The Contingent Claims Analysis Approach

Introduction to the Contingent Claims Analysis Approach for Stress Testing

Dale F. Gray • Andreas A. Jobst • Cheng Hoon Lim • Yingbin Xiao

Contingent claims analysis (CCA) is a risk-adjusted balance sheet concept. It derives a coherent measure of credit risk based on the impact of uncertain changes in future asset values relative to promised payments on the valuation of debt obligations. It translates this uncertainty into quantifiable risk indicators that measure risk exposures to reveal whether balance sheet risks are building or subsiding. Such quantitative risk indicators also incorporate forward-looking information. CCA represents a generalization of the option pricing theory pioneered by Black and Scholes (1973) and Merton (1973). It is forward looking by construction, providing a consistent framework based on current market conditions rather than on historical experience.

CCA determines the risk-adjusted balance sheet based on three principles: (1) the values of liabilities (equity and debt) are derived from asset dynamics; (2) liabilities have different priority (i.e., senior and junior claims); and (3) assets (such as the present value of income flows and proceeds from asset sales) follow a stochastic process. Assets may be above or below promised payments on debt, which represent the default barrier. When there is a chance of default, the repayment of debt is considered "risky," to the extent that it is not guaranteed in the event of default. Risky debt is decomposed into two components: (1) the default-free value of debt and deposits; and (2) the risk margin that compensates for the "expected loss to bank creditors" from default over a specific time horizon, which can be measured by the value of an implicit put option in the CCA model.[1] Because CCA combines market prices and balance sheet information to inform a risk-adjusted measure of individual default risk, the evaluation of solvency conditions is linked inherently to investor perception as implied by the institution's equity and equity option values (which determine the implied asset value of the firm conditional on its leverage and debt level).

CCA FOR INDIVIDUAL CORPORATE OR FINANCIAL INSTITUTIONS

Several widely used techniques have been developed to calibrate CCA. These methods use a combination of balance sheet information and forward-looking information from equity markets, which were first applied to individual corporate and extended to financial institutions (by Merton, Moody's KMV, and others). The market value of assets of corporations and financial institutions cannot be observed directly but can be implied using financial asset prices. From the observed prices and volatilities of market-traded securities, one can estimate the implied asset values and volatilities of the underlying assets in financial institutions.

Most CCA models use market information plus balance sheet information. An advantage of CCA is that it provides high-frequency risk indicators and is very useful in capturing the nonlinearity between market capitalization, assets, and expected losses/default probabilities. Many stress test models can accommodate default probabilities calculated from CCA/Merton-type models as inputs into the calculation of loss distributions used for value-at-risk (VaR) and capital adequacy

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[1] Note that if uncertainty in the risk-adjusted balance sheet is ignored, i.e., set to zero, the result is the accounting balance sheet where there is no measure of credit risk (i.e., implicit put option goes to zero if volatility is zero) (Gray and Malone, 2008).

assessments. Thus, CCA represents an alternative method for analyzing financial stability when detailed prudential data on individual bank performance are not available. The caveat is that markets can overreact, and, in some cases, illiquidity can distort prices and affect CCA-based indicators. In Chapter 23, Ruiz-Arranz demonstrates the use of CCA to determine the risk of and expected losses from corporate sector defaults in the United Kingdom and the most vulnerable economic sectors. The analysis is complemented by accounting-based debt-at-risk analyses of corporate and household balance sheets.

EXTENSIONS OF THE BASIC CCA FRAMEWORK

CCA represents a flexible modeling approach that can be applied to an array of analyses. They can be extended to measure sovereign risk and to analyze the impact of banking system risk on the sovereign and feedback effects to banking risk as well as funding costs; to estimate the relationship between macroeconomic factors and the time pattern of bank assets or credit risk indicators, which is then applied to stress scenarios to project banking risks; and to analyze government implicit and explicit contingent liabilities using the Systemic CCA framework. Another application of CCA is to use short-term assets and liabilities in financial institutions to measure and analyze liquidity risk and systemic liquidity risk.

Measuring sovereign risk

CCA can be applied to determine the interaction between the risk-adjusted balance sheets of the government and monetary authorities. A marked-to-market balance sheet may be constructed to provide a structural framework that identifies balance sheet risks, incorporates uncertainty, and yields quantifiable risk indicators. The main outputs of this framework include sovereign credit risk indicators for foreign currency debt, sensitivity measures, and sovereign VaR. These sovereign risk indicators incorporate both forward-looking market prices and nonlinear changes in values and should consequently have greater predictive power in estimating sovereign credit risk than would traditional macroeconomic vulnerability indicators or accounting-based ratios. Gapen and others apply CCA to 12 emerging market economies in Chapter 24 to estimate the risk indicators for foreign currency debt. CCA also can be adapted to sovereigns that have only local currency debt—the calibration process uses debt data and the term structure of sovereign credit default swap (CDS) and bond spreads (Gray and Jobst, 2010a, 2010b).

Using the CCA approach to analyze sovereign risk has merits from a policy and stress testing perspective. The ability of the CCA approach to provide a structural interpretation of the sovereign balance sheet, unique to each economy, is a valuable contribution in the area of policy design and risk management, translating policy choices and changing economic conditions directly into quantitative indicators of financial soundness. It is well suited to a more robust analysis of debt sustainability as compared with the widely used debt-to-GDP ratio, which is a static, backward-looking accounting indicator.

Linking banks to macroeconomic factors for stress testing

CCA can be used with satellite models that link macroeconomic factors to the bank CCA model. Econometric relationships can be estimated between macro factors and the implied bank assets, distance to distress, or default probability or expected losses. Then stress test scenarios of macroeconomic factors can be used to project changes in bank assets, which in turn affect the bank credit risk indicators and equity value. One application of this type of approach is described by Gray and Walsh in Chapter 25. The study estimates risk indicators for the major Chilean banks using CCA, which are linked to macroeconomic and financial factors. The scenarios derived in the chapter illustrate how stress testing can be used with the CCA bank model to assess the magnitude and persistence of responses of bank credit risk across banks in the system.

Jointly stress testing banking and sovereign risk

CCA can be applied to analyzing banking sector and sovereign risk feedbacks. It allows sovereign risk to be measured as an exposure (expected loss to holders of sovereign debt and sovereign spreads) instead of an accounting ratio (sovereign debt to GDP). CCA can capture nonlinear feedbacks that lead to bank and sovereign destabilization spirals. For example, the negative impact on banks of holding sovereign debt can lead to higher sovereign contingent liabilities leading to increased sovereign risk (higher spreads), which in turn further reduces the value of banks' sovereign debt holdings. The vicious circle eventually leads to a weakening in sovereign support, leading to higher bank spreads and funding costs (Gray and Jobst, 2010a, 2010b, 2011a, 2011b). Finally, the systemic risk dynamics are interlinked with important new measures of risk-adjusted economic output value via the CCA economy-wide balance sheets (Gray and Malone, 2010).

Measuring the size and impact of government support/guarantees

Relatedly, CCA facilitates measurement and analysis of implicit and explicit government guarantees and their impact on bank funding costs. The expected losses calculated for each financial institution from equity market and balance sheet information using CCA can be combined with information from CDS markets to estimate the government's contingent liabilities (Gray and Jobst, 2009). The price of insuring against default by a financial institution is reflected in its CDS spreads, which capture only the expected loss *retained* by the financial institution and borne by unsecured senior creditors. Thus,

the difference between the implied CDS and the actual CDS spreads reflects the explicit and implicit guarantees.

Measuring systemic risk ("Systemic CCA" and "Systemic risk-adjusted liquidity")

The Systemic CCA is a forward-looking, market data–based analytical framework for measuring joint default risk of financial institutions using an advanced form of CCA (Gray and Malone, 2010; Gray and Jobst, 2011c; Jobst and Gray in Chapter 26). It extends the risk-adjusted balance sheet approach underpinning CCA by modeling systemic risk of multiple institutions with "too-big-to-fail" properties falling into distress as a portfolio of individual expected losses, which are calculated from equity market and balance sheet information. Changes in market conditions (and their impact on the perceived risk profile of each firm via its equity price and volatility) establish market-induced linkages based on their sensitivity to common risk factors, which define the dependence structure of individual expected losses. Accounting for both linear and nonlinear dependence and its effect on joint expected losses can deliver important insights about the joint tail risk of multiple entities, and this method of measuring "tail dependence" is better suited to analyzing extreme linkages of multiple entities over time.

The Systemic CCA approach can be used to quantify the contribution of specific institutions to the dynamics of the components of systemic risk. The application of this methodology to the U.K. banking sector is discussed by Jobst and Gray in Chapter 26. In addition, CCA offers a promising framework for measuring and analyzing systemic liquidity risk by using the short-term risk-adjusted balance sheet with the default barriers calibrated to reflect rollover risk. Jobst applies the systemic risk-adjusted liquidity (SRL) dynamic factor model to U.S. banks in Chapter 27 and demonstrates its use within a stress testing framework.

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