

# Recent Experiences on Macro-Stress Testing and Turbulences in Small Open Economies

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## The Usual Disclaimer

- The views expressed in this discussion are my own. They do not necessarily reflect those of the Federal Reserve Bank of Dallas or the Federal Reserve System.
- I have benefited from discussions with Ethan Cohen-Cole and Jose Fillat. My views do not necessarily reflect theirs (particularly if I'm in error), and they do not reflect those of the Federal Reserve Bank of Boston either.

# The Challenge

- Assessing the risk of large losses and possible default of a specific bank is important
  - ...so is the impact that such an event would have on other banks in the system
- Default dependence amongst the banks in a system is key for monitoring and ensuring financial stability
  - ...but dependence is often non-linear
- This is a difficult task
  - because defaults are 'tail events'
  - because of limited information

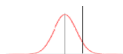
# The Methodology

- Proposed Bank Stability Measures - easily implementable in data constrained environments. Three steps:
  - Estimate the PD for each individual bank in the system
  - Estimate the Banking System Multivariate Density using the CIMDO-copula
  - Based on the banking system multivariate density, compute banking stability measures
    - Joint probability of default, Systemic Default effect Measure, Conditional Probability of Default Given that other Banks default, Default contagion Matrix
    - The Banking Stability Index: the expected number of bank defaults given that at least one bank defaults

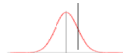
# The Methodology

**Step 1:**

View the Banking System as a Portfolio of Banks



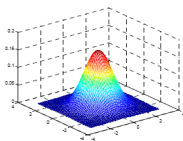
PoD of Bank X



PoD of Bank Y

**Step 2:**

Estimate individual Banks' PoDs.

**Step 3:**

Recover the Banking System's Multivariate Density (BSMD)

**Step 4:**

Estimate Banking Stability Measures (BSMs)

## The Obvious Advantages

- It can be applied to different countries with different data sources
- The estimation of the multivariate density is independent of the method applied to estimate the individual PDs
- Banking-system's joint likelihood of default is easier to interpret
- Banking stability measures take account of non-linear dependences, not just linear dependences as correlations do

# Comments on the Estimation of the PD

- There are essentially three distinct approaches,
  - Structural Approach
    - theoretical PDs are model-dependant
    - do we believe the underlying assumptions (e.g., Merton, 1974) hold particularly during crisis episodes?
  - Out-of-the-money option prices
    - in general implies that the PDs are risk-neutral
    - how do we interpret joint and conditional PDs with risk-neutral versus 'real' probabilities?
  - CDS Spreads
    - this is the avenue chosen in this paper

## Comments on the CDS spreads

- Definition of CDS Spread: It is a percentage of the notional amount (expressed in terms of bps) that the investor is paid per annum (aka quoted spread). If credit event occurs, the investor pays the buyer of protection a onetime credit loss equal to par minus recovery.
  - there are many definitions for the spread: I-spread, Z-spread, Par CDS Equivalent Spread... Which one should we use?
  - all of them have different quantifications of risk. For example, the z-spread discounts the future cash flows of the bond at the yield curve rates, the I-spread takes the discount as YTM (flat yield curve), matching a treasury maturity to the bond's maturity

## Comments on the CDS spreads

- Usage of CDS market data has many pros and a few cons
  - technically, we obtain risk neutral PDs. Should we convert them to real world PDs? How do we interpret them?
  - counterparty risk (see, e.g., AIG) - there are collaterals posted (margin), but not clear how much collateral is needed to cover counterparty risk
  - CDS do not protect against all defaults - it covers credit events (e.g., bankruptcy, modified restructuring...)
  - Risk of a short squeeze if there is a bankruptcy of an overprotected entity

## Comments on the CIMDO-copula

- A CIMDO-recovered multivariate distribution is a distribution with the minimum cross-entropy (Kullback, 1959) relative to the "prior" that default is triggered by a drop in the firms asset value below a threshold whose marginal density is consistent with the PDs inferred before
- A growing number of parametric copulas
  - the Normal copula, the Frank copula, the Plackett copula, the BB1 copula, the BB7 copula, the generalized asymmetric Gumbel copula, the Perturbed Normal copula
  - The Bernstein copula - Used for FX modelling (see, e.g., Hurd et al., 2007)
  - Can we rule them all out? Is the PIT the only criterion we should use to compare competing copulas?
- CIMDO-copulas outperform parametric ones under the Probability Integral Transformation (PIT) criterion.  
Alternative criterion: e.g.,  $L^2$ -distance

## Suggestions on an Intermediate Step

- The Pearson correlation coefficient only captures the first-order, or linear, association between two random variables
- There are numerous additional nonlinear measures of dependence
  - some are finite dimensional, e.g. Spearman's Rho and Kendall's Tau
  - some are infinite dimensional e.g. copulas and the local correlation function of Bjerve and Doksum (1993)
- A copula function fully describes the dependence structure (linear and non-linear),
  - ...but we are often interested in simple summary statistics that indicate the extent and the direction of comovement

## Suggestions on an Intermediate Step

- The two most common concordance measures are Kendall's tau and Spearman's rho,
  - Kendall's tau: difference between the probability of a joint outcome with the same sign,  $P[(X_1 - X_2)(Y_1 - Y_2) > 0]$ , and the probability of a joint outcome with different signs,  $P[(X_1 - X_2)(Y_1 - Y_2) < 0]$  - i.e., the difference between the probability of the variables either rising or falling together (concordance) minus the probability of them moving in different directions (discordance).
  - Spearman's rho: measures the correlation between rank ordered data.
- **BOTTOM LINE:** Once you have computed a multivariate density, why not using summary statistics like Spearman's Rho and Kendall's Tau?

## Looking at Paths for Future Research

- QUESTIONS: Copulas characterize the linear and non-linear dependences at each point in time
  - *Can we use this information to develop early warning signals?*
  - *Dependencies, even non-linear dependencies, imply a relationship between two variables, but not causality*
    - *...we may need to build some theory to explain those non-linearities*
  - *Can we use this information to do stress testing?*

## Suggestions on Stress-Testing

- On the latter, perhaps use the CoPoD framework to do stress-testing in response to macro shocks (Segoviano and Padilla, 2006):

$$a = \Phi^{-1}(PD)$$

$$a = \beta X + e,$$

where  $\beta$  and  $e$  are possibly uncertain

- This forces us to take a stand on the structural model
- Give financial regulators a better understanding of the effect of macroeconomic shocks on the stability of the financial system
  - ...providing a quantifiable risk assessment

## Suggestions on Stress-Testing

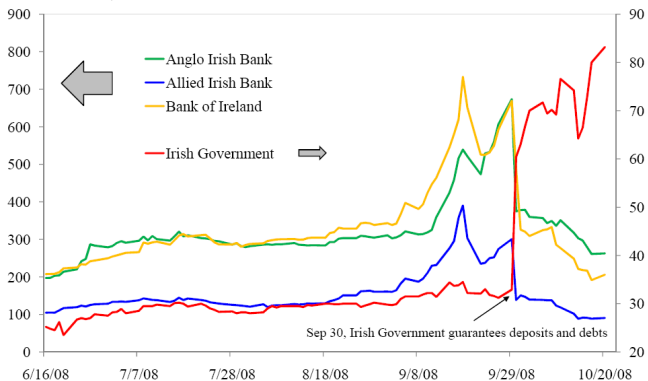
- The proposed stress test procedure involves four steps
  - (i) The definition of 'sensible' macroeconomic risk scenarios
  - (ii) The effects of the macroeconomic shocks are incorporated into the PDs of loans grouped by sector or rating (CoPoD)
  - (iii) Recover the corresponding PMDs from the risk scenarios that need to be evaluated with the use of the CIMDO methodology and the CoPoD PDs (as exogenous variables)
  - (iv) Simulate several indexes of stress of the banking system, e.g., the BSI

# Is Bank Risk Self-Contained?

- The case of Ireland

## Credit Risk Transferred from Banks to the Irish Government

5 Yr. CDS Prices, Basis Points

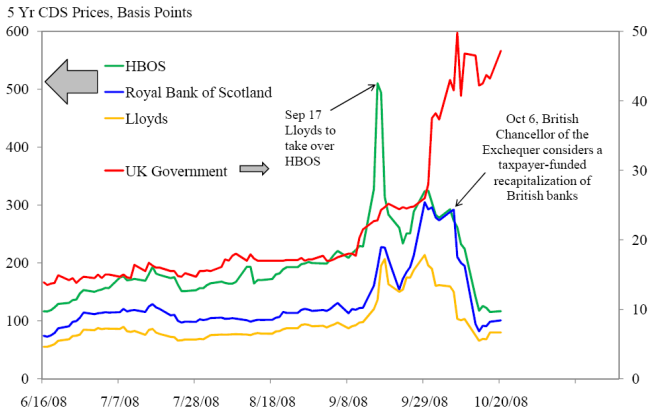


Source: Bloomberg

# Is Bank Risk Self-Contained?

- The case of the UK

## News of Rescue Plan Brings U.K. Banks' Default Risk Down



Source: Bloomberg

## What's with the Government?

- In the current financial turmoil, we have seen patterns of shifting risk (e.g., Ireland)
- PDs implied from CDS spreads may be misleading - not fully reflecting the balance of risks if, e.g., there are risk-shifting agreements
  - highlights a limitation on the use of CDS to infer PDs
  - it could also be indicative of the fact that financial stability may not be assured
  - non-linear dependence between financial system and the broad economy or large players like the government

## What's with the Government?

- QUESTION: The BSI is defined as the expected number of bank defaults given that at least one bank defaults. What happens if:
  - Governments intervene to rescue institutions that otherwise would have failed?
  - if Governments implicitly or explicitly follow the rule of "too big to fail" for the core banks in the financial system?
  - how does the role of Government policy play into our understanding of the impact of systemic risk or the financial stability of the system?

## To Wrap-Up

- Very important topic of discussion
- Very interesting and timely contribution to the literature
- Great potential for applications on macro stress-testing, financial stability surveillance, etc.
  - ...I am already looking forward to more contributions coming out of this research agenda