Measuring and Analyzing Sovereign and Financial Risks and Feedbacks Using Contingent Claims Analysis (CCA)

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Presentation to Macro Financial Modeling Conference

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The views expressed in this presentation are those of the authors and should not be attributed to the International Monetary Fund, its Executive Board, or its management.
Outline of Presentation

Contingent Claims Analysis (CCA)

Applications:


Economy-wide interlinked CCA balance sheets (household, commercial real estate, banking, sovereign) applied to the Irish banking and sovereign crisis

Paper 2: “Modeling Banking, Sovereign, and Macro Risk in a CCA Global VAR” Gray, Gross, Sydow, Paredes 10/2013

Joint work with ECB - 15 European countries plus US with banking, sovereign, and corporate CCA risk indicators and macro variables in Global VAR
Traditional Analysis is Incomplete

- Traditional macroeconomic and banking models do not adequately measure risk exposures of financial institutions and sovereigns and cannot be used to understand the transmission and amplification of risk within and between balance sheets in the economy.

- Sovereign debt analyses focus on debt sustainability (stocks, flows and debt to GDP), not sovereign risk exposures (contingent liabilities, expected losses on sovereign debt).

- A fundamental point is that accounting balance sheets or a flow-of-funds do not indicate risk exposures, which are forward-looking.
Macrofinancial Risk Analysis

- Framework integrates risk-adjusted balance sheets using Contingent Claims Analysis (CCA) and default risk into macro financial models. CCA is an excellent tool for analyzing macrofinancial linkages.

- Time pattern of CCA risk indicators can be linked to macroeconomic variables and to monetary policy, DSGE, and other models.

TOOLKIT FOR MACRO RISK ANALYSIS
Core Concept of Contingent Claims Analysis (CCA): Merton Model

- Value of liabilities derived from value of assets.
- Liabilities have different seniority.
- Randomness in asset value.

Assets = Equity + Risky Debt
= Equity + Default-Free Debt – Expected Loss
= Implicit Call Option + Default-Free Debt – Implicit Put Option
CCA is Generalization of Black, Scholes, Merton Option Pricing Theory

- Liabilities derive their value from assets
- Assets are stochastic (changes driven by income flows, asset sales, or changes in value, including credit risk/guarantees)
- Uncertain changes in future asset value, relative to the promised payments on debt are the driver of forward-looking values of equity and risky debt.
- Key elements are Asset value (A) at time 0, asset return volatility (σ), default barrier (B = PV of promised payments on debt, time horizon (T) and risk-free rate (r).
- Note: one does not have to know the expected returns to use CCA/Merton models for valuation of liabilities!
CCA is Based on Proven, Well-tested Calibration Techniques

Tools and techniques for calibrating CCA balance sheets of corporates and financial institutions are decades old. Commercial sources available (e.g. Moody’s KMV)

The structural CCA model, with its embedded fundamental volatility, endogenously changes as values change

It helps explain complex risk, especially expected losses in financial system and “insidiousness” of risk exposures where small changes in value can lead to very large changes in risk due to convexity!
Banks and Corporates: Calibrate (Unobservable) Market Value of Asset and Implied Asset Volatility Using Market Data

**INPUTS**
- Value and Volatility of Market Capitalization, E
- Debt Distress Barrier B (from Book Value)
- Time Horizon

**USING TWO EQUATIONS WITH TWO UNKNOWNS**

\[ E = A \cdot N(d_1) - B \cdot e^{-rt} \cdot N(d_2) \]

\[ E \sigma_E = A \sigma_A \cdot N(d_1) \]

** Gives:**
- Implied Asset Value \( A \) and Asset Volatility \( \sigma_A \)
- Default Probabilities Spreads, Risk Indicators

Fair-value credit spread = \(-1/T(\ln(1-\text{Exp Loss}/B)) = -1/T(\ln(1-\text{Risk Neutral DP*LGD}))\)
Implicit and explicit government guarantees depress observed CDS spreads. We can use the difference to calculate the market implied government guarantee (contingent liability)
Tradeoffs between Market Capitalization, Market Value of Assets, Default Probability, and Expected Loss
Bank of Ireland Example (Moody’s KMV data, 2008)

Value of Bank Assets falls from 200 to 165 bn €

Market Cap falls 10 to 0.3 bn €

Default Probability increases from 0.3% to 16%

Expected Losses increase from 4 to 48 bn Euros
CCA has robustness

It does not depend on expected returns;

It does not depend on preferences;

It is designed to be modular (can be integrated with many models of consumption and investment);

Retains the (endogenous) non-linearity of values and risk exposures, and can linked to macro models in different ways.
CCA Balance Sheet: Assets Minus Liabilities equal Zero

For a sector, sub-sector or individual institution

CCA Balance Sheet

Assets
+or - Implicit or Explicit Guarantees \{Implicit Put Options\}

minus

Equity / Jr. Claim
\{Implicit Call Option\}

minus

(Default-free Value of Debt
– Implicit Put Option)

= 0
Inter-linkage of Banking Sector and Government CCA Balance Sheets

Government is short a portfolio of implicit financial guarantees \((-\sum_{l}^{k} \alpha_{G,B_l} P_{B_l})\).

\(PV(R_G - E_G) + A_{G,Other}\) is present value of the primary fiscal surplus and other assets. Banking sector distress cause higher guarantees which lowers sovereign assets, increasing the government’s expected losses (\(+P_{GLC}\))

<table>
<thead>
<tr>
<th></th>
<th>Financial</th>
<th>Government</th>
</tr>
</thead>
<tbody>
<tr>
<td>Banks ((j,1..k))</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Asset</strong></td>
<td>(A_{j})</td>
<td>(PV(R_G - E_G))</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(+A_{G,Other})</td>
</tr>
<tr>
<td><strong>Guarantees</strong></td>
<td>(+\alpha_{G,j} P_{B,j})</td>
<td>(-\sum_{1}^{k} \alpha_{G,B_l} P_{B_l})</td>
</tr>
<tr>
<td><strong>Equity/Jr. Claims</strong></td>
<td>(-E_{B,j})</td>
<td>(-E_G)</td>
</tr>
<tr>
<td><strong>Barrier</strong></td>
<td>(-\overline{B}<em>{B,j} - i</em>{B,j})</td>
<td>(-\overline{B}<em>{GLC} - i</em>{GLC})</td>
</tr>
<tr>
<td><strong>Put</strong></td>
<td>((1-\alpha_{G,B_l}) P_{B,j})</td>
<td>(+P_{GLC})</td>
</tr>
<tr>
<td><strong>Sum</strong></td>
<td>0</td>
<td>0</td>
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</tbody>
</table>
**Interlinked CCA Balance Sheets for an Economy (sectors are short and long risk exposures)**

<table>
<thead>
<tr>
<th></th>
<th>Corp Real Estate</th>
<th>Commercial Real Estate</th>
<th>Households</th>
<th>Financial Banks (j,1..k)</th>
<th>Government</th>
<th>Foreign</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asset</td>
<td>$A_C(f(I_p))$</td>
<td>$A_{CRE}$</td>
<td>$A_{FIN}$</td>
<td>$A_{H,RE}$</td>
<td>$A_j$</td>
<td>$PV(R_G - E_G)$ + $A_{G,Other}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$+A_L$</td>
<td>$+E_{H,RE}$</td>
<td></td>
<td></td>
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<tr>
<td>Cont.</td>
<td></td>
<td></td>
<td>$-E_C$</td>
<td>$-E_{CRE}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A &amp; L</td>
<td>$-E_H$</td>
<td>$-E_{H,RE}$</td>
<td>$-E_{B,j}$</td>
<td></td>
<td></td>
<td>$-E_G$</td>
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<tr>
<td>Equity/</td>
<td>$-C_H$</td>
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<tr>
<td>Jr. Claims</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Barrier</td>
<td>$-\bar{B}_C$</td>
<td>$-\bar{B}_{CRE}$</td>
<td>$-\bar{B}_{H,RE}$</td>
<td>$-\bar{B}<em>{B,j} - i</em>{B,j}$</td>
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<td></td>
<td>$-i_C$</td>
<td>$-i_{CRE}$</td>
<td>$-i_{H,RE}$</td>
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<td></td>
</tr>
<tr>
<td>Put</td>
<td>$+P_C$</td>
<td>$+P_{CRE}$</td>
<td>$+P_{H,RE}$</td>
<td>$(1 - \alpha_{G,Bj})P_{B,j}$</td>
<td>$+P_{GLC}$</td>
<td></td>
</tr>
</tbody>
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Source: Adapted from Gray and Malone 2008 and Gray, Merton, Bodie 2008

CCA values calculated using risk-free rate
Economy-wide CCA Balance Sheet Models Capture Non-linear Risk Transmission

- Interlinked implicit options result in compound options that exhibit highly non-linear risk transmission, as seen a variety of financial crises

- Note that if asset volatility in CCA balance sheets is set to zero:
  - Implicit put options go to zero; Measurement of (non-linear) credit risk and transmission is not possible
  - Call option “equity” equations become sector net worth equal to present value of Consumption plus Investment
  - Traditional macroeconomic inter-temporal budget constraint is the result, it’s the sector junior claim formula when volatility is 0! The change from one period to next gives macroeconomic accounting balance sheets and traditional flow-of-funds are the result.

See Background Annex slides and Appendix 2 of paper one for more details
Model Applied to Ireland: Risk Transmission from Household, Commercial Real Estate, Corporate, to Banks and then to Government

Household Consumption + Investment + Government Consumption ≈ Flow GDP

<table>
<thead>
<tr>
<th>Household</th>
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<tbody>
<tr>
<td>Financial Assets</td>
<td>Cons and Household Worth</td>
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<tr>
<td>Income</td>
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<tr>
<td>Equity in Household RE</td>
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<table>
<thead>
<tr>
<th>Household Real Estate Balance Sheet</th>
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<tbody>
<tr>
<td>Real Estate</td>
<td>Equity in Household RE</td>
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<tr>
<td></td>
<td>Risky Mortgage Debt</td>
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<tr>
<th>Corporate Sector Balance Sheet</th>
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<tbody>
<tr>
<td>Assets (f(Ip))</td>
<td>Equity</td>
</tr>
<tr>
<td>Risky Debt</td>
<td></td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th>Bank 1</th>
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<tbody>
<tr>
<td>Loans</td>
<td>Equity</td>
</tr>
<tr>
<td></td>
<td>Risky Debt</td>
</tr>
<tr>
<td></td>
<td>Deposits</td>
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</tbody>
</table>

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<tr>
<th>Bank 2</th>
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</thead>
<tbody>
<tr>
<td>Loans</td>
<td>Equity</td>
</tr>
<tr>
<td></td>
<td>Risky Debt</td>
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<tr>
<td></td>
<td>Deposits</td>
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<table>
<thead>
<tr>
<th>Government</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>(Revenues minus Expenditures)</td>
<td>Equity</td>
</tr>
<tr>
<td>Other Assets Minus Guarantees to Banks</td>
<td>Risky Sovereign Debt</td>
</tr>
</tbody>
</table>
Key Elements of the Ireland Property Boom/Bust, Banking Crisis followed by Sovereign Crisis

Property prices rose 450% in decade up to 2006, market correction starts in 2007.

Bank loan losses rise, bank share prices decline.

Fiscal position deteriorates substantially.

Fears of bank failure after Lehman, prompt government to provide blanket guarantee to banks Sept 30, 2008

Anglo Irish taken over in early 2009 followed by establishment of National Asset Management Agency to “clean-up” banks

Cost to government 35-40% GDP, sovereign crisis, IMF/EU/ECB bailout program starts 2010

Debt to GDP goes from 30% in 2006 to 115% in 2012; Fiscal deficit rises to 30% of GDP in 2010
Property prices (residential and commercial) fall 50% to 60% from 2007, stabilize in 2012

Source: Moody’s CreditEdge, author estimates
Transfer of Risk: Ireland CDS spreads of banks declined following blanket guarantees September 30, 2008 immediately triggering sovereign CDS spread increases
Market Implied Guarantee Costs for Three Major Irish Banks (Billion Euros)

Uses FVCDS and CDS to back out implicit government guarantee, 3 yr horizon; Anglo Bank drops out of sample in 2/2009
Growth Rates of Credit and GDP in Ireland

Growth Rate of Credit is correlated with increasing Implied Market Value of Bank Assets
Household Real Estate Assets, Liability Default Barrier, and Calculated Household Real Estate Equity and Expected Losses (Billion Euros)

High Income Household CCA Balance Sheet

Low Income Household CCA Balance Sheet

Household Real Estate BS uses time series of values of housing assets, default barrier then calculates the equity and expected losses
Comparison of Expected Losses from HH, CRE, and Corporates to Contingent Liability Estimates and to Actual Banking Losses Paid by Government (Billion Euros)

Sources: Author estimates, CreditEdge, Central Bank of Ireland data
Implied Sovereign Assets Closer to Default Barrier 2010-2011, with high Sovereign CDS spreads

Term structure of CDS inverted in 2010-2011
Household “Parent” Balance Sheet Assets (CCA estimated household equity, financial assets, income)

Household Consumption Declines, with a Lag, Compared to Decline in Total Assets

Different models can be used to model consumption out of assets, empirical or with utility functions; same with investment
Model Extensions and Further Applications

Model can be used for stress testing banks and sovereigns with feedbacks to real economy; brings default risk into models

Counterfactuals: curbing credit growth early on?, counter cyclical capital buffers and subordinated debt for banks?, Loan to Value ratios increases?

Good example warning on blanket guarantees, tool to analyze Too Big to Fail risks

Way forward to on combinations of policies to target growth while simultaneously targeting “safe level” of banking system and sovereign credit risk

Derive tradition inter-temporal budget constraint and flow of funds as special case where volatility is zero.

Estimate present value of risk-adjusted GDP i.e. CCA based economic output measure. (see Annex)
Spillovers from the Sovereign to the Banks and Banks to Sovereigns

DOMESTIC

SOVEREIGN

A. Mark-to-market fall in value of govt bonds held by local banks
B. Increase in bank funding costs
C. Erosion in potential for official support

E. Similar sovereigns come under pressure

FOREIGN

SOVEREIGN

D. Mark-to-market fall in value of govt. bonds held by foreign banks
F. Contagion channels (A, B, & C as above)

I. Increase in contingent liabilities of govt.

BANKS

I. Increase in contingent liabilities of govt.

G. Rise in counter-party credit risk
H. Withdrawal of funding for risky banks
Modeling Banking, Sovereign and Macro Risk in a CCA Global VAR
IMF WP 13/218 (joint work with ECB staff Marco Gross, Matthias Sydow, and Joan Paredes)

Framework for analysis the interactions of banking sector risk, sovereign risk, GDP growth, credit for 15 EU countries plus the US. (55 banks total)

Uses CCA risk indicators for the banking systems (derived from FVCDS) and corporate sectors and sovereigns in each country, Expected loss ratios from CCA for banks and corporates and sovereign EL backed out of sovereign CDS)

Together with the GVAR (Global Vector Autoregression) model for each country, endogenous weight matricies

Impulse responses captures the non-linearity of changes bank credit spreads, sovereign spreads and corporate credit risk and impact on GDP growth and credit
Model Structure: Inputs and scenarios/shock origins

CCA-GVAR Model Framework

CCA bank by bank risk indicators (53)
→
CCA banking system risk indicators (16)

CCA sovereign credit risk indicators (16)

CCA corporate credit risk indicators (16)

GVAR Model
(16 local country models)

GDP data (16 series)
Credit data (16)
Other

Weighting Matrices

Scenario Simulation

Scenario Responses

GDP growth IRs
Credit IRs
Banking system IRs
Corporate sector IRs
Sovereign IRs
INPUT DATA: Example of Ireland Risk Indicators (EL Ratios); GDP Growth and Credit Growth RHS
Nonlinear relationships for typical bank (EDF, capital ratio, EL, and FV spread) - “lower risk zone” and smaller “safe zone” show by red outlines

Distressed, high risk condition
OUTPUT RESPONSES TO Shock Scenario 1: Negative Shock to Spanish and Italian Sovereigns

Responses show increases in all sovereign and bank FVCDS spreads

SOVEREIGNS: FVCDS (bps)

ITALY and SPAIN sovereigns shock origins, 5% marginal prob; 0.7% joint prob
Scenario 1 (cont.)

Negative Shock to Spain and Italy
Sovereigns: Bank and
Sovereign FVCDS
increase; Real GDP
growth down; Credit
growth down
Shock Scenario 2

Positive Shock to Spain and Italy Sovereigns: Bank and Sovereign FVCDS to “safe zone”; Real GDP up; Credit Growth up

Real GDP

Credit
Scenario 3

Negative Shock to Spain and Italy Banks: Bank and Sovereign FVCDS increase; Real GDP growth down; Credit growth down
# Ongoing work on Quantitative Analysis of Various Risk Mitigation Policy Options to Mitigate Bank and Sovereign and Boost Growth

<table>
<thead>
<tr>
<th>On-Balance Sheet Adjustment Policies to Mitigate Risk to:</th>
<th>Risk Transfer-Type Instruments and Policies to Mitigate Risk to:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Banks</strong></td>
<td><strong>Sovereign</strong></td>
</tr>
<tr>
<td>Increase market capital</td>
<td>Increase regulatory capital; Increase solvency ratio</td>
</tr>
<tr>
<td>Increase assets and lower asset risk</td>
<td>Macroprudential policies that affect credit growth</td>
</tr>
<tr>
<td>Debt equity conversion/Bail-in</td>
<td>Extending debt maturity or restructuring</td>
</tr>
</tbody>
</table>

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**Source:** International Monetary Fund
Calibrating sovereign CCA balance sheets and modeling bank-sovereign destabilization risks

Better analysis of how components of GDP (household consumption, investment, and government consumption) are related to bank, corporate, and sovereign risk indicators (CCA-VAR models)

Stress testing sovereigns and banks together

Comparison of CCA and systemic CCA to other systemic risk models, such as S-Risk, MES, CoVaR
Background slides
5. UNIFIED MACROFINANCE FRAMEWORK

Targets: Inflation, GDP, Financial System Credit Risk, Sovereign Credit Risk

Financial Stability Policies:
- Capital Adequacy
- Financial Regulations
- Economic Capital

Monetary Policies:
- Policy Rate
- Liquidity Facilities
- Quantitative Actions

Fiscal and Debt Policies:
- Fiscal Policy
- Debt Management
- Reserve Management

Household CCA Balance Sheet(s)
Financial Sector CCA Model
Financial System Credit Risk Indicator
Monetary Policy Model
Sovereign CCA Balance Sheet Model
Global Market Claims on Sovereign
Interest Rate Term Structure
Guarantees
Sovereign Equity Claims (from Capital Injections)
Traditional Flow and Accounting Framework
No Risk-Adjusted Balance Sheets (Asset Volatility = 0)
No Credit Risk or Guarantees; No Risk Exposures

Financial Stability Policies:
- Capital Adequacy
- Financial Regulations

Monetary Policies:
- Policy Rate
- Liquidity Facilities
- Quantitative Actions

Fiscal and Debt Policies:
- Fiscal Policy
- Debt Management
- Reserve Management

Household Accounting Balance Sheet(s)
Bank Accounting Balance Sheets
Monetary Policy Model
Government Accounts Flow of Funds

Interest Rates
Credit Flows
Capital Injections

Global Market Flows

Corporate Accounting Balance Sheet(s)
References:

Macrofinancial Risk Analysis, Gray and Malone (Wiley Finance book Foreword by Robert Merton)


Garcia et al. 2011 “Incorporating Financial Sector into Monetary Policy Models: Case of Chile” IMF WP/11/228
Several Types of CCA Risk Indicators

Credit Risk Indicators:

- **Distance to Distress** (number of standard deviations of asset value from distress)
- **Default Probability**
  - Risk Neutral Default Probability = $N(-d_2)$
  - Estimated Actual Default Probability = $N(-d_2 - MPR)$
- Credit spread, $s$, in basis points
- Implicit Put Option (Expected Loss Value) and Value of Risky Debt (Default-free value of debt – expected loss)
- Expected Loss Ratio
Black-Scholes-Merton Equity Implicit Call Option Formula (Assets=A, Default Barrier=B, volatility of asset return (sigma), time horizon T, risk-free rate r)

\[
E(t) = A(t)N(d_1) - Be^{-rT}N(d_2)
\]

\[
d_1 = \frac{\ln\left(\frac{A}{B}\right) + \left(r + \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}
\]

\[
d_2 = \frac{\ln\left(\frac{A}{B}\right) + \left(r - \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}
\]
CCA Risk Indicators and Values

Value of Risky Debt, $D$ (B=distress barrier, P=implicit put option)

$$D = Be^{-rt} - P = Be^{-rt} - (Be^{-rt} N(-d_2) - A_0 N(-d_1))$$

$D$-to-$D$= 

$$d_2 = \frac{\ln\left(\frac{A_0}{B}\right) + \left( r_f - \frac{\sigma_A^2}{2} \right) t}{\sigma_A \sqrt{t}}$$

$$d_1 = d_2 + \sigma_A \sqrt{t}$$

Default Probability

Risk Neutral DP $N(-d_2)$

Estimated Actual DP $N(-d^*_2) = N(-d_2 - \lambda \sqrt{t})$

$$d^*_2 - d_2 = \frac{\mu_A - r_f}{\sigma_A} \sqrt{t} = \lambda \sqrt{t}$$

Credit Spreads

$$s_{SrDebt} = -\frac{1}{t} \ln \left( 1 - \frac{P_{BSr}}{B_{Sr} e^{-rt}} \right)$$
Setting Volatility to 0 in sector CCA equation

The implicit put option for an arbitrary sector is given by the formula

\[ P_t = B_t N(-d_{2t}) - (A_t + R_t) N(-d_{1t}) \]

The most junior claim, equity, is valued as a call option:

\[ J_t = (A_t + R_t) N(d_{1t}) - B_t N(d_{2t}) \]

where \( A_t \) now stands for the value of non-reserve assets, \( R_t \) is the value of reserve assets, and \( B_t \) is the default barrier, all at time \( t \).

Setting \( \sigma_A = 0 \) yields

\[ N(-d_{1t}) = N(-d_{2t}) = 0 \]

So that the implicit put option value goes to zero, \( P_t = 0 \) and
Call option “equity equation” becomes sector net worth equal to present value of Consumption plus Investment

With zero volatility \( N(d_1) = N(d_2) = 1 \) so that equity

\[
\tilde{J}_t \equiv J_t (\sigma_A = 0) = (A_t + R_t) - B_t
\]

Since the formula is not a contingent claims valuation when volatility is zero, we have defined the quantity \( \tilde{J}_t \equiv J_t (\sigma_A = 0) \) to denote the accounting “equity”, or accounting “net worth” calculation of deterministic assets minus a measure of the book value of debt. We will call \( \tilde{J}_t \) the sector “net worth.”

From a macroeconomic perspective, the net worth of each sector is tantamount to the inter-temporal budget constraint that lies at the core of the flow-of-funds calculation. If all consumption and investment expenditures are taken as discretionary, for simplicity, then at any time, the net worth of the sector is equal to the present value of consumption and investment expenditures:

\[
\tilde{J}_t = \sum_{i=0}^{\infty} \beta^i (C_{t+i} + I_{t+i})
\]
Traditional inter-temporal budget constraint is the result, it’s a sector junior claim formula when volatility is 0; change from one period to next gives flow of funds

The valuation formula for the net worth of the sector stated above is equivalent to the following inter-temporal budget constraint of the type familiar to macroeconomists:

$$\sum_{i=0}^{\infty} \beta^i y_{t+i} + R_t - \sum_{i=0}^{\infty} \beta^i DS_{t+i} = \sum_{i=0}^{\infty} \beta^i (C_{t+i} + I_{t+i})$$

This budget constraint states that the present value of income, plus reserves, minus the present value of debt service, is equal to the present value of consumption plus investment expenditures. **Note that contingent liabilities do not show up in the budget constraint equation. This is a very important result: the inter-temporal budget constraint of traditional macroeconomic analysis is similar to the pricing formula for the junior claim of the sector when volatility is set equal to zero.**

From here, it is a short step to get to a macroeconomic flow-of-funds equation. A simple manipulation of the inter-temporal budget constraint yields the following relationship between the flow variables in period $t$:

$$Y_t + R_t - \beta R_{t+1} - DS_t = \bar{J}_t - \beta \bar{J}_{t+1} = C_t + I_t$$
FURTHER APPLICATIONS – Inter-linked CCA model gives New risk-adjusted GDP, and risk-adjusted external account measures

Solving for the put option in the financial sector one can see the put option depends on the implicit put options in other sectors. It is the compound nature of this put option which can lead to sudden non-linear increases in value.

\[ P_F = E_F + \bar{B}_F - A_F = E_F + \bar{B}_F - \eta_{DCF}(\bar{B}_C - P_C) + \eta_{DLCF}(\bar{B}_{GLC} - P_{GLC}) + \eta_{DH}(\bar{B}_H - P_H) \]

Combining all the components of the junior claims or call option values across the economy (households, government, and foreign sector) gives the CCA-based Economic Output

\[ EO_{CCA} = E_H + \sum_{i} E_H + E_G + f_{EC} E_C + f_{EF} E_F. \]

The sum of all foreign claims across the sectors is defined as the risk adjusted external account.

\[ \text{Risk Adjusted External Account} = f_{EC} E_C + f_{EF} E_F + f_{DC}(\bar{B}_C - P_C) + f_{DF}(\bar{B}_F - (1-\alpha)P_F) + f_{GLCH}(\bar{B}_{GLC} - P_{GLC}) \]

Chart 24: Government support to the banking sector: impact on the budget deficit

Source: Eurostat.

Chart 23: Irish general Government debt and contributions to change in debt

Source: Department of Finance, Eurostat.
Notes: Projections are calculated using Department of Finance April 2013 Stability Programme Update details for 2012-2015. Outturn data based on April 2013 Maastricht Returns (Eurostat).
Debt to GDP goes from 30% in 2006 to 115% in 2012; Fiscal deficit rises to 30% of GDP in 2010

Figure 12: Public Debt and Deficit Ratios to GDP

Debt is Left Scale, Deficit is Right Scale