Stress Testing—The Link between Macro and Micro

Introduction to a Special Issue of the International Journal of Central Banking

Iman van Lelyveld

The events since autumn 2007 have highlighted a need to test the assumptions of industry risk measurement and pricing models and anticipate the potential impact of changes in financial market conditions that are significantly outside the bounds of historical norms. Stress testing is a generic term that is frequently used to describe a variety of techniques that are applied to assess the importance of assumptions that underlie economic models and forecasts.

Stress tests can be simple or complex, and they can be performed at many different levels of aggregation, including at the portfolio level, at the institution level, or at an aggregate level for a nation's entire financial system. Stress tests may, for example, be used to assess the economic impact of a single economic shock like a drop in equity prices or a spike in default rates. Alternatively, stress tests may involve the use of multiple econometric models to arrive at an assessment of the systemwide implications of a complex macroeconomic scenario. Various types of stress tests are regularly employed by individual banks, central banks, and financial supervisory authorities to assess the potential impacts of events that include slowdowns in economic activity, breakdowns in market mechanisms, violations of modeling assumptions, or changes in historical correlation and investor behavior patterns.

Stress testing features prominently in the context of Basel II, where stress tests are (i) a means for adjusting average probabilities of default (PDs) for stress conditions (Pillar 1); (ii) a procedure for assessing the robustness of IRB risk parameters such as PD or loss given default (LGD) (Pillar 1); (iii) a requirement to assess the impact of economic recession on regulatory capital requirements (Pillar 1 "cyclicality stress test"); and (iv) a means to assess the global impact on a bank's risk profile and capital adequacy of adverse events or changes in market conditions including counterparties' ability to honor financial contracts (Pillar 2).

While the need for sound stress-testing practices is a cornerstone of modern risk management and a requirement in both Pillar 1 and

2 of Basel II, stress-testing practices within banks remain underdeveloped. The 2005 report by the Committee on the Global Financial System (CGFS 2005) found that stress-testing practices in the institutions it surveyed included only a limited number of risks and focused on traded portfolios. Subsequent events have shown that banks have indeed relied too much on models that were based on normal states of the world.

In response to recent events, many supervisory groups have reemphasized the need for enhanced stress-testing practices, and many are in the process of undertaking studies that will lead to enhanced supervisory stress-testing guidance.[1] In contrast to these newly initiated supervisory efforts, most of the papers in this special issue were initiated much earlier by the Research Task Force Stress Testing subgroup (RTF ST group, mandated by the Basel Committee on Banking Supervision). This group was formed more than three years ago with a remit to study stress-testing issues related to infrequently traded and illiquid portfolios and best practice in modeling the link between macroeconomic risk drivers and the microeconomic models that are typically used to estimate credit losses in financial stability stress-testing models. Note that the boundary between what constitutes a traded or a nontraded portfolio is sometimes an arbitrary one, and recent events have shown that this boundary will shift in times of turmoil. Nevertheless, some exposures are more difficult to trade (and evaluate) than others.

For the longer term, formulating macroprudential policy might be another area where the papers in this volume might inform the debate. A consensus on what macroprudential policy entails precisely is yet to emerge, but understanding the link between macro risk drivers and micro credit-risk measures is surely important if we, for instance, want to curb excessive risk buildup in financial systems.

The RTF ST group has delivered on its mandate, and its findings and recommendations have been taken on board by the other, more policy-oriented groups of the Basel Committee. In addition, the group members produced research papers and organized a conference

[1] Supervisory groups that have studied stress tests include the FSF Working Group on Market and Institutional Resilience, the Senior Supervisors Group, and various Basel Committee subgroups.

at which academics presented their insights.[2] The present special issue provides a selective overview of what the state of play is in modeling the link between macro risk drivers and micro risk measures, especially under stressed conditions.

This special issue has four types of papers. First, we start with a thorough overview of how central banks and supervisory agencies have approached this issue, written by Foglia. It is thus an overview of where we stand. Next, we have a paper (Allesandri et al.) that proposes a framework for modeling these issues. The third type consists of those papers that, in a sense, would fit in the framework just sketched, although they are well-rounded modeling exercises in their own right. The papers written by Åsberg and Shahnazarian, Bernhardsen and Syversten, Duellmann and Erdelmeier, and Simons and Rolwes fit in this category. Finally, we have a more methodological paper (Breuer et al.) on choosing scenarios. Let me now provide a little more detail on each of these papers.

The first paper, written by Antonella Foglia, documents how many central banks and authorities have built their own stress-testing tools in order to assess the stability of financial institutions.[3] These tools differ from those of financial institutions in that they are more focused on the stability of the financial system as a whole. Considerable research has been carried out in this area with regard to the macro-micro link of credit risk, which might also be helpful for advancing credit-risk stress testing of infrequently traded portfolios. Therefore, a review of the analytical expertise developed at central banks and supervisory authorities can offer useful suggestions to supervisors to build up a common analytical background that may be useful in their review process of the various stress-testing requirements of the Basel II framework. This review might also be a helpful input in designing currently hotly debated macroprudential tools and policies.

In the surveyed approaches, system-focused stress testing can be seen as a multistage process with four steps. The first step is

[2] Available RTF ST group papers not included in this issue are Castrén, Dées, and Zaher (2008), Castrén, Fitzpatrick, and Sydow (2009), Gutiérrez Girault (2008), and Huang, Zhou, and Zhu (2009).

[3] The paper is based on a survey on the quantitative methods used at selected central banks and supervisory agencies and has benefited greatly from group members' comments.

the design of the macroeconomic stress scenario. These are simulated using (i) structural macroeconomic models used by the central bank for macroeconomic forecasts and monetary policy analysis, (ii) (reduced-form) VAR models, and (iii) pure statistical methods that model the multivariate distribution of macro-financial variables using nonlinear dependency structures. In the second step of the process, macro variables are mapped to microeconomic indicators of banks' credit risk, usually by means of a "satellite" or auxiliary model. Unlike the macroeconomic model, the credit-risk satellite model is often estimated on individual banks' and even individual borrower data. These auxiliary models provide the link between macroeconomic stress scenario conditions and loan performance at the sector or bank level. One can distinguish between two modeling approaches: one based on data on *loan performance*, such as nonperforming loans (NPLs) and loan loss provisions (LLPs), and a second approach based on *micro-level data* related to the default risk of the household and/or the corporate sector. In both cases the dependent variable is regressed against various macroeconomic variables, such as the nominal interest rate, the inflation rate, the percentage change of real GDP, and the percentage change in the terms of trade. The macroeconomic model is then used in the third step to project the time path of macro variables under stress conditions. These estimates are fed into the auxiliary model of credit risk in order to determine the stressed credit quality indicators. The final step of the stress-testing process is usually an assessment of whether banks can withstand the assumed shock.

An important extension to the typical stress-test process focuses specifically on the impact measure. Instead of producing point estimates under any assumed stress scenarios, one important objective of the latest work is to derive a *credit loss distribution* for the banking system as a whole, extending to a systemwide analysis the framework adopted at a micro level by many financial institutions in their risk-management systems.

Finally, depending on the availability of detailed data, it is important to calculate the impact at the bank-by-bank level and not only for an aggregated portfolio of the entire system, in order to be able to understand the distribution throughout the system, which can be useful for understanding the potential for contagion and confidence effects on stability.

The paper by Allesandri et al. moves us from the current state of play to a proposed framework for assessing financial stability. In this model, the authors model the effects of macro shocks to UK banks on a highly detailed level. They incorporate asset-side feedbacks and network effects, and discern market, credit, and interest rate risk. The incorporation of network effects allows for contagious defaults as well.

Next we turn to four papers that each take a different approach to capture macro-micro linkage and answer the question of whether macroeconomic fluctuations are important for understanding credit risk. Researchers take two general approaches to answer this question. Some researchers analyze the dependence of credit-risk measures on observables like fluctuations in GDP. Others start from the idea that the business cycle is inherently unobservable.[4] With regard to the first approach, researchers either model the (expected) default of individual firms[5] or aggregate default numbers, sometimes at the sector level.[6] The most important lessons from these papers seem to be as follows:

- Adding macroeconomic information improves our understanding of credit risk. The study by Åsberg and Shahnazarian shows that forecasting default frequencies can be improved by including macroeconomic factors. Bernhardsen and Syversten show a similar result.
- There is a need to be mindful of hidden risks. Duellmann and Erdelmeier show that although direct exposures to one sector (the automobile sector) might be limited, risks might still be significant because this particular sector affects many other sectors in case of stress. Simons and Rolwes show that our understanding of aggregate defaults improves if shocks common to all sectors are accounted for. This is an alternative way to model the sometimes unobserved correlation between risks across sectors.

[4] Papers following this approach which were presented at the conference are Bruche and González-Aguado (2009), Koopman, Lucas, and Schwaab (2008), and Jiménez and Mencía (2009).

[5] Åsberg and Shahnazarian (2009), Bernardsen and Syversten (2009), Duellmann and Erdelmeier (2009).

[6] Simons and Rolwes (2009).

Last but not least, we turn to one of the key challenges in implementing stress tests: the scenarios chosen should be sufficiently bad to yield stressful results but not so outlandish that decision makers decide that such circumstances will not happen, at least not in their lifetime. This dynamic results in scenarios that are generally relatively mild. Breuer et al. propose a method to identify those scenarios that are extreme but not too extreme. As it is a flexible approach and straightforward to implement, it might be useful for practitioners and supervisors and central banks alike.

Taken together, the papers in this special issue provide a good overview of where the modeling of linkage between macro factors and micro risk drivers stands at this moment. It's clear that these models do not answer all the questions that the current crisis has brought to light. The almost universal collapse of the interbank money market and other wholesale markets and the importance of feedback effects are important aspects that are not well captured in these models, to mention just two issues. Nevertheless, the lessons drawn are relevant, especially once the financial system reverts to functioning normally. Credit risk at the portfolio level cannot be well captured if (exceptional) movements in macro factors are not incorporated in their modeling.

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