Discussion of "Systemic Risk and the Solvency-Liquidity Nexus of Banks"*

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1. Introduction

The financial crisis of 2007–9 demonstrated the strong interactions between the solvency of institutions and liquidity problems in the financial system (see Paulson 2010, Bernanke 2013, and Geithner 2014 for the U.S. perspective). While the Federal Reserve began providing emergency liquidity to U.S. institutions in mid-2007, it took recapitalizations, via the stress tests in the spring of 2009, to decisively turn the crisis around.

Whereas the acquisition of Bear Stearns, the failure of Lehman Brothers, and the government's takeover of AIG were triggered by liquidity shortages, each of those institutions was ultimately in distress due to deeply rooted solvency problems, which were addressed by a combination of private- and public-sector actions.

Examining the shadow banking sector, Covitz, Liang, and Suarez (2013) document that the magnitude of runs on asset-backed commercial paper (ABCP) conduits was at least partially linked to the degree of credit distress of the asset collateral. Perhaps surprisingly, even banks with access to the discount window and deposit insurance experienced run-like dynamics (Brunnermeier 2009, Huang and Ratnovski 2011, and Iyer, Puri, and Ryan 2012).

Against this backdrop, Pierret's (this issue) study of the solvency-liquidity nexus of banks is very welcome. While an extensive theoretical literature has investigated the relative importance of

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liquidity and solvency for the determination of bank runs (Allen and Gale 1998, Rochet and Vives 2004, Diamond and Rajan 2005, and Morris and Shin 2008), surprisingly few empirical studies address the topic (for an exception, see Cornett et al. 2011).

Pierret's contributions are threefold. First, Pierret documents Granger causality between solvency and liquidity. Liquidity is measured by the difference between short-term debt and total assets, while solvency is measured by Acharya, Engle, and Richardson's (2012) *SRISK*. Hence, the measure of liquidity is a contemporaneous balance sheet measure, while *SRISK* is at least in part a forward-looking market-based measure. Higher *SRISK* measures a greater capital shortfall. The definition of *SRISK* is

$$SRISK_{it} = MV_{it}\{k(Lvg_{it} - 1) - (1 - k)(1 - LRMES_{it})\},$$

where MV is the market value of equity, Lvg is market leverage $(MV + \text{Debt})/MV$, and $LRMES$ is long-run marginal expected shortfall, a measure of firms' exposures to an aggregate shock.

Pierret shows that a shock to *SRISK*, increasing solvency risk, is followed by lower short-term debt: The interpretation is that the market limits the amount of short-term funding that a firm can receive when it becomes riskier (Pierret, this issue, table 1). Conversely, higher short-term debt Granger-causes higher *SRISK* (Pierret, this issue, appendix 3, available online). A firm with higher short-term debt is therefore more vulnerable to solvency, as measured by *SRISK*.

This first set of results is consistent with the notion that the liquidity management of firms and the market assessment of solvency are intertwined, hence the title of the paper, "Systemic Risk and the Solvency-Liquidity Nexus of Banks." There is an important asymmetry in the response of solvency to liquidity versus liquidity to solvency: While higher short-term debt Granger-causes more *SRISK*, more *SRISK* Granger-causes less short-term debt. The interpretation is that short-term debt makes firms fragile, while more fragility causes depositors to withdraw funding.

Pierret's second result concerns the impact of a capital shortfall on the solvency-liquidity nexus (Pierret, this issue, table 1, column 3). Firms with a capital shortfall experience a stronger reaction of *SRISK* to shocks in short-term debt. And, in the other direction,

firms with a capital shortfall experience a larger decline of short-term debt when *SRISK* unexpectedly increases. Both of the Granger-causality results are consistent with the notion that firms with a capital shortfall (high *SRISK*) are financially constrained.

SRISK is a composite indicator consisting of the market value of equity, market leverage, and long-run marginal expected shortfall. Pierret investigates which of the components of *SRISK* is most important for predicting the level of short-term debt (Pierret, this issue, table 3). Pierret shows that improvement in in-sample fit comes from the ratio of market capitalization to total assets (MV/TA), rather than from the long-run marginal expected shortfall ($LRMES$) or the quasi-market leverage (Lvg).

In addition to the three main results highlighted here, Pierret also shows that alternative measures of bank risk, including Adrian and Brunnermeier's (2010) systemic risk measure, CoVaR, as well as regulatory capital ratios, such as the tier 1 capital ratio, do not Granger-cause short-term debt (table 3). Furthermore, Pierret reports out-of-sample forecasting results (table 4).

The remainder of my discussion is structured as follows. First, I will address identification of shocks in Pierret's vector autoregressions. Next, I will discuss the policy relevance of the findings. Finally, I will make some comments regarding theory. The discussion ends with a conclusion in section 5.

2. Identification

Pierret uses Granger causality based on vector autoregressions to identify the solvency-liquidity nexus. Unfortunately, Granger causality is not true causality. It is a measure of temporal correlations. It can answer this question: When series x moves, does series y tend to follow? What it cannot answer is whether other factors might be moving both x and y. While vector autoregressions are powerful and useful tools, and Granger causality is a useful notion, these results must be interpreted with care.

In Pierret's application, the particular concern is that (co)movement of the solvency and liquidity measures over the sample period was due to shocks that are not truly exogenous to either solvency or liquidity. In particular, after the financial crisis, both solvency and liquidity were heavily impacted by policy changes.

Liquidity was particularly influenced by the Federal Reserve's asset purchase program, which resulted in a sharp increase in central bank reserves in the banking system and a corresponding increase in the deposits-to-assets ratio.

Solvency, on the other hand, was crucially influenced by the tightening of regulations, primarily through the supervisory stress tests. Hence the post-crisis trends in capital and liquidity were impacted importantly by changes in monetary and regulatory policies, and it is likely that the Granger-causality tests are picking up such changes in policy, as well as reactions to truly exogenous shocks.

Measurement of causality in the run-up to and eruption of the crisis is similarly subject to identification issues. For example, both solvency and liquidity had first-order exposures to banks' involvement in shadow banking activities. Banks that were involved in shadow banking increased their leverage covertly by moving risk onto the balance sheets of special-purpose vehicles that were ultimately backstopped by credit lines from the banks. Once the crisis erupted, many banks moved such shadow bank assets back onto their balance sheets, creating funding shortages since these assets were typically funded in unsecured interbank markets.

Due to the riskiness of the assets, solvency concerns were triggered around the same time as funding liquidity problems emerged. Hence a valuation shock to the assets in off-balance-sheet shadow bank vehicles caused both solvency and liquidity shocks, and the vector autoregression does not have enough information to disentangle the effects of these shocks from one another.

Of course, researchers in banking and corporate finance—and in applied microeconomics, more generally—have recognized such identification concerns. In recent years, the literature has shifted toward emphasizing plausibly exogenous variation in the empirical identification of causality.

In banking, Peek and Rosengren (2000) have used bank exposure to the Japanese real estate shock to causally identify the impact of loan supply shocks on economic activity. Ashcraft (2005) has used FDIC-induced closures of healthy bank branches due to the distress of the parent as exogenous variation to identify the impact of banking on regional real activity. Mian and Sufi (2009) have used cross-sectional information to identify the impact of lending in the run-up to the housing crisis on the severity of the downturn,

exploiting a differences-in-differences type of identification strategy. Agarwal et al. (2014) measure the impact of supervision on bank performance using exogenous variation in the supervisory schedule across agencies. Angrist and Pischke (2014) provide an overview of techniques in that field.

Ideally, Pierret would present an identification strategy that would allow her to identify exogenous shocks to solvency and liquidity, which would then have allowed her to trace out the nexus between solvency and liquidity in a causal manner. Of course, Pierret is not the only one to struggle with these issues and, to my knowledge, no paper since the crisis has come up with an instrument for the separate identification of liquidity and solvency shocks that could be readily used in the study. Exogenous shocks would have to be unanticipated by the banks, the shareholders of the banks, and the depositors of the banks.

But most shocks impact both solvency and liquidity directly, and there is very little variation in the data that isn't anticipated by somebody. Mian and Sufi's (2009) identification strategy, exploiting cross-sectional heterogeneity before and after the crisis, might suggest a way for Pierret to identify more plausibly causal relationships, compared with the current vector autoregression setup.

3. Policy Implications

The nexus between solvency and liquidity is of primary importance for monetary and regulatory policy. In fact, Pierret starts her paper by citing Federal Reserve Governor Daniel Tarullo's (2013) speech on financial stability, which explicitly discusses the interaction between solvency and liquidity.

Recently, the Federal Reserve proposed a rule that would include a capital charge proportional to the amount of short-term wholesale funding in the macroprudential GSIB surcharge (GSIB stands for global systemically important banking organizations).[1] If implemented, this framework would provide incentives for the largest U.S. banking organizations to hold substantially increased levels of

[1]See the Federal Reserve's announcement at http://www.federalreserve.gov/newsevents/press/bcreg/20141209a.htm and the Federal Register notice at http://www.gpo.gov/fdsys/pkg/FR-2014-12-18/pdf/2014-29330.pdf.

high-quality capital as a percentage of their risk-weighted assets, which would, in turn, encourage such firms to reduce their systemic footprint and lessen the threat that their failure would pose to overall financial stability.[2] This rule is currently only at the proposal stage and is not expected to be phased in until early 2019.

Pierret's work could potentially inform policymakers about the magnitudes of the interactions between solvency and liquidity fragility. In principle, the types of calculations that Pierret is undertaking could help determine the appropriate level of a capital surcharge for short-term wholesale funding. However, even if the identification issues discussed above could be resolved, additional aspects of the solvency-liquidity nexus would have to be taken into account.

First, the interrelation between solvency and liquidity fragility would be expected to vary as a function of the level of capital and liquidity regulation. What I really would like to have seen is a calculation that would answer the following: To what extent would a marginal increase in the capital requirement allow the relaxation of a liquidity requirement (or a liquidity backstop), keeping the overall level of fragility constant? Or, in reverse, to what extent would a government guarantee for runnable deposits allow a relaxation of capital requirements, keeping overall fragility constant? While the theoretical literature cited above might pin down a precise answer to such questions, the theoretical models are too abstract to be translated into policy. Hence a precise estimate of the substitutability of capital and liquidity would be very welcome. To date, we have no such concrete policy guidance.

Second, Pierret's investigations do not uncover the underlying economic frictions that give rise to the interrelatedness of solvency and liquidity problems. The theoretical literature proposes a number of possible channels, including coordination problems, fire-sale externalities, and network effects, among others. The cross-sectional information contained in Pierret's bank-level data could be helpful in pinning down different drivers of the solvency-liquidity nexus. For example, interaction terms with the fraction of wholesale funding

[2]U.S. banking organizations currently subject to the GSIB surcharge include Bank of America, Bank of New York Mellon, Citigroup, Goldman Sachs, JPMorgan Chase, Morgan Stanley, State Street, and Wells Fargo.

over total deposits, the degree of intrafinancial exposure, or the potential for fire-sale vulnerability[3] could be helpful in linking the interrelatedness of solvency and liquidity to specific economic mechanisms. In fact, the data suggest a very wide variety of asset allocations and funding profiles across banking organizations. For example, the banks that own large dealer subsidiaries have very different funding profiles compared with banks that engage mainly in traditional lending activities.

Third, Pierret's framework does not provide a link to aggregate vulnerability, or aggregate lending activity of banks. In the language of Adrian and Boyarchenko (2012), regulators face a systemic risk-return trade-off: Tighter regulation tends to reduce aggregate vulnerability, but credit intermediation becomes more expensive. Regulators have to weigh the overall level of risk in the financial system against the cost of reduced credit intermediation.

To the extent that capital and liquidity requirements might be substitutable, they will have a differential impact on the optimal amount of capital and liquidity, and precise calibration might thus improve welfare. However, while Pierret shows that solvency and liquidity are interrelated at the firm level, she does not make the connection to aggregate solvency or liquidity risk. Relatedly, the *SRISK* measure that is used to gauge solvency risk takes the overall amount of stress in the system as given and asks how big the capital shortfall of an individual institution might be. In contrast, Adrian and Brunnermeier's (2010) CoVaR measure asks to what extent the distress of an individual institution might impact the overall level of systemic risk.

Fourth, the nexus of solvency and liquidity matters for ex post crisis intervention. During the unfolding of the 2007–9 financial crisis, the primary policy tools consisted of liquidity injections by the Federal Reserve. Subsequently, it became clear that liquidity alone could not resolve the crisis, as capital shortages in the banking system were exacerbating existing adverse economic shocks. As a result, the banking regulators, together with the U.S. Treasury, started to focus on ways to recapitalize the banking system. Ultimately, Troubled Asset Relief Program (TARP) funds were used to this end, and

[3]Duarte and Eisenbach (2014) present a measure of fire-sale risk for U.S. banks.

the first supervisory stress test in 2009 was explicitly targeted at recapitalization of the banking system.

More extensive knowledge of the interrelation between capital and liquidity shortages would certainly have helped calibrate lender-of-last-resort policies, as well as recapitalizations. In fact, the Federal Reserve's Comprehensive Liquidity Assessment and Review (CLAR) complements its Comprehensive Capital Analysis and Review (CCAR) and helps regulators gauge capital and liquidity adequacy under assumed stress scenarios from an ex ante perspective.[4] The Federal Reserve introduced CLAR and CCAR after the crisis, recognizing the importance of forward-looking measurement of both solvency and liquidity fragilities.

4. Theory

My final comment on Pierret's paper concerns the theoretical foundations of the capital-liquidity nexus. While banking regulation is traditionally analyzed with partial equilibrium models that feature coordination failures as the key rationale for regulation (see relevant citations in Pierret's paper), more recently a literature on financial intermediation within macroeconomic equilibrium has emerged (see He and Krishnamurthy 2013 and Brunnermeier and Sannikov 2014). This literature analyzes banking regulations from a new vantage point, providing new and potentially useful insights. The paper that is particularly relevant for Pierret (this issue) is by Adrian and Boyarchenko (2013), who study capital and liquidity requirements jointly.

Adrian and Boyarchenko (2012) develop a macro-finance model with a financial sector that features an endogenous leverage cycle. Capital requirements are risk based, implying a tighter constraint on intermediary risk taking when volatility is high. Volatility and the price of risk are determined jointly, along with the amount of lending and overall macroeconomic activity. Adrian and Boyarchenko (2013) add a liquidity requirement similar to the Basel Committee's proposed liquidity coverage ratio.[5]

[4]See Tarullo (2014).

[5]See http://www.bis.org/publ/bcbs238.pdf.

Both the liquidity requirement and the risk-based capital requirement aim at containing risk taking in the financial sector. However, the impacts of the liquidity and the capital requirements on systemic risk, and aggregate growth, differ. While Adrian and Boyarchenko (2013) show that both types of prudential regulation can help reduce systemic risk, capital requirements typically have a stronger adverse impact on growth, via increased credit intermediation costs. Banking regulators thus face different risk-return trade-offs, depending on the types of regulations used.

Future research on the solvency-liquidity nexus could use the structure of Adrian and Boyarchenko's (2013) model to achieve identification. Of course, the linear vector autoregression approach of Pierret (this issue) would have to be adapted to incorporate the nonlinearities in Adrian and Boyarchenko's (2012, 2013) models, which are essential in models of systemic risk.[6] The advantage of incorporating more economic structure would be that causality, within the model, could be directly estimated, and explicit links to policy instruments could be made. Importantly, these models explicitly allow for welfare analysis, which can connect the solvency-liquidity nexus to welfare-improving capital and liquidity policies.

5. Conclusion

The nexus between solvency and liquidity is an important topic of research. Pierret is to be applauded for taking an important first step in analyzing empirically the joint dynamics of solvency and liquidity constraints over time. While the study is a welcome first step, I believe that further progress in understanding the topic could be made by extending the study in three directions.

First, identification of shocks could be improved by exploiting cross-sectional variation, or by uncovering an instrument that would help overcome the endogeneity problems typical of vector autoregressions. Ideally, an instrumental-variable approach would identify plausibly exogenous liquidity and solvency shocks. In the absence of an instrumental-variable strategy, cross-sectional variation in capital

[6] Dewachter and Wouters (2014) have proposed methodology estimation of the DSGE model by He and Krishnamurthy (2013).

and liquidity could be exploited more forcefully to achieve identification, perhaps along the lines of Mian and Sufi (2009).

Second, policy conclusions are difficult to draw from the paper, as the magnitude and possibly even direction of Granger causality might be endogenous to liquidity injection policies by the central bank, as well as the evolution of regulatory capital and liquidity standards over time. While the paper documents temporal correlations between solvency and liquidity, the quantitative results of the study cannot serve as a basis for setting regulatory policy.

Finally, the use of a structural model of the macroeconomy with a financial sector that faces capital and liquidity shortages, as presented by Adrian and Boyarchenko (2013), might further improve the analysis. The advantage of a structural approach is that it allows the identification of causal relationships, even in the absence of instruments or quasi-experiments. Furthermore, such a model lends itself to welfare analysis and facilitates the quantification of changes in capital or liquidity requirements, which is useful for analyzing the effects on the level of systemic risk, the pricing of credit, and the average growth rate of the economy. Future research in this vein will surely benefit from the empirical insights on the nexus between solvency and liquidity as presented in Pierret (this issue).

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