International Journal of Forecasting 30 (2014) 691–713

Contents lists available at ScienceDirect

International Journal of Forecasting

journal homepage: www.elsevier.com/locate/ijforecast

Stress-testing US bank holding companies: A dynamic panel quantile regression approach

Francisco B. Covas [a,*], Ben Rump [b], Egon Zakrajšek [a]

[a] Division of Monetary Affairs, Federal Reserve Board, United States

[b] Division of Banking Supervision & Regulation, Federal Reserve Board, United States

ARTICLE INFO

Keywords:
Macroprudential regulation
Stress tests
Capital shortfalls
Density forecasting
Quantile autoregression
Fixed effects

ABSTRACT

We propose an econometric framework for estimating capital shortfalls of bank holding companies (BHCs) under pre-specified macroeconomic scenarios. To capture the nonlinear dynamics of bank losses and revenues during periods of financial stress, we use a fixed effects quantile autoregressive (FE-QAR) model with exogenous macroeconomic covariates, an approach that delivers a superior out-of-sample forecasting performance relative to the standard linear framework. According to the out-of-sample forecasts, the realized net charge-offs during the 2007–09 crisis fall within the multi-step-ahead density forecasts implied by the FE-QAR model, but are frequently outside the density forecasts generated using the corresponding linear model. This difference reflects the fact that the linear specification substantially underestimates loan losses, especially for real estate loan portfolios. Employing the macroeconomic stress scenario used in CCAR 2012, we use the density forecasts generated by the FE-QAR model to simulate capital shortfalls for a panel of large BHCs. For almost all institutions in the sample, the FE-QAR model generates capital shortfalls that are considerably higher than those implied by its linear counterpart, which suggests that our approach has the potential to detect emerging vulnerabilities in the financial system.

Published by Elsevier B.V. on behalf of International Institute of Forecasters.

1. Introduction

The 2007–09 global financial crisis and its aftermath of stubbornly high unemployment and sluggish growth in the United States and Europe have spurred renewed calls for active macroprudential regulation, with the aim of preventing the build-up of risks in the financial system, while at the same time reducing the social and economic costs of financial instability. At its core, the macroprudential approach to financial regulation argues for the bridging of the gap between the traditional macroeconomic policies and the conventional microprudential regulation of financial institutions, in order to limit the economic fallout arising from a systemic distress in the financial sector (Acharya, Pedersen, Philippon, & Richardson, 2009; Bank of England, 2009). As part of that effort, in recent years, bank stress tests have become an indispensable part of the toolkit used by central banks and other regulators to conduct macroprudential regulation and supervision (Greenlaw, Kashyap, Schoenholtz, & Shin, 2012; Hanson, Kashyap, & Stein, 2011; Hirtle, Schuermann, & Stiroh, 2009).

When conducting a stress test, regulatory authorities typically employ a two-pronged approach. In the "bottom-up" approach, the models used to estimate losses and revenues employ proprietary granular data on institution-specific portfolios – provided by the banks under the condition of strict confidentiality – which contain detailed information about the characteristics of individual loans. A complementary approach involves "top-down" models, which rely on bank-level income and balance sheet data

* Corresponding author.
E-mail addresses: Francisco.B.Covas@frb.gov (F.B. Covas), Bernard.C.Rump@frb.gov (B. Rump), Egon.Zakrajsek@frb.gov (E. Zakrajšek).

0169-2070/$ – see front matter. Published by Elsevier B.V. on behalf of International Institute of Forecasters.
http://dx.doi.org/10.1016/j.ijforecast.2013.11.003

for generating estimates of the institution-specific and industry-wide losses and revenues. The results of the top-down stress testing models are particularly useful for benchmarking the aggregated results from the bottom-up models, as well as for evaluating the banks' proposed capital plans under different macroeconomic scenarios.[1]

In a top-down stress testing exercise – the primary focus of this paper – the paths of macroeconomic variables that correspond to a particular stress scenario are typically mapped into bank-specific capital outcomes using (log-) linear time series and/or panel-data econometric models. Although linear top-down models are used extensively by regulatory authorities around the world, they have some important shortcomings. In particular, a common criticism of such models relates to their inability to capture the nonlinear behavior of bank losses during periods of financial distress, dynamics that can generate significant capital shortfalls and are an important feature of the boom-bust nature of credit-driven cyclical fluctuations; see Drehmann, Patton, and Sorensen (2007) for a thorough discussion.

Our paper aims to improve on this aspect of the top-down stress-testing approach. Specifically, we propose a dynamic panel quantile econometric framework for the major components of net charge-offs and pre-provision net revenue, and use it to estimate the density forecasts of banks' regulatory capital ratios under a pre-specified stress scenario. This top-down approach, which is well-suited for capturing the nonlinear aspect of bank losses during cyclical downturns, does indeed generate density forecasts for losses that have relatively heavy right tails in periods of macroeconomic stress, a distinct feature of the data that is impossible to capture with the standard linear regression framework. In particular, we estimate a strong nonlinear effect in losses for several key loan portfolios, as well as in trading income, an especially volatile and cyclically-sensitive component of bank profits.

In our framework, the nonlinear behavior of losses is driven importantly by the dynamics of the loss process because the impact of the lagged response variable in a dynamic quantile model is generally estimated to be increasing in the quantiles of the innovation process. This result implies that an adverse shock to the credit quality of, for example, the residential real estate loan portfolio makes the associated charge-offs more persistent, an effect that significantly increases the thickness of the right tail of the density forecast for such losses. Furthermore, this mechanism is amplified as the out-of-sample forecast horizon expands, because a bank that draws a sequence of such negative shocks would see its losses escalate sharply over a relatively short period of time.

In contrast, the degree of persistence in a dynamic linear model is invariant to the size of the underlying shocks, and the density forecasts generated using linear panel-data models have much thinner tails. In fact, according to our pseudo out-of-sample forecasting exercise, the realized net charge-offs during the 2007–09 financial crisis are inside the multi-step-ahead density forecasts implied by the dynamic quantile model, but are frequently outside the density forecasts generated using the corresponding linear model, especially for the loan portfolios that were most affected by the recent crisis. These results provide a compelling argument that focusing on the conditional mean forecast is unlikely to reveal the full extent of the expected losses during a period of deteriorating economic conditions, and that stress tests should pay careful attention to outcomes at the tails of the distribution.

A key objective of stress tests is to determine whether banks' regulatory capital ratios will remain above a specified minimum threshold over the forecast horizon implied by a severe, but plausible, macroeconomic scenario. One important contribution of our top-down stress testing approach is that we use simulation methods to generate the density forecasts for bank losses and revenues – and the implied density forecasts for regulatory capital – objects that provide a complete description of the uncertainty associated with our forecasts. By focusing on the density forecasts – as opposed to the point forecasts, as is typically done in practice – we obtain an estimate of the probability distribution of all possible values of the variables of interest, conditional on a given macroeconomic scenario; for example, by estimating the conditional distribution of regulatory capital outcomes, we can calculate the probability that a bank will violate the specified capital threshold at any point during the forecast horizon. We can also calculate the expected capital shortfall, the amount of capital a bank would need to raise, on average, to ensure that it will not violate a regulatory capital requirement under a given macro scenario.

To evaluate the methodology proposed in the paper, we perform a pseudo stress test. Specifically, for a panel of large US bank holding companies (BHCs), we estimate a trajectory of projected capital shortfalls, conditional on the severely adverse macroeconomic scenario specified by the Federal Reserve in the actual stress test, the Comprehensive Capital Analysis and Review (CCAR) conducted in early 2012. Under these conditioning assumptions, our simulations indicate that the quantile autoregressive framework generates considerably higher capital shortfalls than those implied by the corresponding linear specification. In combination with more accurate out-of-sample forecasts, this result suggests that the top-down models based on quantile autoregressions have higher odds of identifying emerging vulnerabilities in the financial system than their linear counterparts, and thus they may prove to be more reliable early-warning systems.

This paper fits into the rapidly growing body of literature on applied macro stress testing. Comprehensive

[1] A somewhat different taxonomy is often used to classify macro stress test models: (1) portfolio credit risk models; (2) structural models; and (3) reduced-form models. In portfolio credit risk models – a widely used class of models – the default process is typically modeled using a probit model relating macroeconomic factors to the probability of default of individual firms or a portfolio of loans. In structural stress test models – the rarest category – a dynamic stochastic general equilibrium (DSGE) model is used to model the transmission of shocks to endogenous macroeconomic variables, which are then linked to loss and default rates through a "satellite" model. Reduced-form models – one class of models which are investigated in this paper – are typically time series or panel-data models that link charge-offs or loss provisions to macroeconomic factors. In general, these three classes of stress test models are concerned primarily with macroeconomic risk; an interesting overview of the various sources of bank risks from a practitioner's point of view is provided by Kuritzkes and Schuermann (2008).