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How to Capture Macro-Financial Spillover Effects in Stress Tests?

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How to Capture Macro-Financial Spillover Effects in Stress Tests?[1]

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Abstract

One of the challenges of financial stability analysis and bank stress testing is how to establish scenarios with meaningful macro-financial linkages, i.e., taking into account spillover effects and other forms of contagion. We come up with an approach to simulate the potential impact of spillover effects based on the "traditional" design of macro-economic stress tests. Specifically, we examine spillover effects observed during the financial crisis and simulate their impact on banks' liquidity and capital positions. The outcome suggests that spillover effects have a highly non-linear impact on bank soundness, both in terms of liquidity and solvency.

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ABBREVIATIONS AND ACRONYMS

AM	Advanced Markets
CCC	Constant Conditional Correlation
DCC	Dynamic Conditional Correlation
EBA	European Banking Authority
EM	Emerging Markets
EMBI	Emerging Markets Bond Index
FSAP	Financial Sector Assessment Program
GARCH	Generalized autoregressive conditional heteroskedasticity
GIIPS	Greece, Ireland, Italy, Portugal, and Spain
GIP	Greece, Ireland, and Portugal
LTROs	Long Term Refinancing Operations
OeNB	Austrian National Bank
RWAs	Risk-Weighted Assets
SIBs	Systematically Important Banks
WEO	World Economic Outlook

I. INTRODUCTION

Stress testing has garnered broad attention during recent years, which has spurred numerous conceptual developments.[5] Yet, overarching approaches to establish macro-financial linkages, and explicitly capture the non-linearity of shocks (originating from spillover effects and other types of contagion) are still evolving. Such linkages have seen a particularly significant growth during the last decade (e.g. Frank et al, 2008) and are therefore an important dimension to be captured by meaningful empirical analysis. This paper focuses on the design of stress tests to capture spillover effects and demonstrates the potential impact based on a case study.

The first part of the paper deals with the establishment of macro-financial scenarios which are explicitly informed by spillover effects. Scenario design for macroeconomic stress tests is typically based on an "indirect approach" (Jobst and others, 2013; see Figure 1): (i) first, economic and financial variables are estimated conditional on a macroeconomic scenario; (ii) in the second step, the trajectories of the economic and financial variables are translated into bank solvency and liquidity[6] measures based on so-called "satellite" or "auxiliary" models. Three approaches have commonly been used to predict economic and financial variables under stress (see Foglia 2009): (i) a structural econometric model; (ii) vector autoregressive methods; and (iii) pure statistical approaches. The satellite models commonly take the form of (panel) regression models. The "direct approach" is based on projections of the actual solvency and liquidity parameters without an explicit link to the state of economic and financial variables. While this approach could be equally meaningful in terms of the outcome of stress tests, it does not allow for a detailed story-telling and can underestimate the importance of non-linear macro-financial factors for bank-specific stress tests.

Modeling contagion effects and their impact typically constitute a challenge (see Jobst and others 2013, for example). By definition, spillover effects and other dynamic contagion effects are implicitly captured in past data, but not necessarily if one uses structural econometric models - usually perceived as being "best practice." Even if potential spillover events are captured in past data, this data might not be representative for a future scenario if e.g. linkages between economies and banks have become gradually more intense over time. In this study, we focus on spillover effects originating from the recent sovereign debt crisis. Other spillover catalysts could be, for instance, a macroeconomic downturn in a major world economy as well as the failure of a large financial institution such as in the case of Lehman Brothers.

We aim to come up with a stress testing approach that captures spillover effects in detail. Our solution is an amended version of the indirect approach: the starting point is to establish a macroeconomic scenario, typically not informed by potential spillover effects,

[5] For work on stress testing at the IMF, for example, see Jobst and others (2013).

[6] For liquidity stress tests, most tests have typically relied on the "direct" approach.

at least not explicitly. In the second step, the potential marginal increase of stress due to spillover effects is estimated by translating the spillover effects into reduced output paths, i.e., an adverse macroeconomic scenario.

In terms of the stylized design of macro-economic stress tests (Figure 1), we thereby implicitly incorporate a quasi-feedback loop into the linear design of traditional stress tests – through a sensitivity type approach.[7] The approach could also include a test for interbank bank contagion, as shown in Figure 1. We build on previous IMF work to establish an explicitly iterative process, i.e., establish a scenario informed by initial spillover effects based on a structural econometric approach, compute the impact on banks' solvency parameters, re-compute the resulting spillover effects and feed them back to the structural model etc. until an equilibrium is reached.[8] The approach presented herein uses proxies for the "ultimate" impact of spillovers for different advanced and emerging economies conditional on the evolution of sovereign spreads in the Euro area periphery (that serves as the stress catalyst). Dynamic effects can also be captured via "direct" approaches, as done by Jobst and Gray (2013), for example, but renders the outcome a reduced-form type.[9]

Specifically, we infer from market data the magnitude of sovereign spread spillovers effects resulting from an increase in peripheral EU sovereign debt spreads, while controlling for changes in the market sentiment (i.e., risk aversion) and macroeconomic factors. Using market data, we seek to capture point-in-time and dynamic time series' effects, while recognizing the limitations of using market data, i.e., that they might not necessarily "only" reflect underlying vulnerabilities and risks. The translation of sovereign spread spillovers into a loss of output is based on recent work at the IMF (Vitek and Bayoumi, 2011).

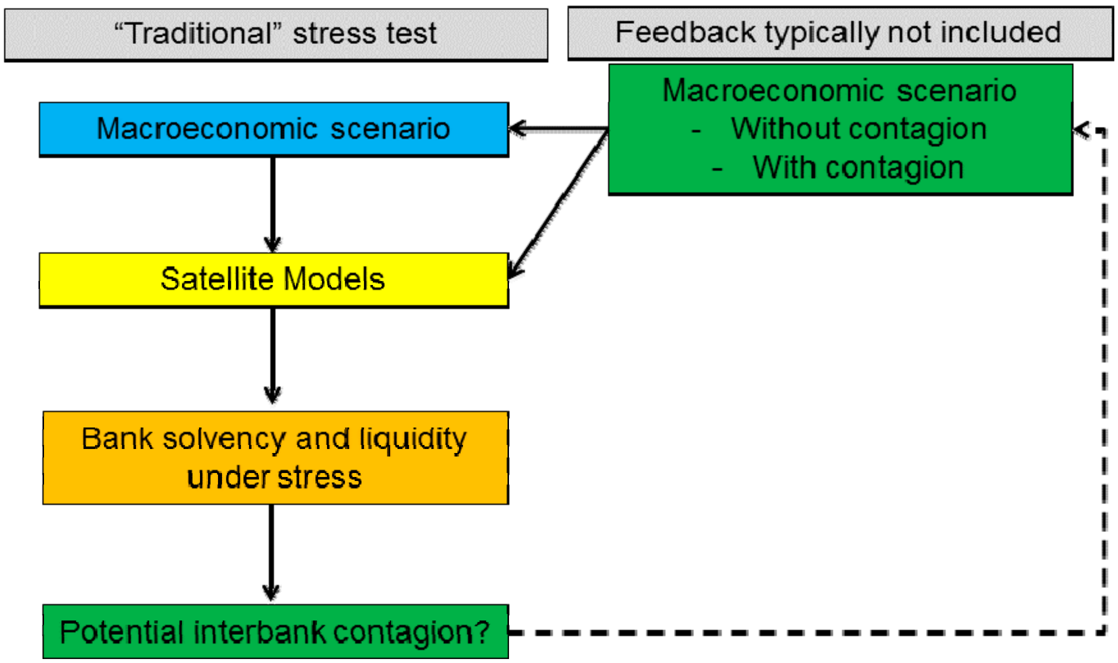
Two approaches are used to capture the spillover effects in sovereign debt markets: panel regressions and a GARCH model. The panel regressions, which are used to establish an "average" impact of spillover effects during periods of stress on AM and EM countries, respectively, suggest that increasing sovereign risk in the Euro periphery was a major driving force behind spillover effects. As expected, risk aversion, measured through changes in the VIX and high yield spreads, is found to increase during periods of financial stress, exhibiting a non-linear pattern. Country-specific macroeconomic factors also matter, but to a lesser degree, and their impact does not appear to change significantly under periods of stress.

[7] Further information on macroeconomic scenarios used for FSAPs can be found in Jobst and others (2013).

[8] At the IMF, such analyses were carried out by combining the work of Schmieder, Puhr and Hasan (2011) and Vitek and Bayoumi (2011) as part of early warning analysis and vulnerability exercises. It should be noted that running such an approach requires close cooperation between staff running macroeconomic forecasts and staff simulating the impact of stress at the bank level (typically done by financial stability departments).

[9] See also IMF (2011, 2012) for further information on related work.

Figure 1. Stylized Design of Stress Tests



Source: Authors

GARCH models were run to obtain more granular spillover effects, such as the country-specific co-movements between peripheral European GIIPS[10] sovereign debt spreads and the corresponding spreads in the banks' home countries (i.e., the 25 most systemically important financial systems, the "S-25" sample) for specific points in time. The study reveals significant differences in terms of the spillovers across countries, with a higher impact observed for most core Euro area countries (in particular during peak periods of the crisis) than for Scandinavian countries, Switzerland, the UK and most non-European countries. The findings also show a flight-to-quality element, i.e., a negative co-movement of GIIPS spreads with German Bunds and U.S. Treasuries.

In the second part of the paper, we illustrate how the established spillover effects would feed through to banks based on a case study for 154 large international banks from the "S-25" country sample. The impact of different degrees of spillover on banks' solvency and liquidity positions is compared with baseline type conditions (which corresponds to realized stress scenarios in recent years unlike in "normal" times). Stress at the bank level is simulated based on a recently developed IMF stress testing framework for liquidity (Schmieder, Hesse, Neudorfer, Puhr and Schmitz, 2012) and benefits from work on

[10] GIIPS refers to Greece, Ireland, Italy, Portugal and Spain.

solvency (Schmieder, Puhr and Hasan, 2011; Hardy and Schmieder, 2013), which together allow running integrated solvency and liquidity scenarios.[11]

The outcome suggests that spillover effects have a highly non-linear impact on bank soundness, both in terms of liquidity and solvency. It is thereby shown (once more) that the design of stress scenarios is a highly crucial element of stress testing, and is sensitive with respect to the outcome of stress tests.[12] The magnitude of the impact on bank solvency and liquidity could serve as a benchmark for other studies, while recognizing that future spillover channels could be highly different, both in terms of direction and magnitude. In this sense, our study could help to identify potential systemic vulnerabilities ex ante, a role that stress tests have not necessarily played in the past for a number of reasons (see Borio, Drehmann and Tsatsaronis 2012, for example).

The paper is organized as follows. Section II investigates financial spillovers at the sovereign and bank level, based on panel regressions and a GARCH model framework. Section III provides a brief overview of the stress testing framework used to simulate the impact of spillover effects on bank liquidity and solvency. Section IV shows the impact of different degrees of spillover based on a case study. Finally, section V concludes and offers some avenues for future research. The appendix also shows an illustrative country example.

II. Financial Spillovers from the Euro periphery to the Rest of the World

A. Panel Approach

Financial market linkages across economies have grown significantly in recent decades, which was felt strongly when the financial crisis started in 2008 with the failure of Lehman Brothers, and later continued to become a sovereign debt crisis especially in the European periphery. AM financial spillovers have been a dominant determinant of AM and EM financial soundness during the previous years.

Recent studies identified three important factors for spillover effects (e.g., Caceres and Unsal, 2011): (i) a stress spillover catalyst – in this study AM sovereign debt yields; (ii) risk aversion in global markets; and (iii) country-specific risk factors.

Herein, we sought to establish benchmark parameters to simulate spillover effects at the bank level. Initially, we construct a risk premium variable for our sample of 35 countries.[13] The risk premium is the spread between 10 year domestic treasuries to U.S.

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[11] The frameworks were developed in the context of recent FSAPs and IMF technical assistance, extending the seminal work of Čihák (2007), and drawing upon work at the Austrian National Bank (OeNB).

[12] See also Taleb and others (2012) how to test the sensitivity (i.e., non-linearity) of the outcome of stress tests.

[13] The sample of countries includes Australia, Austria, Belgium, Brazil, Canada, China, Cyprus, Denmark, Finland, France, Germany, Greece, Hong Kong SAR, Hungary, India, Ireland, Italy, Japan, Korea,

(continued…)

Treasuries for non-European AM countries, to German Bunds for AM countries in Europe, and to the JP Morgan Emerging Markets Bond Index (EMBI) for the EM countries.[14]

Based on random effects' panel regressions the sovereign spreads are regressed on three sets of peripheral spreads: average spreads for (i) the European peripheral countries (GIIPS); (ii) for the GIP (Greece, Ireland, Portugal); and (iii) for IT-ES (Italy and Spain); Risk aversion) is identified by two variables, high yield spreads and the VIX. The former is the difference between yields to maturity of Moody's Aaa rated and Baa1 rated U.S. corporate bonds. The latter is the implied volatility for S&P 500 index options. Trade openness, liquidity (proxied by M2 to GDP and the level of reserves to GDP), inflation rates, GDP growth, the current account, the level of public debt and deficits to GDP ratios are used as macroeconomic control variables to capture country-specific cyclical effects.

The regressions are estimated for two time periods based on quarterly data: (i) 2006–2012 and (ii) 2008–2012. The choice of the two sample periods is meant to capture the impact of the systemic stress.

The results (displayed in Tables I.1-2 in Appendix I) present various model specifications considered useful to identify drivers of spillover stress and their actual impact, respectively. Using the sovereign debt spreads of the 35 sample countries as the dependent variable, Table I.1 shows the outcome for 2006–2012 and Table I.2 for 2008–2012:

The results confirm previous studies in that all three factors – i.e., a catalyst, risk aversion and country-specific factors are actually important to explain financial stress (measured in terms of sovereign spreads), at least for the current financial crisis:

- Increasing sovereign risk in the Euro periphery was found to be a catalyst for spillover effects,
- The global perception of risk magnifies stress conditions as do expected future interest rates;
- Country-specific macroeconomic factors also matter, but to a lesser degree.
- While the impact[15] of country-specific factors does not appear to change significantly under stress, the impact of the former two factors is higher during 2008-2012, i.e., in the period covering only the crises years (compared to the full sample period).

Luxembourg, Malta, Mexico, Netherlands, Norway, Poland, Portugal, Russia, Singapore, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom, and the United States.

[14] The panel regressions adjust for exchange rate changes.

[15] Measured in terms of the R-squared and the actual coefficients.

For the longer sample period (i.e., 2006–2012) a one percentage point change in Euro periphery sovereign spreads (i.e., GIIPS and GIP) translates into a 0.2–0.3 percentage point change of sovereign debt spreads in the 35 sample countries (Table I.1). Global risk aversion (measured by changes in high yield spreads) has an even higher impact - a one percentage point change in high-yield spreads translates into around 0.6 percentage point change in sovereign spreads. As global risk aversion and high-yield spreads are highly correlated during episodes of stress, the joint impact on the peripheral spreads is exacerbated – which is illustratively in a comparison of the coefficients in Tables I.1 and I.2. The transmission of risk premium shocks from Italy and Spain to the countries in the sample is more pronounced than for the GIPs. Depending on the model specification the availability of domestic liquidity and trade openness also contribute to some degree to spillovers.[16]

The outcome for the crisis period only (covering the years from 2008–2012, Table I.2) indicates that the coefficients for all three major drivers, i.e., European periphery shocks, global risk aversion, as well as the slope of the US yield curve are higher than for the period including pre-crisis years (Table I.1). A one percent shock to Euro periphery spreads translates into a 0.5 percentage point increase in the risk premium of the 35 sample countries if the shock originates in the GIPs and a one percentage point increase in spreads if it originates in Italy and Spain. Hence, it seems that the size of the peripheral European country determines the size of spillovers, as expected. Moreover, global risk aversion shocks also translate almost one-to-one into spreads.

B. DCC GARCH Approach

The panel regression approach provided the average spillover effect on countries' sovereign spreads. Below, we complement the above by estimating country-specific daily co-movements, in order to differentiate more between countries, and to come up with the range of the potential spillover impact observed over time. We use a multivariate GARCH framework for the estimation, which allows for heteroskedasticity of the data and a time-varying correlation in the conditional variance. Specifically, the Dynamic Conditional Correlation (DCC) specification by Engle (2002) is adopted, which provides a generalization of the Constant Conditional Correlation (CCC) model by Bollerslev (1990).[17] The DCC GARCH models are estimated in first differences to account for the non-stationarity of the variables in the crisis period.

[16] For robustness check, a separate set of regressions were run to estimate the impact of expectations of higher interest rates, represented by the slope of the US Treasury yield curve on the global risk premium. Results indicate that a steepening of the curve implies higher costs of borrowing for the periphery countries.

[17] Given the high volatility movements during the recent financial crisis, the assumption of constant conditional correlation among the variables in the CCC model is not very realistic especially in times of stress where correlations can rapidly change. Therefore, the DCC model is a better choice since correlations are time-varying.

These econometric techniques allow us to analyze the daily co-movement of the GIIPS spreads and the sovereign bond spreads of our sample of AMs and EMs. The GIIPS spreads are included into the model as a conditioning variable, as is the VIX. The methodology is therefore closely aligned to the one of the panel regression and further explained in Appendix II.

We choose as the sample period daily data from 2007 to end August 2012, with a view to cover the full crisis period. As before, for the European AMs we measure the risk premium of 10-year instruments as the difference between the average GIIPS spread as well as those of the domestic treasuries to German Bunds. For the non-European countries, the spread to the 10-year U.S Treasury bonds is calculated and for EM countries we use the EMBI Global spread and the HSBC Asian U.S. Dollar spread for Asian countries.

As expected, our findings suggest that the spread between GIIPS to German Bunds exhibits a higher degree of co-movement with the risk premia for European countries than non-European countries (Figures 1–4). In particular, implied DCC GARCH correlations with the GIIPS spread were as high as 0.7–0.8 for Austria, Belgium, France, and the Netherlands during episodes of systemic stress (Figure 1, upper panels). In contrast, the GIIPS co-movement with the UK spread to German Bunds is relatively low and oscillates between 0 and 0.2, while the model implied correlation with the Swiss spreads reaches a maximum of 0.4 (Figure 1, left hand panel at bottom). The results also show that the spreads of the Scandinavian countries, namely Denmark, Norway, Sweden, and Finland (with higher average levels though),[18] on average exhibit a lower co-movement with the GIIPS spread than their continental European peers (Figure 1, right hand panel at bottom). The outcome does also suggest a constant level of stress, with some easing towards the end of the observation period, a finding which also applies to the non-European sovereigns.

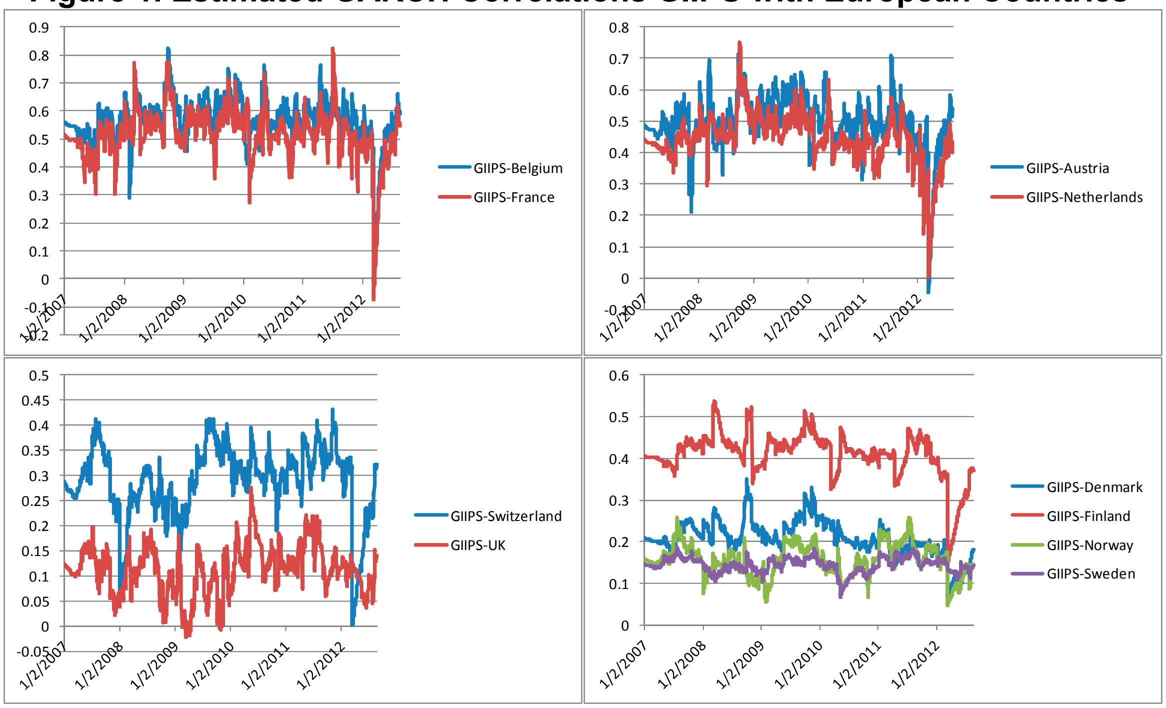
Co-movements of the GIIPS spread with Australian and Canadian spreads (relative to U.S Treasury bonds) are rather low with implied correlations up to 0.2 (Figure 2). Looking at the Asian countries Hong Kong, Japan, and Singapore shows a somewhat higher correlation with the GIIPS spread of up to 0.3 and with one jump to 0.4. In terms of EM countries, results suggest that China's co-movement with the GIIPS spread is rather subdued compared to the other EMs Brazil, Mexico, Russia, and Turkey (Figure 3). Out of this EM sample, Turkey has the highest implied correlation with the GIIPS during episodes of system stress at up to 0.6.

Since the onset of sovereign debt crisis by 2009, the average GIIPS interest rates exhibit a negative correlation with both the German Bund and U.S. Treasury interest rates (Figure 4). Since 2009, the implied correlation has turned negative for both countries, with lows

[18] Finland is the only Euro area country within the sample, which seems to explain the higher level of correlations.

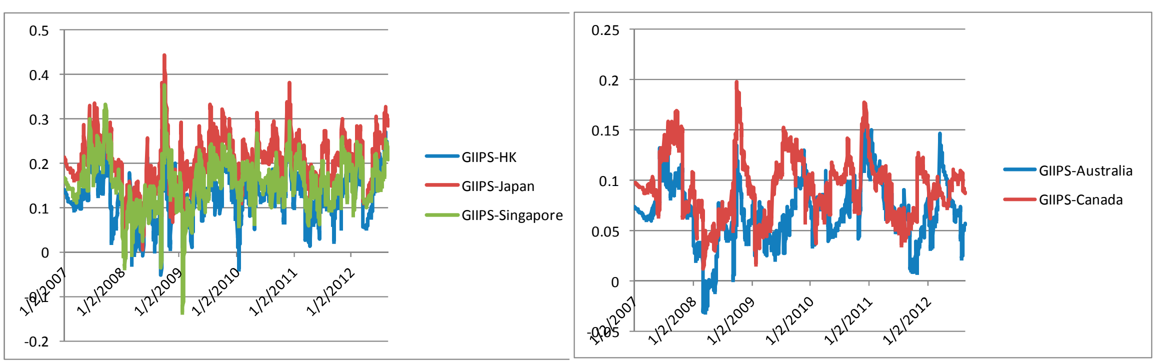
at -0.4 (US) and -0.6 (Germany), indicating a sudden flight to safety, in line with other recent studies (IMF 2011, for example).

Figure 1. Estimated GARCH Correlations GIIPS with European Countries



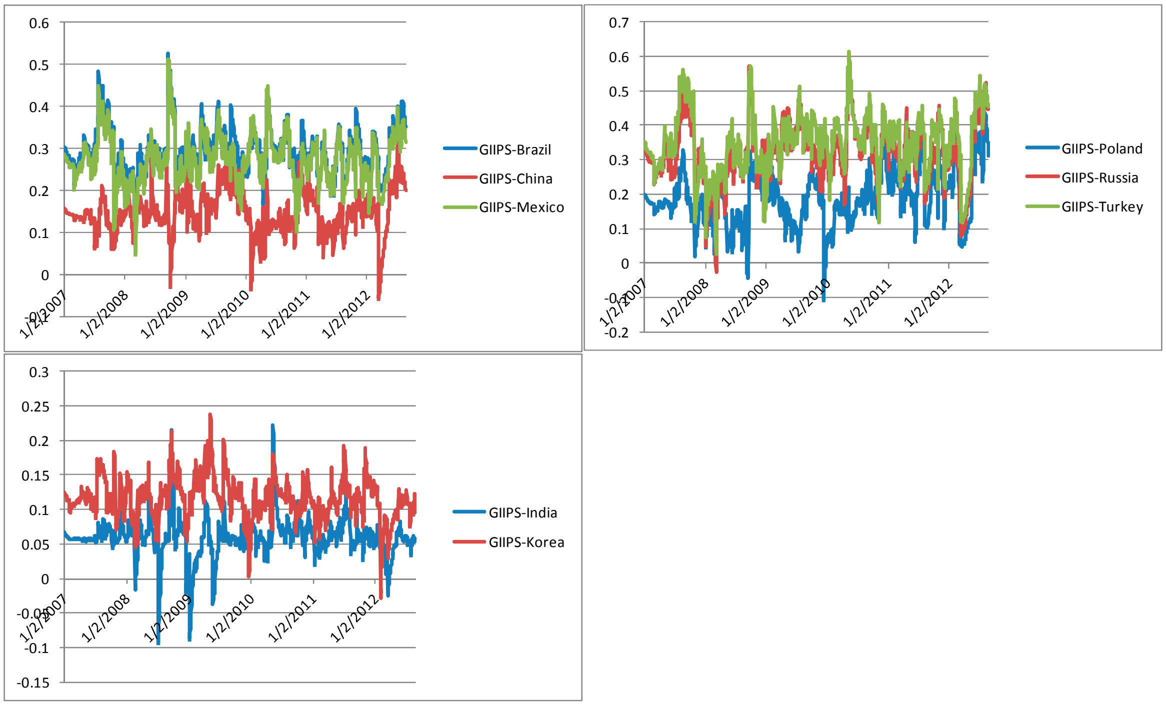
Source: Bloomberg and Authors' Calculations

Figure 2. Estimated GARCH Correlations GIIPS with Non-European Countries



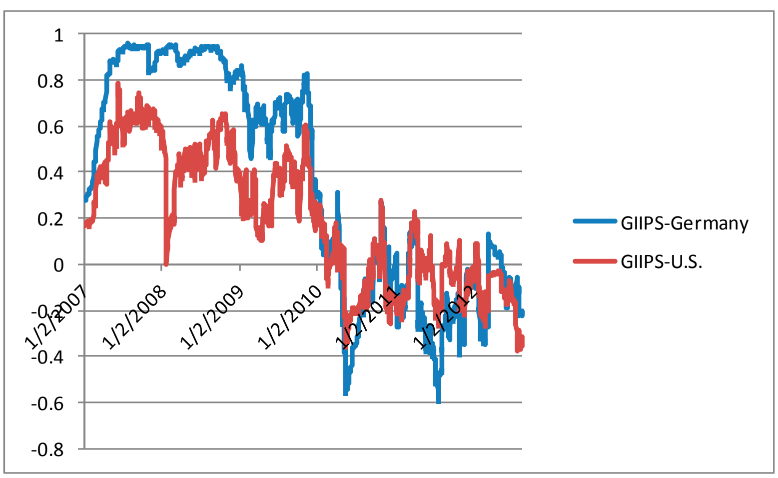
Source: Bloomberg and Authors' Calculations

Figure 3. Estimated GARCH Correlations GIIPS with EM Countries and Korea



Source: Bloomberg and Authors' Calculations

Figure 4. Estimated GARCH Correlations GIIPS with Germany and the U.S.



Source: Bloomberg and Authors' Calculations
Note: Unlike the other GARCH models, the average GIIPS interest rates are taken and not the GIIPS spread to German Bunds

III. Liquidity and Solvency Stress Testing

The area of stress testing has seen a number of advances during recent years. Our study uses a recently developed IMF liquidity stress testing framework to run integrated solvency and liquidity stress tests. The liquidity stress testing framework presented in Schmieder et al (2012) was developed in the context of recent FSAPs (Financial Sector Assessment Program)[19] and IMF technical assistance, extending the seminal work of Čihák (2007), and drawing upon work at the Austrian National Bank (OeNB).[20] An overview of recent academic and policy research on integrating liquidity and solvency stress testing is given in box 1.

In this study, the focus is on scenario design, namely building integrated scenarios for solvency and liquidity risks that take into account spillover effects and feedback loops.[21] The central question becomes how the findings established in section II can be used to inform bank-level stress tests.

Nevertheless, while we attempt to condense a wealth of information and assumptions to establish integrated scenarios this should not, in any sense, give a false sense of precision. Instead, we recommend running a whole range of scenarios which can build upon the ones established in the study, with varying degrees of severity. Reverse stress tests can be also included.[22] This is an important way forward to obtain a better understanding of key solvency and liquidity risks faced by banks, and to gain a more comprehensive view on their respective risk tolerance.

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[19] Examples include Chile, Germany, India, Spain, Turkey, and the UK.

[20] It is complemented by a previously developed solvency stress testing tool by Schmieder, Puhr and Hasan (2011). While developing the solvency and liquidity stress testing frameworks, four key facts were accounted for, which constitute key challenges of contemporaneous financial stability analysis: (i) the availability of data varies widely, and lack of data is common; (ii) both solvency and liquidity risk have various dimensions, which requires multi-dimensional analysis, thereby integrating risks; (iii) designing and calibrating scenarios is challenging, even more so for liquidity risk than for solvency risk (mainly as liquidity crises are relatively rare and originate from different sources); and (iv) communication of stress test results is a key integral part of the exercise. The answer to these multiple dimensions are Excel based balance sheet type frameworks.

[21] The exercise thereby reflects key principles for liquidity stress testing put forward by the Basel Committee in the aftermath of the first wave of shocks following the default of Lehman Brothers (BCBS 2008).

[22] The work by Taleb and others (2012) and Schmieder and Hardy (2013), for example, could be useful to consider in this context.

Box 1. Integrating Liquidity, Solvency Risks and Bank Reactions in Stress Tests

Banks have numerous and overlapping ways to react to credit and funding shocks. High-quality capital and profits are usually the first line of defense, and retained earnings can help buffer banks' capital levels. In terms of liquidity, banks have an inherent counterbalancing capacity to generate liquid assets by using high-quality eligible securities as collateral to generate market funding or, if interbank markets freeze entirely, central bank funding. As seen post- Lehman, fire sales of securities can also be an option to generate liquidity, but at a considerable cost in an environment of sharply declining asset prices. Deleveraging, especially targeted at assets with higher risk weights, is also a way to raise capital adequacy ratios by reducing risk-weighted assets (RWAs). In practice, banks have been using a combination of these, as well as other hybrid measures, ranging from debt-to-equity conversions to issuance of convertible bonds to optimizing risk-weighted assets, to react to shocks.

Incorporating banks' reactions to shocks is a critical component for the design of informative stress tests, especially over longer time horizons. This, however, requires modeling solvency and liquidity shocks in a coherent manner because *first*, when banks react to financial stress, the source of the shock (solvency or liquidity) is not always clear; and *second*, the measures banks take in reaction to these shocks have both capital and liquidity aspects that are not easy to disentangle.

Recently, a number of analytical approaches have attempted to integrate solvency and liquidity more systematically.

- Empirical work includes Van den End (2008)[23] at the Dutch Central Bank and Wong & Hui (2009) from the Hong Kong Monetary Authority[24], for example. Barnhill & Schumacher (2011) developed a more general empirical model, incorporating the previous two approaches that attempt to be more comprehensive in terms of the source of the solvency shocks and compute the longer term impact of funding shocks.
- Schmieder and others (2012) provide an Excel based framework that allows running liquidity tests informed by banks' solvency conditions, and to simulate the increase in funding costs resulting from a change in solvency.
- An integrated approach to model funding liquidity risks and solvency risk is the Risk Assessment Model for Systemic Institutions (RAMSI) developed by the Bank of England (Aikman et al., 2009). The framework simulates banks' liquidity positions conditional on their capitalization under stress, and other relevant dimensions, such as a decrease in confidence among market participants under stress. A recent attempt by the Austrian National Bank to come up with an integrated framework and to overcome operational challenges identified with previous work on integrated models, the Applied Risk, Network and Impact assessment Engine (ARNIE), should also be mentioned (OeNB, 2013).

For an overview of liquidity stress tests, including the link to solvency, see also BCBS (2013). Hardy and Hesse (2013) examine the EBA stress tests.

Source: Based on Oura and Schumacher (2012)

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[23] Van den End (2008) developed a stress testing model that tries to endogenize market and funding liquidity risk by including feedback effects that capture both behavioral and reputational effects. A number of central banks and bank supervisors have been successfully using the Monte Carlo framework of Van den End (2008).

[24] The authors sought to explicitly capture the link between default risk and deposit outflows. Their framework allows simulating the impact of mark-to-market losses on banks' solvency position leading to deposit outflows; asset fire sales by banks is evaporating and contingent liquidity risk sharply increases.

Liquidity Stress Testing Approach

We apply an implied cash-flow approach to simulate the impact of bank-run type stress scenario. The banks' liabilities are broken down into demand and term deposits, short-term wholesale funding (including bank and secured funding), derivatives' funding as well as long-term funding such as senior debt or subordinated debt. On the asset side, we include a range of potentially liquid asset positions such as cash, government, trading and investment (both available-for-sale and held-to-maturity) securities, loans and advances to banks and reverse repos and cash collateral. Given European periphery banks' increasing collateral use of pools of loans (such as covered bonds) for liquidity, we also include a crude definition of banks' loan level as a portion of their total assets.

Solvency Stress Testing Approach

We use rules of thumb for solvency stress testing as proposed by Hardy and Schmieder (2013) and thereby a simplified solvency test.[25] Credit losses, banks' pre-impairment income and the trajectories of Risk-Weighted Assets (RWAs) for a 2-year horizon were simulated based on the GDP trajectories, with and without spillover effects. The capital shortfall was measured against a tier 1 capital ratio (Tier 1 capital/Risk-weighted Assets) of 6 percent, below which a bank is considered undercapitalized.[26]

IV. Integration of the Financial Spillover Analysis with the Stress Testing Approach

Our integrated approach to simulate stress at the bank level is illustratively shown in Figure 5:

1. Scenario design: We use the GDP trajectories of a specific macroeconomic scenario, the WEO baseline scenario for 2013–14 as of April 2012, and add the spillover stress component.
2. Spillover analysis: The outcome of the spillover analysis (see above), measured through a widening of sovereign spreads, worsens the macroeconomic scenario, and is used as a sensitivity analysis. The translation of the spillover effects into the revised macroeconomic trajectories is based on recent IMF work.
3. Soundness of banks: The scenario is translated into bank level stress parameters to simulate both the banks' solvency and liquidity positions, drawing on work by Hardy and Schmieder (2013) and Schmieder, Hesse, and others (2012), respectively.

[25] However, it should be noted that the evidence is based on a comprehensive set of data from 16,000 banks during the last 15 years (as available).

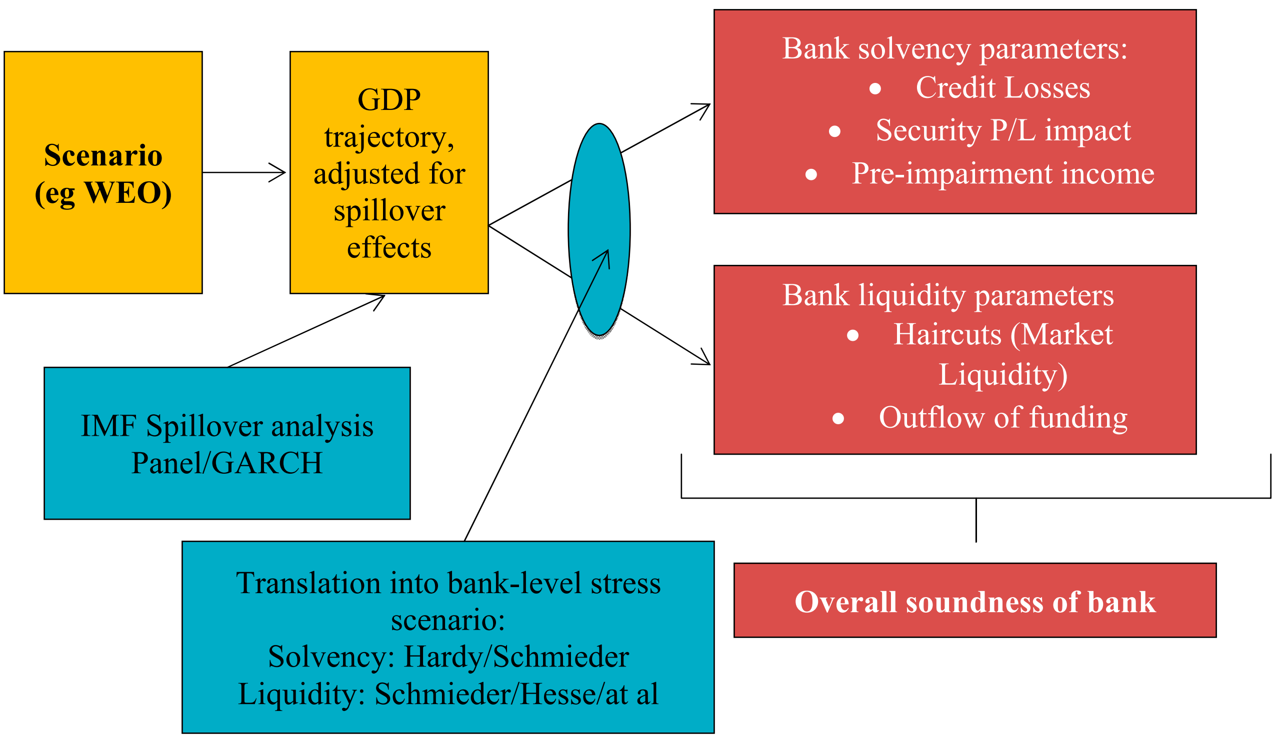
[26] Please note that this specific choice is meant for illustration only—through a similar level as used for the European stress tests conducted in 2010 and 2011, for example.

We use bank-level data from Bankscope (from end-June 2012) for large Systematically Important Banks (SIBs). In total, our sample includes 154 large banks from the following 26 countries:

Austria, Australia, Belgium, Brazil, Canada, Switzerland, China, Germany, Denmark, Finland, France, UK, HK, India, Japan, Korea, Luxembourg, Mexico, Netherlands, Norway, Poland, Russia, Sweden, Singapore, Turkey, and the USA.

Our sample comprises almost the full EBA sample for the European banks (except for the banks in the GIIPS countries) and includes the largest banks in the non-European countries. In total, it captures $84 trillion of bank assets (i.e., about 50 percent of the assets held by banks worldwide), $39 trillion non-bank deposits and around $7 trillion of government securities held by banks.

Figure 5. Overview of the Concept to Simulate Stress at the Bank Level



Source: Authors

Scenarios

We refer to four different scenarios: The April 2012 WEO baseline scenario for 2013–14 (Scenario 1); and three spillover scenarios (referred to as scenarios 2.x) conditional on scenario 1 – scenarios that banks could potentially face in case increasing degrees of spillovers affect the general growth trend.

Specifically, scenario 1 is adjusted for an increase of GIIPS spreads by 100 (scenario 2a), 200 (2b) and 300 (2c) basis points, respectively. We further distinguish between the spillover impact observed during periods of substantial financial stress (using the panel regression for 2008–12 and the GARCH model for 2010–12) and during periods of less significant stress (using the panel regression for 2006–12 and the GARCH model for 2008–12), i.e. refer to a total of six spillover scenarios (2a/1, 2a/2, 2b/1, 2b/2, 2c/1, 2c/2).

For the banks' solvency, we simulate their Tier 1 capital ratios by end-2014, based on the evolution of the main solvency dimensions (banks' income and losses). For liquidity, we determine the impact of a worst-case idiosyncratic shock to the bank's liquidity profile on top of the impact on liquidity resulting from the macroeconomic/spillover scenarios. Illustrative examples are provided in Appendix IV (solvency) and V (liquidity).

Impact on bank solvency

As outlined above, we use the outcome of the 2012 IMF Spillover Report, which simulates the impact of a 300bp increase in peripheral countries' spreads (including a lower yield increase for core countries) on European countries' GDP paths based on the IMF G-35 model (drawing upon Vitek and Bayoumi, 2011).

Appendix IV provides an illustrative example for a stylized Austrian bank. In the first step, the increase of Austrian sovereign debt spreads is simulated, using the evidence established in section II. A 100 basis point shock of GIIPS spreads (scenario 2a) would thereby result in an increase of Austrian spreads by 24 basis points for less significant spillover stress (scenario 2a/1) and 50 basis points (2a/2) for more substantial spillover stress. Measured relative to the April 2012 WEO baseline scenario for Austria, suggesting real GDP growth rates of 1.8 percent (2013) and 2.2 percent (2014), spillover analysis carried out at the IMF (2012) would predict a drop of real GDP growth by about 0.45 percentage points for scenario 2a/1 (less significant spillover stress), whereby the GDP trajectory becomes 1.4 percent (2013) and 1.8 percent (2014). For a period with more significant spillover (scenario 2a/2), the impact is about twice (0.9 percentage points), whereby the GDP trajectory is 0.9 percent (2013) and 1.3 percent (2014). For a 200 basis point shock (scenario 2b), growth drops by 1.7 percentage points and for 300 basis points (scenario 2c) by 2.6 percentage points (per year) under substantial spillover conditions (Annex IV).

We then use the satellite models by Hardy and Schmieder (2013) to determine banks' loan impairment levels and pre-impairment income for 2013 and 2014.[27] For a stylized bank with loss impairment rates of 0.5 percent and a pre-impairment return on capital of 10 percent in 2012[28], loan impairment rates are simulated to decrease slightly under the

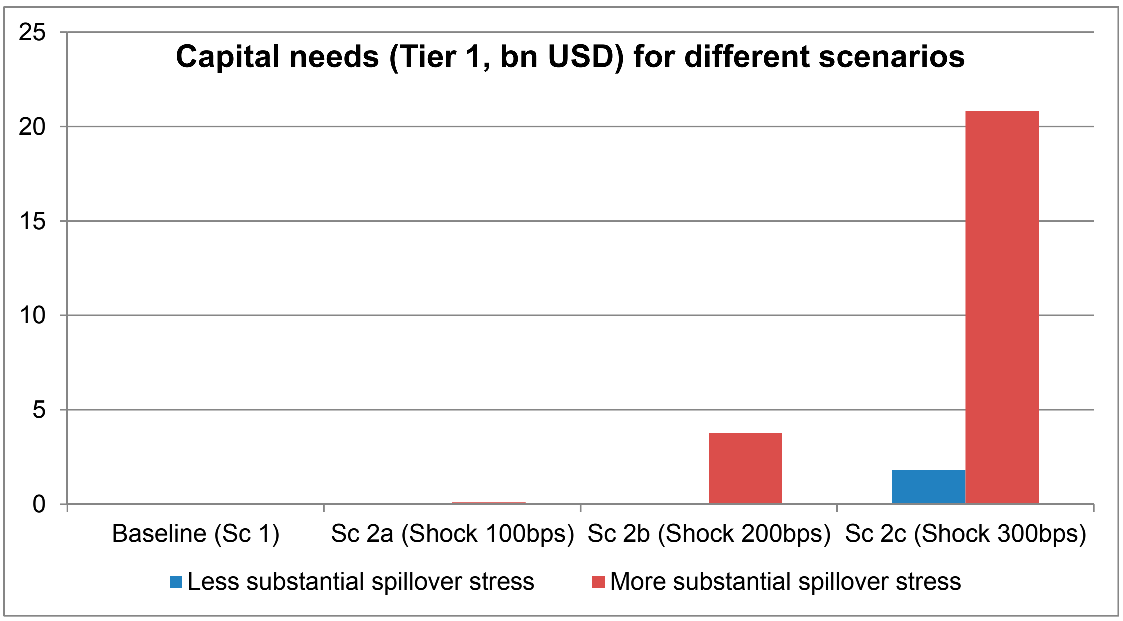
[27] For simplification, we assume that banks' are affected according to their domestic scenarios, i.e., that their business is pre-dominantly based in their home country.

[28] In a few cases, the latest available figures were from 2011.

baseline scenario and mild spillover conditions, while they would increase (non-linearly) under increasing levels of spillover stress. The same pattern holds for pre-impairment income. This input is used to simulate the bank's capital, Risk-weighted assets (RWAs)[29], and capital ratio. Again, the same pattern holds, with a decrease of the stylized banks' capital ratio to 7.5 percent under the most severe scenario, which is above the hurdle rate in terms of Tier 1 capital to pass the stress test (6 percent).

The outcome of this solvency stress test applied to the 154 banks presented in Figure 6 shows that the large international banks would be in a position to digest the baseline scenario plus some level of spillover stress, while additional stress in the Euro area periphery results would have a highly non-linear impact on potential capital needs. The non-linearity results from two factors: (i) the non-linearity in the satellite models for loan impairment rates and pre-impairment income; and (ii) the effect of the kick-in of capital needs for banks that fall below the hurdle rate.

Figure 6. Outcome of Solvency Stress Tests



Source: Authors

Impact on bank liquidity

For the liquidity stress test, we simulate the impact of stress on both banks' market liquidity (i.e., their ability to fire sale assets) and funding liquidity (i.e., the potential

[29] The RWAs are simulated based on work by Schmieder and others (2011), assuming point-in-time credit risk parameters.

outflow of funding).[30] Again, we assume that the bank is affected by the shock in its home country.[31]

The link between the level of stress and bank liquidity is established based on empirical work of Schmieder, Hesse and others (2012). We link the GDP trajectories implied by the changes of sovereign spreads to funding shocks experienced by the most affected banks during the Lehman crisis. In other words, we simulate highly adverse idiosyncratic liquidity shocks conditional upon macroeconomic conditions.

In line with (very limited) empirical evidence, we expect the relationship between the shock and the potential adverse impact on the bank level to be highly non-linear (as implied by the scenarios in Appendix III, and in addition to the non-linearity for the banks hitting the hurdle rate, as for capital). Under a worst case scenario, banks would experience a shock equal to a "Lehman Brothers type" scenario, the "severe stress scenario" in Appendix III (this shock level represents how the stress at the time of the Lehman Brothers event affected the banks that were most severely hit, i.e. overlays a market shock with an idiosyncratic liquidity shock). The stress level relative to the one experienced by banks at the time of the Lehman Brothers crisis is established via the cumulative GDP trajectory under stress compared to the long term average. For the stylized example presented in Appendix V, the stress level is at 0.65, i.e., the benchmark funding stress parameters (for the "severe stress scenario") in Appendix III have to be multiplied by 0.65. The funding available for the specific banks under the ECB's Long Term Refinancing Operations (LTROs) is inferred from country-level data and used as a cushion for the relevant European banks.

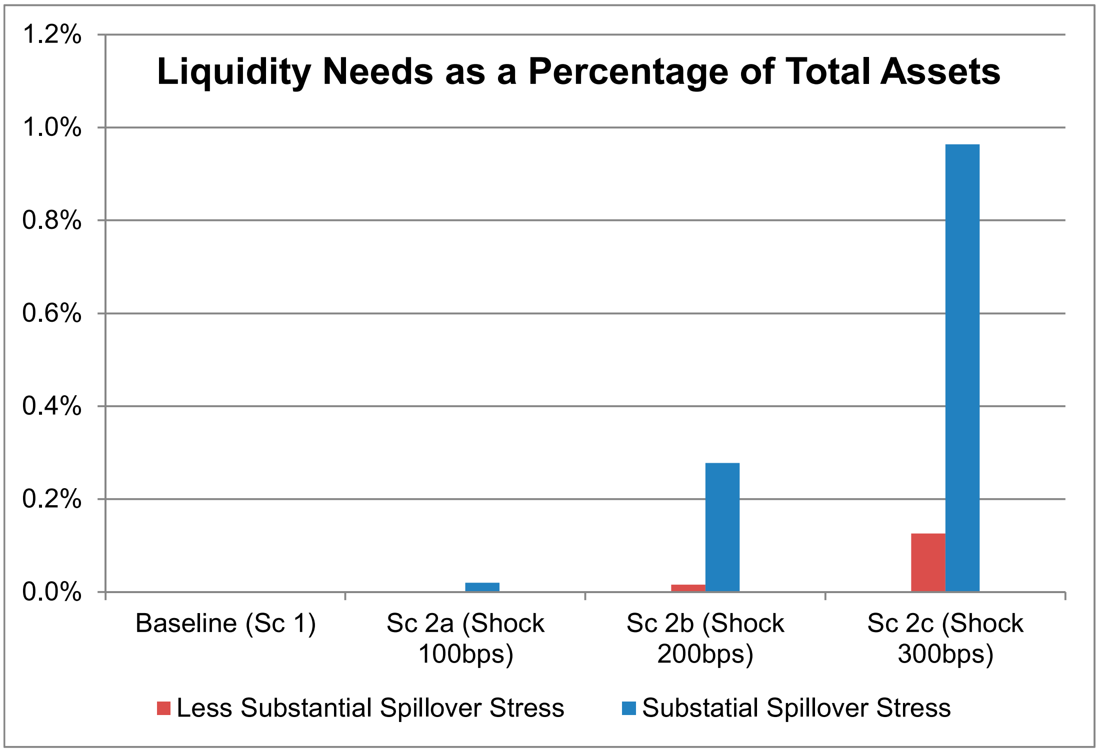
Figure 7 shows the outcome of this liquidity stress test. Under the baseline scenario all banks have sufficient liquidity, as expected. Adding spillover stress triggers a non-linear increase of liquidity needs (which occur in case the liquidity needs exceed the available liquidity generated via fire sales), and more substantial spillover stress makes the stress highly non-linear. Measured against Tier 1 capital rather than total assets, the substantial spillover stress leads to a maximum liquidity shortfall of 20 percent for the entire bank sample for scenario 2c/2 (300bp spread shock, significant spillover stress) and close to 6 percent for scenario 2b/2 (200bp spread shock), compared to 0.3 percent and 1 percent if measured against total assets.[32]

[30] Unlike for the solvency scenario, we do not simulate stress for a specific point in time; rather, the simulated stress conditions reflect a worst-case situation resulting from the general macroeconomic conditions as well as an idiosyncratic shock to the bank conditional.

[31] In other words, it is assumed that all of its assets are based in the home country, which is a crude simplification.

[32] We did not explicitly model a central bank response as the Lender of Last Resort (LOLR) to mitigate the estimated liquidity shortfall. In reality and as seen during the crisis period, central banks would provide large liquidity support to solvent banks subject to an appropriate haircut.

Figure 7. Outcome of Liquidity Tests in Terms of Assets



Source: Authors

V. Conclusion

This study attempted to contribute to an important challenge faced by current financial stability analysis, namely to capture spillover effects and other types of contagion that ultimately determine macro-financial stress at the bank level.

By integrating recent IMF work on financial spillover analysis and stress testing, we use a novel framework that allows shedding some light on the potential impact of spillover effects on bank-level solvency and liquidity. Nevertheless, we recognize that significant additional effort and evidence is needed to make the modeling of dynamic macro-financial linkages more robust, not least due the many potential channels of spillover and contagion, the fact that the use of crude data available for stress tests is subject to uncertainty, and other factors that contribute to uncertainty (such as mixed evidence for the use of market data).

The outcome of the stress tests suggests that spillover effects observed for the sovereign debt markets in recent years have a highly non-linear impact on bank soundness, both in terms of liquidity and solvency. This implies (once more) that the design of stress scenarios is a crucial element of stress testing, and is very sensitive with respect to the outcome of stress tests. The approach used in this paper is meant to be menu for future analyses of the impact of potential spillovers. Sensitivity analysis and reverse stress tests appear to be an important complement in this context.

APPENDIX 1. OUTCOME OF PANEL REGRESSIONS ASSESSING SPILLOVER RISKS

Table I.1. Panel Regressions, 2006Q1–2012Q2 (Dependent variable: Sovereign Spreads of 35 sample countries)
(Quarterly data)

Explanatory VARIABLES[1]	(1)	(2)	(3)	(4)	(5)	(6)
GIIPS spread	0.237***	0.244***				
	(0.045)	(0.047)				
GIP spread			0.288***	0.289***		
			(0.046)	(0.047)		
Italy/Spain spread					0.611***	0.653***
					(0.09)	(0.094)
High-yield spread	0.666***		0.621***		0.357	
	(0.242)		(0.229)		(0.30)	
VIX		0.348		0.342		-0.070
		(0.238)		(0.229)		(0.291)
Openness	0.015	0.015	0.031*	0.030*	0.025	0.025
	(0.017)	(0.017)	(0.016)	(0.016)	(0.020)	(0.021)
M2/GDP	0.080***	0.078***	0.061***	0.060***	0.053***	0.051**
	(0.017)	(0.017)	(0.016)	(0.016)	(0.020)	(0.020)
Constant	0.297**	-0.632	0.256*	-0.660	0.700***	0.997
	(0.131)	(0.744)	(0.136)	(0.718)	(0.166)	(0.912)
R-squared (within)	0.77	0.70	0.79	0.73	0.79	0.78
Observations	415	415	435	435	454	454
T	25	25	23	23	26	26

Standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$
[1] Right Hand side variables are in logs.

Table I.2. Panel Regressions, 2008Q1–2012Q2 (Dependent variable: Sovereign Spreads of 35 sample countries)
(Quarterly data)

Explanatory VARIABLES[1]	(1)	(2)	(3)	(4)	(5)	(6)
GIIPS spread	0.492***	0.463***				
	(0.105)	(0.106)				
GIP spread			0.511***	0.479***		
			(0.090)	(0.090)		
Italy/Spain spread					1.002***	0.998***
					(0.173)	(0.175)
High-yield spread	1.042***		1.033***		0.735**	
	(0.299)		(0.279)		(0.366)	
VIX		0.823**		0.813***		0.517
		(0.322)		(0.301)		(0.397)
Openness	0.018	0.017	0.034*	0.033*	0.033	0.032
	(0.021)	(0.021)	(0.019)	(0.019)	(0.027)	(0.027)
M2/GDP	0.078***	0.075***	0.057***	0.056***	0.045*	0.043*
	(0.020)	(0.020)	(0.018)	(0.018)	(0.025)	(0.025)
Constant	-0.133	-2.418**	-0.216	-2.459**	0.308	-1.117
	(0.222)	(1.084)	(0.222)	(1.022)	(0.246)	(1.307)
R-squared (within)	0.93	0.78	0.91	0.78	0.91	0.85
Observations	321	321	357	357	341	341
T	18	18	18	18	18	18

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
[1] Right Hand side variables are in logs.

Table I.3. Main Explanatory Variables

Factor	Variable	Description
Sovereign Risk	GIIPS spread	Average of Euro periphery sovereign spreads to German Bunds
	GIP spread	Average of Greece, Ireland and Portugal sovereign spreads to German Bunds
	Italy/Spain spread (IS spread)	Average of Italy and Spain sovereign spreads to German Bunds.
Risk aversion	High-yield spread	Difference between yields to maturity of AAA rated and BAA rated corporate US bond
	VIX	Implied volatility of S&P 500 index options.
Macroeconomic environment	Openness	Sum of imports and exports to GDP ratio
	M2/GDP	Broad money to GDP ratio

Source: Authors

Appendix II. Outline of the DCC GARCH Method

The DCC model is estimated in a three-stage procedure. Let r_t denote an *n x 1* vector of asset returns, exhibiting a mean of zero and the following time-varying covariance:

$$r_t \mid \Im_{t-1} \sim N\left(0, D_t R_t D_t\right) \quad (1)$$
$$\text{where } D_t = diag\left\{\sqrt{h_{it}}\right\}$$

Here, R_t is made up from the time dependent correlations and D_t is defined as a diagonal matrix comprised of the standard deviations implied by the estimation of univariate GARCH models, which are computed separately, whereby the i^{th} element is denoted as $\sqrt{h_{it}}$. In other words in this first stage of the DCC estimation, we fit univariate GARCH models for each of the five variables in the specification. In the second stage, the intercept parameters are obtained from the transformed asset returns and finally in the third stage, the coefficients governing the dynamics of the conditional correlations are estimated. Overall, the DCC model is characterized by the following set of equations (see Engle, 2002, for details):

$$\begin{aligned}
D_t^2 &= diag\{\omega_i\} + diag\{\kappa_i\} \circ r_{t-1}r'_{t-1} + diag\{\lambda_i\} \circ D_{t-1}^2 \\
\varepsilon_t &= D_t^{-1} r_t \\
Q_t &= S \circ (\iota\iota' - A - B) + A \circ \varepsilon_{t-1}\varepsilon'_{t-1} + B \circ Q_{t-1} \\
R_t &= diag\{Q_t\}^{-1} Q_t diag\{Q_t\}^{-1} \\
S &= E[\varepsilon_t \varepsilon'_t]
\end{aligned} \quad (2)$$

Here, S is defined as the unconditional correlation matrix of the residuals ε_t of the asset returns r_t. As defined above, R_t is the time varying correlation matrix and is a function of Q_t, which is the covariance matrix. In the matrix Q_t,ι is a vector of ones, A and B are square, symmetric and ∘ is the Hadamard product. Finally, λ_i is a weight parameter with the contributions of D_{t-1}^2 declining over time, while κ_i is the parameter associated with the squared lagged asset returns. The estimation framework is the same as in Frank, Gonzalez-Hermosillo and Hesse (2008) or Frank and Hesse (2009).

APPENDIX III. BENCHMARK STRESS SCENARIOS

Scenario	**Moderate Stress Scenario**	**Medium Stress Scenario**	**Severe Stress Scenario**	**Very Severe Stress Scenario**
Severity (x times Lehman/1)	0.25	0.5	1	2
Liquidity Outflows				
Customer Deposits				
Customer deposits (Term)	2.5 percent	5 percent	10 percent	20 percent
Customer deposits (Demand)	5 percent	10 percent	20 percent	40 percent
Wholesale Funding				
Short-term (secured)	5 percent	10 percent	20 percent	40 percent
Short-term (unsecured)	25 Percent	50 Percent	100 Percent	100 Percent
Contingent liabilities	0 Percent need funding	5 Percent need funding	10 Percent need funding	20 Percent need funding
Liquidity Inflows				
Haircut for Cash	0 Percent	0 Percent	0 Percent	0 Percent
Haircut for Government Securities/2	1 Percent	2 Percent	5 Percent	10 Percent
Haircut for Trading Assets/3	3 Percent	6 Percent	30 Percent	100 Percent
Proxies, specific assets	Equities: 3; Bonds: 3	Equities: 4-6; Bonds: 3-8	Equity: 10-15; Bonds (only LCR eligible ones): 5-10	Not liquid
Haircut for other securities	10 Percent	30 Percent	75 Percent	100 Percent
Proxies, specific assets	Equities: 10; Bonds: 10	Equities: 25; Bonds: 20 (some not liquid)	Equity: 30; Bonds (only LCR eligible ones): 20-30	Not liquid
Percent of liquid assets encumbered/4	10 Percent (or actual figure)	20 Percent (or actual figure plus 10 ppt)	30 Percent (or actual figures plus 20 ppt)	40 Percent (or actual figures plus 30 ppt)

1/ The Lehman type scenario would correspond to a scenario encountered by banks that were hit severely during the 30 day period after the Lehman collapse, i.e. a stress situation within a stress period rather than an average; The scenario has been put together based on expert judgment, using evidence as available.

2/ The haircut highly depends on the specific features of the government debt held (rating, maturity, market depth) and can be higher or lower. The figures displayed herein are meant for high quality investment grade bonds, taking into account recent market conditions. The same applies for the remainder of the liquid assets. For the securities in the trading book, it is assumed that they are liquidated earlier, resulting to lower haircuts.

3/ A haircut of 100 Percent means that the asset is illiquid, i.e., the market has closed.

4/ The figures account for a downgrade of the bank, which triggers margin calls, and higher collateral requirements for generally. Please note that the unencumbered portion applies to a gradually narrower definition of liquid assets.

Source: Schmieder, Hesse and others (2012)

APPENDIX IV. ILLUSTRATIVE EXAMPLE FOR THE SOLVENCY TEST

The table provides an illustrative example for a hypothetical bank in Austria.

Step 1.1: Spillover impact in sovereign debt markets observed for Austria

Scenario (increase of GIIPS sovereign debt spreads by…)	Impact on Austria, average for 2006-2012		Impact on Austria during peak spillover stress (2008-2012)	
	Increase of spreads (bps)	Source	Increase of spreads (bps)	Source
100 bps (2a)	24.4[33] (=24*1.017)	Table I.1, spec (2[34]), Figure 1, top right hand panel	49.8[35] (=49*1.017)	Table I.2, spec (1), Figure 1, top right hand panel
200 bps (2b)	48.8	Same, linear increase assumed	99.6	Same, linear increase assumed
300 bps (2c)	73.2	Same, linear increase assumed	149.4	Same, linear increase assumed

Source: Authors

[33] The average impact of stress (in terms of GIIPS spreads) on Euro area countries is 24 basis points (based on the panel analysis, see Table I.1) and for Austria the relative severity of this impact approximately matches the impact observed for the EU, i.e. it is 1.0 times of this level (GARCH analysis, average impact from 2008–12 based Figure 1, top right hand panel, relative to average of the average impact for other EU countries).

[34] We used the higher impact on the GIIPS spreads from Table I.1 and Table I.2, i.e. specification 2 (Table I.1) and 1 (Table I.2), respectively, i.e. 24 bps and 49 bps, respectively.

[35] The average impact of stress on Euro area countries is 49 basis points (based on the panel analysis, Table I.2) and for Austria the impact is again estimated to be at a similar level (GARCH analysis, average impact from 2008–12, Figure 1, top right hand panel, relative to average of the average impact for other EU countries).

Step 1.2: GDP trajectory for Austria, adjusted for the impact of spillovers

- GDP Elasticity of widening of spreads for Austria estimated for two year period from 2013-2014: 3.5 (based on IMF , 2012)[36]

Trajectory based on evidence for 2006-2012 (i.e., less significant spillovers)

Scenario	2012	2013	2014	Cumulative deviation of output from 2012 real GDP growth level (2013-14), ppts
Baseline (1)	0.9	1.8	2.2	2.2
(2a/1)	0.9	1.4 (=1.8-0.5*3.5*0.244)	1.8 (=2.2-0.5*3.5*0.244)	1.3
(2b/1)	0.9	0.9 (=1.8-0.5*3.5*0.488)	1.3 (=2.2-0.5*3.5*0.488)	0.4
(2c/1)	0.9	0.5 (=1.8-0.5*3.5*0.732)	0.9 (=2.2-0.5*3.5*0.732)	-0.4

Trajectory based on evidence for 2008-2012 (i.e., more significant spillovers)

Scenario	2012	2013	2014	Cumulative deviation of output from 2012 real GDP growth level (2013-14), ppts
Baseline (1)	0.9	1.8	2.2	2.2
(2a/2)	0.9	0.9 (=1.8-0.5*3.5*0.498)	1.3 (=2.2-0.5*3.5*0.498)	0.4
(2b/2)	0.9	0.1 (=1.8-0.5*3.5*0.996)	0.5 (=2.2-0.5*3.5*0.996)	-1.2
(2c/2)	0.9	-0.8 (=1.8-0.5*3.5*1.494)	-0.4 (=2.2-0.5*3.5*1.494)	-3

[36] The GDP elasticities of sovereign debt spreads vary between 0.5 (e.g. Brazil) and 3.5.

Step 2: Simulation of the impact at the bank level (Example for stylized bank)[37]

Change of key solvency parameters

	Loan impairment rates (Percent of credit exposure)			Pre-impairment income (Percent of total capital)		
Scenario	2012	2013	2014	2012	2013	2014
Baseline	0.5	0.4	0.4	10	10.3	10.5
2a/1	0.5	0.45	0.4	10	10.15	10.3
2b/1	0.5	0.5	0.45	10	10	10.1
2c/1	0.5	0.55	0.5	10	9.8	10
2a/2	0.5	0.5	0.45	10	10	10.1
2b/2	0.5	0.7	0.6	10	9.7	9.8
2c/2	0.5	0.9	0.8	10	9.2	9.5

Note: credit growth is assumed to be constant (for simplification)

Evolution of Risk-weighted Assets (RWAs) and Capital

	RWAs (Indexed)			Capital		
Scenario	2012	2013	2014	2012	2013	2014
Baseline	100	90	90	10	10.58	11.21
2a/1	100	95	90	10	10.57	11.18
2b/1	100	100	95	10	10.56	11.15
2c/1	100	105	100	10	10.54	11.12
2a/2	100	100	95	10	10.56	11.15
2b/2	100	120	111	10	10.52	11.08
2c/2	100	140	132	10	10.47	10.99

Note: For simplification, RWA elasticity to credit losses assumed to be 0.5, i.e., for a 1 percentage point change of credit loss rates RWAs will change by 0.5 percentage points.

Evolution of the Bank's Capital Ratio

	Capital Ratio (= Capital/RWA, Percent)		
Scenario	2012	2013	2014
Baseline	10.0	11.8	12.5
2a/1	10.0	11.1	12.5
2b/1	10.0	10.6	11.7
2c/1	10.0	10.0	11.1
2a/2	10.0	10.6	11.7
2b/2	10.0	8.8	9.9
2c/2	10.0	7.5	8.3

[37] See Hardy and Schmieder (2013) for further information.

APPENDIX V. ILLUSTRATIVE EXAMPLE FOR LIQUIDITY

This appendix V provides an illustrative example for a hypothetical bank in Austria.

Step 1: GDP trajectory for Austria, adjusted for the impact of spillovers

The first steps uses the same GDP trajectories as for solvency (see Appendix IV). Accordingly, the severity of the liquidity shock is simulated relative to the Lehman Brothers benchmark scenario in Appendix III. Specifically, based on the observation that the cumulative U.S. real GDP growth deviated by about 8 percentage points from the long-term average, the corresponding figures are computed for each of the scenarios. For Austria (and for the other European countries), the baseline growth rates for 2013-2104 (i.e., 2 percent) are (for simplicity) used as a proxy for the long-term trend. For scenario 2c/2, the cumulative deviation from the baseline is 5.2 percentage points. For the severity of the liquidity test, we therefore use the stress parameters for the severe scenario in Appendix III multiplied by a factor of 0.65 (=5.2/8).

Step 2: Simulation of the impact at the bank level (Example for stylized bank)[38]

Relevant asset and liability balance sheet items are shocked based on the severity of each scenario, i.e., the stress factor (such as 0.65) multiplied by the respective stress parameters. The balance sheet items are taken from Bankscope. For the LTRO, the available total funding was assigned to the single banks based on their size, using the available evidence for the total at the country level.

In the table below, scenario 2c/2 is simulated for a stylized bank based on Austria. The composition of the banks' asset and liabilities resemble those of an average OECD bank.[39] The stress factor reduces the haircuts and outflows of the benchmark scenario. In the example, the bank is able to generate an inflow of 21.5 units of assets, compared to a required level of 13.7 units, whereby the bank remains liquid.

[38] See Schmieder and others (2012) for further information.

[39] See Schmieder and others (2012), p. 38, for more information.

Assets (of stylized bank)				
	Portion of total[40]	Haircut, Percent (Appendix 3)	Haircut Scenario 2c/2	Available assets (fire sales)
Cash and cash-like	4	0	0	4.0
Government securities	6	5	3	5.8
Trading securities	5	30	20	4.0
Other securities	15	75	49	7.7
Loans	60	NA	NA	
Other	10	NA	NA	
Liabilities (of stylized bank)				
	Portion of total[41]	Outflow, Percent (Appendix 3)	Outflow Scenario 2c/2	Required funding
Customer Term deposits	30	10	6.5	2
Customer Demand deposits	20	20	13	2.6
Secured short-term wholesale funding	10	20	13	1.3
Unsecured short-term wholesale funding	10	100	65	6.5
Long-term funding	20	0	0	0
Equity based funding	10	0	0	0
Contingent liabilities	20	10	6.5	1.3

[40] Aligned to the average composition of OECD banks' balance sheets. See Schmieder and others (2012), p. 38.

[41] Aligned to the average composition of OECD banks' balance sheets. See Schmieder and others (2012), p. 38.

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