

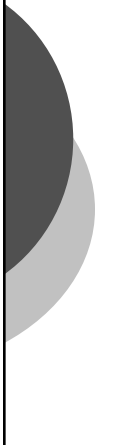


Correlation of Risks, Integrating Risk Measurement – Risk Aggregation

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Statement of the Problem: Need for a New Approach to ERM

- What is Enterprise Risk Management?
 - Aggregating balance sheet risk?
 - Aggregating VaR and EaR of the enterprise?
 - Assigning economic capital to business units?
- An enterprise is a portfolio of businesses, not just assets and liabilities
 - How do you manage the risk of a portfolio of businesses?

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Contributions of the Presentation

- Describes a very comprehensive approach for aggregating the risks for the enterprise
 - Valuation – new modeling results
 - Simulation – credit and market risks
 - Aggregating business risks
- A Case Study: a quantitative risk study by Office of Thrift Supervision (OTS)
 - Highlight: business risk concentration
 - Implications for managing the risks of the business processes of an enterprise
- *My presentation does not represent the views of OTS*

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Outline of the Presentation

- A Case Study (work in progress): Office of Thrift Supervision
 - Data and reports: institutional framework
 - Valuation models
 - Interest rate model
 - Mortgage prepayment model
 - Credit risk model
 - Simulation (“stochastic on stochastic” models)
 - Analysis of simulation results
- Implications for ERM
 - Approaches to aggregating business risks

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Office of Thrift Supervision

- Federal regulator of over 800 savings institutions or thrifts
- Monitors the risks on the balance sheet and the businesses
- Role of OTS examiners
- Ensure safety and soundness of the thrift industry
- Similar to the risk management of an enterprise with multiple businesses



Net Portfolio Value (NPV) Model

- A supervisory tool that identifies thrifts with excessive interest rate risks
 - A starting point for assessing the quality of interest rate risk management practices at individual thrifts
 - Identify outlier thrifts that need more supervisory attention
 - Identify systemic interest rate risk trends within the thrift industry
 - Designed to spot storm clouds on the horizon
- Fair valuation of all balance sheet items in disaggregated level using the CMR schedules
- Determine the market value of equity for each thrift



Schedule CMR and IRR Report

- CMR Filing Statistics (June 30, 2005)
 - 821 OTS-regulated thrifts filed Schedule CMR
 - 58.5% of reports were from voluntary filers
 - 90.7% of institutions that are not required to file Schedule CMR do so voluntarily
- Interest Rate Risk (IRR) Report
 - Over 15 years of historical data



Example of CMR /IRR Report

Input data and Interest Rate Risk Report

Description

30-Year Mortgage Loans
30-Year Mortgage Securities
15-Year Mortgages and MBS
Balloon Mortgages and MBS
6 Month or Less Reset Frequency (Single-Family ARM)
7 Month to 2 Year Reset Frequency (Single-Family ARM)
2+ to 5 Year Reset Frequency (Single-Family ARM)
1 Month Reset Frequency (Single-Family ARM)
2 Month to 5 Year Reset Frequency (Single-Family ARM)
Adjustable-Rate, Balloons (Multifamily & Nonresidential Mortgage)
Adjustable-Rate, Fully Amortizing (Multifamily & Nonresidential Mortgage)
Fixed-Rate, Balloon (Multifamily & Nonresidential Mortgage)
Fixed-Rate, Fully Amortizing (Multifamily & Nonresidential Mortgage)
Adjustable-Rate (Construction & Land Loan)
Fixed-Rate (Construction & Land Loan)
Adjustable-Rate (Second Mortgage)

And More....

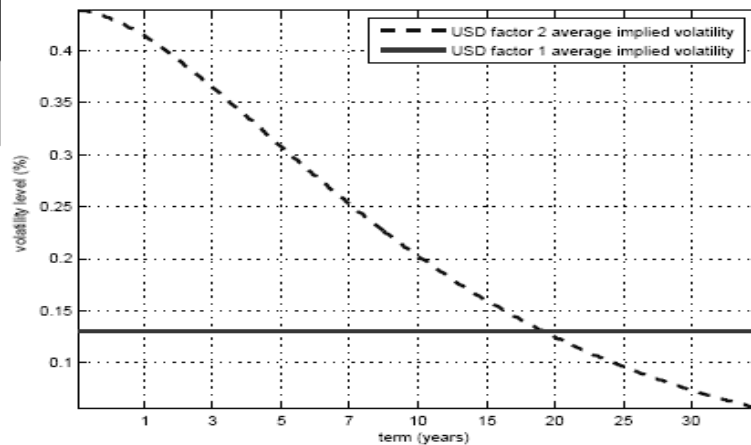
Interest Rate Model

- Generalized Ho-Lee model: n factor implied principal yield curve movements
 - Arbitrage-free calibrated to the Treasury curve
 - Implied mixed lognormal/normal model
 - Implied rate correlations
- Calibrated to the entire swaption surface
- Contrast with BGM (LIBOR, Market), String, Unspanned volatility models.

valuation model - interest rate model

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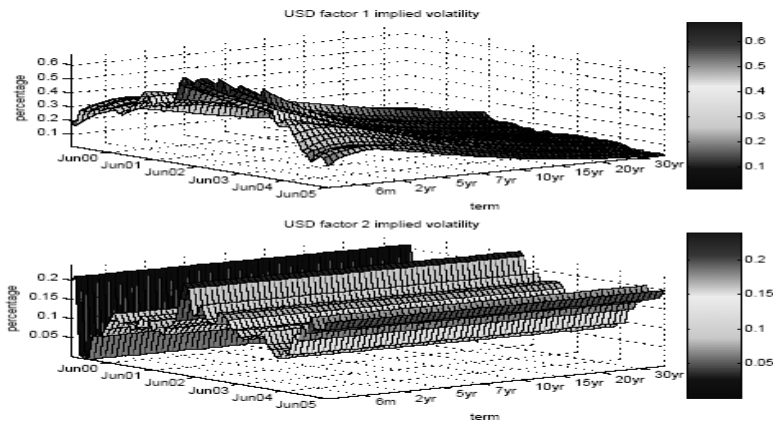
Estimated Implied Volatility Function: Principal movements of the yield curve



valuation model - interest rate model

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Stochastic Movements of the Implied Volatility Functions: Importance of implied correlations and distributions



valuation model - interest rate model

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Valuation Errors of the Generalized Ho-Lee Model: Accuracy and stability of the model (Ho-Mudavanhu (2006))

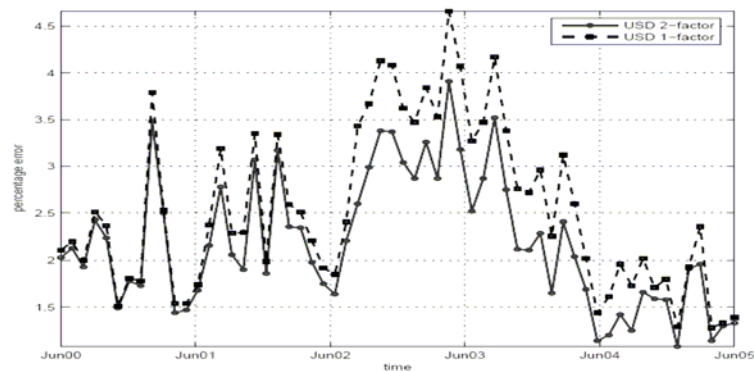


Fig. 10 Comparison of the percentage absolute errors of the one factor and two factor models.

valuation model - interest rate model

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Research on Prepayment and Default Model

- Multinomial logit model
- FICO score
 - Impact on prepayments
 - Impact on the option adjusted spreads
- Multiple prepayment models
 - Hybrid ARMs
 - FRM
- Extension to mortgage loan valuation

Multinomial Prepayment/Default Model:

Specification of the correlation of prepayment and default risks

- $CPR_{i,t} = \exp (x(i, t)' \beta_p) / A$
and
- $CDR_{i,t} = \exp (x(i, t)' \beta_d) / A$
- where $A = 1 + \exp (x(i, t)' \beta_p) + \exp (x(i, t)' \beta_d)$
- $x(i,t)$ independent variables: age, seasonality, refi function, FICO score



Prepayment/Default Model Results: Preliminary results on fixed rate mortgages

- Refi and burnout effect
 - The model confirms the S curve behavior of refi.
 - The burnout effect is significant
- Slope of the yield curve
 - Higher the slope, greater is prepayment (positive)
- Seasoning effects
 - The results confirm the PSA model
 - The results show that the default rate peaks in 5 years
- FICO effect
 - For prepayment, the higher the FICO score, the more likely that the mortgagor prepays
 - In the default model, FICO score is significant
- Size: hot and cold money
 - Larger the origination size, hotter is the money
 - Larger the origination size, the higher is the default risk



Default Risk Modeling: Correlation

- Survival rate: derived from historical cumulative default experience for each rating cohort group
- Recovery rate: by seniority (historical)
- Correlation: by industry (historical)
- Standard deviation: concentration in each industry
- Default event: maturity structure



Default Correlation

- Gaussian and t-dependence copula model
- Input data:
 - Face value/portfolio
 - Loans
 - construction, consumer, commercial
 - Fixed income securities
 - Proportion in
 - Industry group
 - Maturities
 - Ratings



Scenario Generation:

Stochastic simulations of market and credit risks

- Quarterly reporting cycles
 - Time horizon: 3 months
 - Monthly reinvestments
- Antithetic Monte-Carlo simulation
- Same set of scenarios for all the thrifts
- Combined market and credit risks
- Default distribution and economic value over the horizon



Set of Risk Drivers:

Determination of the correlation matrix

- Market Risks
 - Yield curve movements
 - OAS spread risks
 - Equity risks
- Prepayment Risks
 - Coefficients of the prepayment model
- Credit Risks
 - Sector/industry groups
- Large singular correlation matrix
 - Decomposition to independent gaussian processes

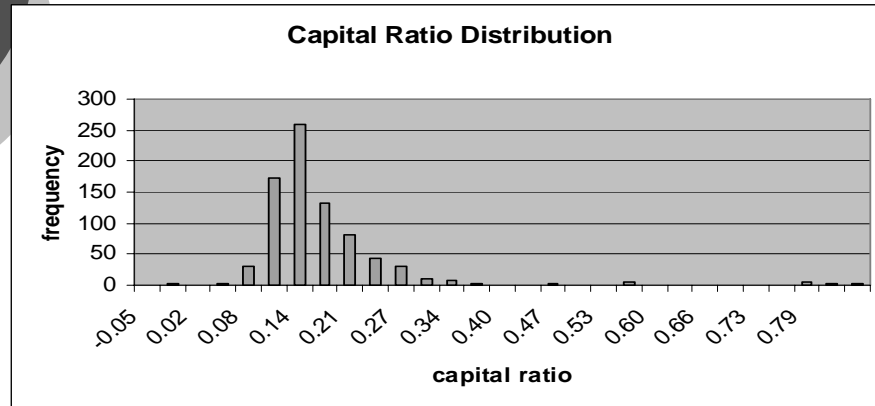


Simulation Results

- Entire thrift population
- Market Value of Equity E: point estimate and distribution
- Risk Measures: Macro-Risk Management Perspective
 - VaR: 90% confidence level, 3 month horizon
 - Capital ratio = economic capital/total asset
 - Critical capital ratio = economic capital at 90% confidence level/total asset

Frequency Distribution of the Capital Ratio based on the Entire Population

Fair value analysis preliminary results December 2005

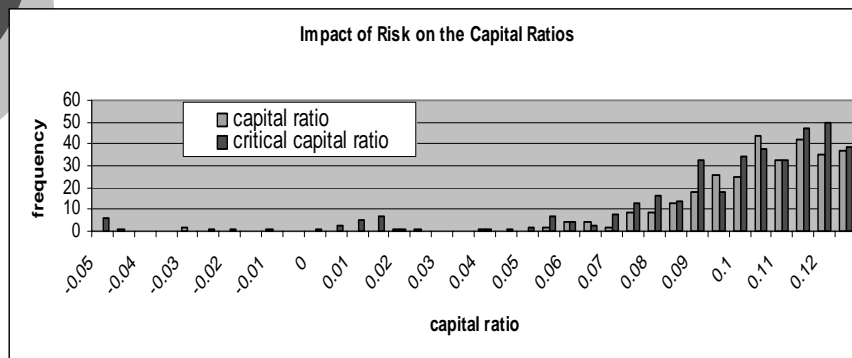


Macro Risk Results

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Impact of VaR at 90% Confidence Level

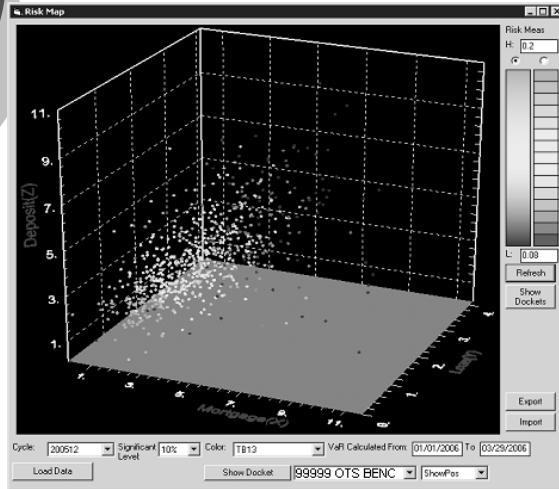
Identify the thrifts with lowered capital ratios



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Risk Map

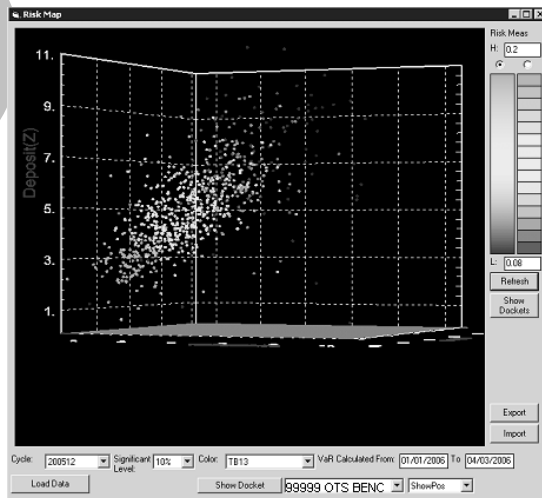
critical capital ratio = F (mortgage/E, deposit/E, loans/E)



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Business Risk Concentration

Variations are driven by funding the mortgages by deposits



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Business Models of Thrifts

Principal Components Analysis (preliminary)

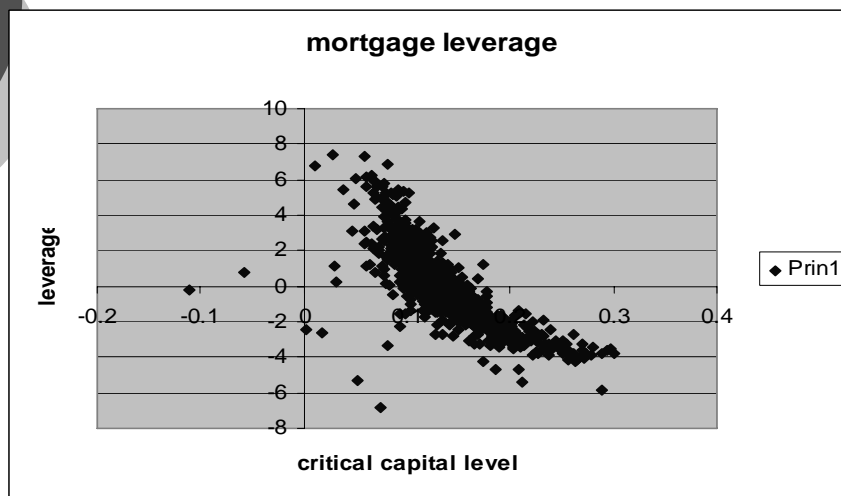
	PC1	PC2	PC3
mortgage/E	0.75	-0.64	0.13
Nonmort/E	0.02	0.23	0.97
Deposits/E	0.65	0.72	-0.19

- PC = principal components
- proportion of variations explained
78% (PC1), 17% (PC2), 5% (PC3)
- E = economic capital or equity

Relating the Risk Profiles to the Business Models:

Variations along PC1 vs Critical Capital

preliminary results





Implications of the OTS Case Study

- Dramatic change in the thrifts' business model
 - Traditional, complex, wholesale, specialty banks
- Concentration of business risks in the banking system
 - Correlation of credit risk and market risk
 - Correlation of business risks: home price collapse, earthquakes, margin calls
- Implications of macroeconomics
 - What are the adverse scenarios for the banking system? Price level, rate level, liquidity level. Inter-relations of risks



Implications of the Case Study for ERM

- An enterprise is a portfolio of businesses, defined in terms of business processes, not only as corporate entities
- ERM should not aggregate the balance sheet risks only
- ERM should consider the correlation of business risks of the business processes



Summary: Aspects of Risk Aggregation

- Implied correlations of interest rates in valuation- interest rate models
- Default risk and product risks are correlated – prepayment models
- Credit risk and interest rate risk correlation – copula function
- Business risks and market/credit risks – business model

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Principle Based Approach

- Calibration to the market prices
 - Law of one price – arbitrage free
- Prospective and retrospective analysis using a quarterly cycle
- Consistency across business units
- Comprehensive aggregation of risks

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Conclusions

- Correlations of risk sources in valuation and simulations: new research results
- Business risk should be considered a distinct risk driver
- Metrics of risks for ERM should be taken into consideration – Correlation of risks, integrating risk measurement – risk aggregation is important
- OTS quantitative risk study highlights many of these issues

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References

- Ho and Lee (2005) "Multifactor interest rate model"
- Ho and Lee (2005) The Oxford Guide to Financial Modeling. Oxford University Press
- Ho and Jones (2006) "Market structure of OTS banks – a business model perspective"
- Ho and Mudavanhu (2006) "Interest rate model implied volatility functions' stochastic movements" *Journal of Investment Management* (forthcoming)
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