A MACRO-FINANCE VIEW ON STRESS-TESTING

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For most financial practitioners, stress-testing is a "must-do" activity, even if it is not a regulatory requirement. Such stress-testing encompasses a wide range of sophisticated and quantitative exercises, including assessments of market, credit and liquidity risks. This article discusses several approaches and outlines a foundation for a robust and consistent stress-testing framework.

Risk-neutral valuation is widely used in academic and applied finance to model and simulate the behavior of security prices. However, this methodology has significant limitations. It is not well suited to forecast out-of-sample data and its model parameters lack clear economic interpretation. We argue below that a macro-finance approach may be more appropriate for forecasting and stress-testing exercises, even though such models may generate larger pricing errors than others (such as option theory formula models).

More importantly, option pricing models built as partial equilibrium modules cannot incorporate cross-asset correlation in a robust and transparent fashion. Additionally, they suffer from an assumption of market completeness. In contrast, macro-finance models clarify the role of real business cycles in asset price determination and can anchor expectations based on multiple sources of information. Critically, because they are built with general equilibrium techniques, macro-finance models better capture feedback effects and are thus more suited for comprehensive and consistent stress testing.

Among the more commonly used models three classes can be identified: large scale *Structural Macro Models, Dynamic Stochastic General Equilibrium models* (DSGE models), and *Vector Autoregressive Models* (VARs).

Structural Macro Models, developed by Laurence Klein (Nobel 1980) consist of large systems of aggregate demand and supply equations with explicit modeling of industries and macro sectors. They are not connected to economic theories of consumer decision and production.

Dynamic Stochastic General Equilibrium models, developed by Tom Sargent (Nobel 2011), Edward Prescott (Nobel 2004), and Robert Lucas (Nobel 1995), are modern macro-economic models with micro foundations. They account for the inter-temporal optimizing behavior of agents such as consumers, firms and government with rational expectations. These models also incorporate inter-temporal consistency and market-clearing conditions for both complete and incomplete markets. Central banks and other institutions often employ DSGE models, although they may limit them to key macro-economic series.

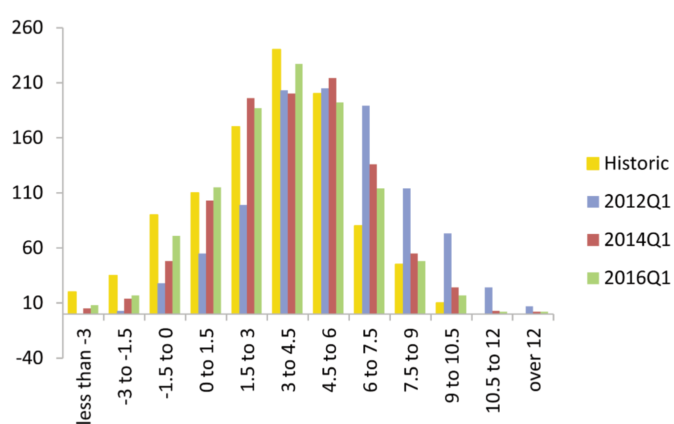
Vector Autoregressive Models and Structural VARs were pioneered by Chris Sims (Nobel 2011). These systems of equations are data-driven models and are generally easier to implement and maintain than other models discussed. They relate economic variables of interest to their specific history and to exogenous variables. Although they do not seamlessly connect to economic theory, they often serve as "work-horse" models for short-term forecasting. They are also suitable for satellite models that incorporate financial or other variables with an effect on the macro-economy.

Each of these models provides baseline forecasts, simulations, and system responses to one-variable shocks, and other relevant post-estimation outputs. They also maintain internal consistency based on the system's equilibrium conditions. An advantage of the macro-finance approach versus others is that the macroeconomic variables can be explicitly modeled (as opposed to being inferred from simulations on asset pricing models).

This is particularly important for practitioners who want to test their portfolios under particular events, something not easily performed with other models. They can build specific event-driven and data-driven scenario reflecting plausible economic developments like a double-dip recession or crisis in the Euro zone. These can be precisely calibrated such that a specific drop in GDP growth will translate to relevant unemployment, interest rates, housing prices, and so on. These forecasts and scenarios can then be viewed in the context of a distribution of economic outcomes that are consistent with a particular narrative of risks facing the economy. (Generally the baseline forecast will be the mean forecast interpreted as the most likely outcome of the model.)

Data-driven scenarios can be generated by drawing simulations around estimated DSGE or SVAR models constrained to follow relevant distributions, Monte Carlo simulations from normal distributions, or by drawing from the distribution of estimation errors in the historical sample (non-parametric bootstrapping). The latter captures richer dynamics in the data and should generate more interesting and accurate scenarios than some other approaches.

Real GDP Simulations, Annual Growth Rates, %



Source: Moody's Analytics

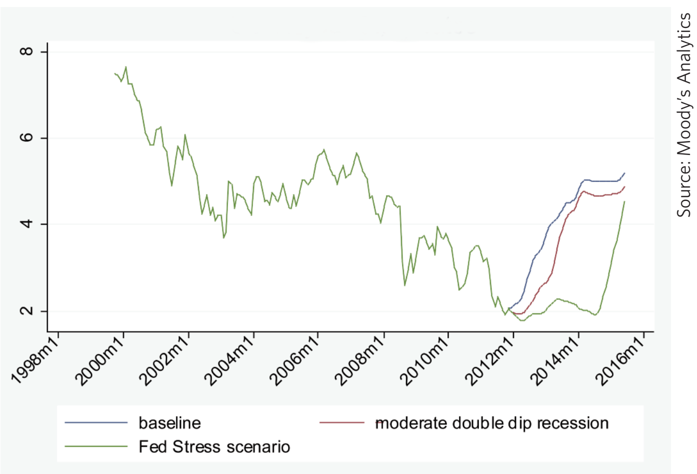
Stress-Testing Key Risk Parameters: Interest Rates, CDS Spreads & Ratings Migrations

The methodology to stress test in a general equilibrium framework uses "satellite" models with explicit links to macro variables.

Term Structure of Interest Rates

The macro-finance literature surveyed in Rudebusch (2010) models interest rates for different maturities as a function of two latent components extracted with factor analysis techniques: the so-called level and slope of the curve. These components are modeled as autoregressive processes related to the macro-economy through a term capturing expectations about the medium term inflation target (for the level) and through terms capturing the reaction of monetary policy to short run fluctuations in GDP and inflation (for the slope).

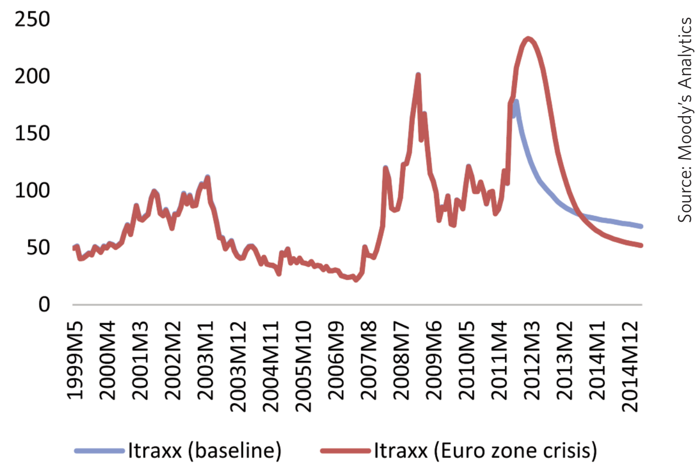
US 10 Year Swap Rates



Corporate CDS Spreads

The empirical behavior of corporate CDS indices has seldom been investigated in economic literature. A multivariate, parametric, semi-structural approach illustrated below uses explanatory variables based on modern portfolio theory. A principal component, the Corporate Credit Factor (CCF), extracts relevant information from the covariance matrix of different CDS indices, which are modeled as autoregressive processes exogenously driven by the CCF. Since CDS traders consider the information on corporate creditworthiness embedded in equity indices the CCF is specified as a function of a risk-appetite factor that captures the systemic corporate risk.

ITraxx Investment-grade CDS Index



Ratings Migrations

The evolution of ratings migration probabilities can be analyzed as a time series with three distinct groups be defined: (1) ratings that keep their status (diagonal of a transition matrix); (2) ratings that are downgraded or upgraded by one notch; (3) and ratings that are downgraded or upgraded by two or more notches. Ratings in the diagonal are fairly stable and can thus be modeled as the residual elements from the one- and two (or more)-notch movements. One-notch movements are interrelated to a high degree and are modeled as a constrained VAR process.

A set of exogenous variables may be included to account for the economic cycle and used to model shocks to the system based on various scenarios. The key feature of movements of two (or more) notches is that their observations are either zero[1] or small positive values, which suggests the use of discrete-choice models. This dual behavior is captured by means of a two-part model: The first designed to predict the occurrence of zeroes, the second is conditional on positive observations. The final model for these transitions is the joint probability of the two parts.

Concluding Remarks

Maintaining consistent scenarios and accounting for cross-correlation across assets requires a fully specified general equilibrium model. Since stress-testing exercises can suffer from correlation biases, macro-financial models may provide a more appropriate framework. To facilitate forecasting and stress testing, we propose using consistent and comprehensive macro models and linking their tail distributional outcomes to relevant risk parameter. Depending on the nature of the asset class being analyzed, additional satellite models may be relevant. Examples include equity indexes, FX rates, and historical and option-implied asset volatilities.

[1] In magnitude, equivalent to zero.

ABOUT THE AUTHORS

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