard liquidity against this unlikely shock.

For those reasons, half a decade after what is considered to have been the start of the credit crunch, the public are more disappointed with the banking sector than ever, as well as with regulators and supervisors who were unable to monitor the proper functioning of the banks in order to avoid the two recessions suffered by the economy since the beginning.

Conclusions

The depth and duration of the financial crisis has led many banks and supervisory authorities, as well as academic and media to question whether stress testing practices were sufficient, prior and after crisis. Also, it led us to question whether those tools were adequate to cope with rapidly changing circumstances. In particular, not only was the crisis far more severe in many respects than it was indicated by banks' stress testing results (BCBS 2009), but it was possibly compounded by an unwanted feedback effect, because of

weaknesses in stress testing practices resulting from reaction to the unfolded events. Nonetheless, stress tests convey information to the market that goes beyond the disclosure of more detailed data (Petrella, Resti 2012), and crisis has revealed serious flaws with relying solely on such an approach to restore confidence to the markets. Indeed, the effect was the opposite completely. At the most fundamental level, the tests assumed that risk is driven by a known and constant statistical process. Firstly, because given a long period of stability backward-looking historical information indicated benign conditions, so that these models did not pick up the possibility of severe shocks, nor the build up of vulnerabilities within the system. Secondly, the financial crisis has again shown that, especially in stressed conditions, risk characteristics can change rapidly as reactions by market participants within the system can induce feedback effects and lead to system-wide interactions. These effects could dramatically amplify initial shocks, as recent crisis have illustrated. Finally, extreme reactions occur rarely and might carry little weight in models that rely on historical data. It also means that they are hard to model quantitatively (BCBS 2009). For these reasons, banks underestimated the strong interlinkages between the lack of market liquidity and funding liquidity pressures which led to a lack of confidence in the main tool to restore the cited trust lost.

On the other hand, with the benefit of hindsight, a widely accepted lesson of the crisis is that '*intrusiveness*' into banks' risk management and governance had been set aside too lightly. A closer and intrusive supervision, unlike '*light touch*' regulation, could identify problems earlier and in some cases prevent or mitigate their effects (Regling, Watson 2010). So, experience has shown that changes of approach among supervisors allowed a build-up of vulnerabilities, even without the shock to liquidity that followed the Lehman Brothers failure; as the ongoing credit crisis has illustrated how increased funding costs and the closure of funding markets can trigger bank failure (Aikman et al. 2009). Likewise, as noted above, capital and liquidity standards affect bank lending behaviour and thereby the economy.

In conclusion, the stress-testing use as tool to recover the lost confidence in banking system as well as their supervisors could be questionable. Consequently, until the actual uncertainty does not become in risk again, through the confidence recovery cited, economic agents would consider the most unfavourable option as the most probable one, which would lead them to hoard liquidity, which prevents a proper capital flow.

Nonetheless, our investigations into this area are still ongoing and the present study is the first step towards enhancing our understanding of relationship between stress testing and liquidity crises linked to confidence crises and regulation crises. A further investigation seems desirable to avoid or mitigate a future similar situation.

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