

# Stressing Bank Profitability for Interest Rate Risk

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*Preliminary and Incomplete*

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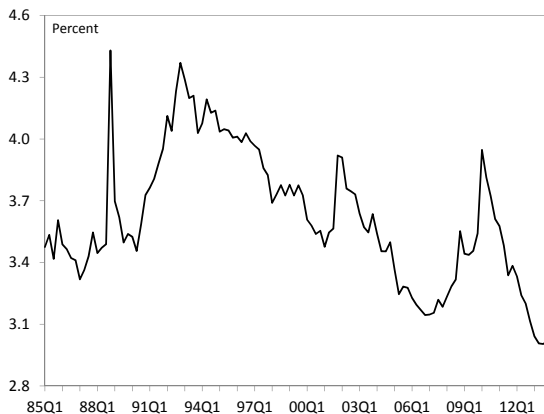
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# This paper

- ▶ Develops models to generate forecasts of bank net interest margins (NIMs), conditional on macroeconomic variables
  - ▶ What are NIMs?
  - ▶ Why do we want conditional forecasts of bank variables in general?  $\implies$  Scenario-based bank stress testing
  - ▶ Why focus on NIMs?
- ▶ Key variables for modeling NIMs
- ▶ Forecasting models
- ▶ Forecast results
- ▶ Simulations results, based around 2013 CCAR/Dodd Frank Act stress test scenarios
- ▶ Sum up: Implications of results for scenario-based bank stress testing

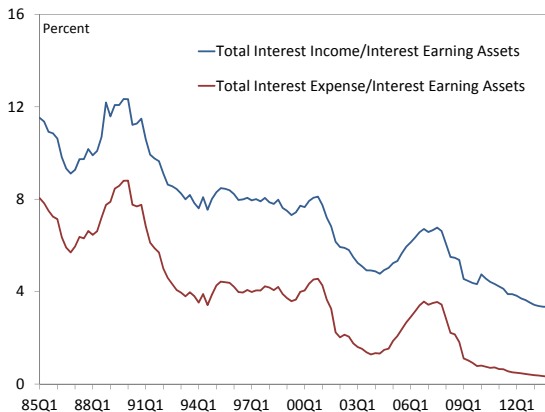
# What are NIMs

$$\begin{aligned}\text{Net interest margins} &= \frac{\text{Net interest income (NII)}}{\text{Interest earning assets}} \\ &= \frac{\text{Interest income} - \text{Interest expenses}}{\text{Interest earning assets}}\end{aligned}$$



# What are NIMs, continued

$$\begin{aligned}\text{Net interest margins} &= \frac{\text{Net interest income (NII)}}{\text{Interest earning assets}} \\ &= \frac{\text{Interest income} - \text{Interest expenses}}{\text{Interest earning assets}}\end{aligned}$$



## What are NIMs, continued

$$\text{NIMs} = \frac{\text{Interest income} - \text{Interest expenses}}{\text{Interest earning assets}}$$

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$$\begin{aligned} \text{Net income} &= \text{Income} - \text{Expenses} \\ &+ \text{Realized gains/losses on securities} - \text{Taxes} \\ &+ \text{Other items, adjustments, etc.} \end{aligned}$$

$$\text{Income} = \text{Interest income} + \text{Non-interest income}$$

$$\begin{aligned} \text{Expenses} &= \text{Interest expenses} + \text{Non-interest expenses} \\ &+ \text{Provisions for loan and lease losses} \end{aligned}$$

# Why do we want conditional forecasts in general

- ▶ Prominence of macro stress testing and capital planning in the post-crisis capital regulatory regime
  - ▶ Bank capital adequacy no longer assessed solely on *current* bank capital ratios
  - ▶ Bank capital adequacy also assessed based on *forward-looking pro forma* bank capital ratios; that is, capital ratios *projected* to obtain under some *future* stressful scenario
  - ▶ Lesson from the crisis: Creditor and counterparty confidence in an bank is based on *future* capital ratios under stressful conditions not *current* ratios
- ▶ Prominence of macro stress testing for maintaining confidence in *future* bank capital adequacy during periods of stress

# Why do we want conditional forecasts in general, continued

- ▶ Forward-looking *pro forma* bank capital ratios require forecasts of all components on bank net income, conditional on the stress test's macro scenarios
- ▶ This is why we focus on conditional forecasts

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$$\begin{aligned} \text{Net income} = & \text{Interest income} + \text{Non-interest income} \\ & + \text{Interest expenses} + \text{Non-interest expenses} \\ & + \text{Provisions for loan and lease losses} \\ & + \text{Realized gains/losses on securities} - \text{Taxes} \\ & + \text{Other items, adjustments, etc.} \end{aligned}$$

# Why focus on NIMs

- ▶ Provisions and realized gains/losses on securities are forecast using loan- or securities-level data using credit-risk models
  - ▶ Interest and non-interest income, and interest and non-interest expenses are all forecast with time-series models
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$$\begin{aligned} \text{Net income} = & \text{Interest income} + \text{Non-interest income} \\ & + \text{Interest expenses} + \text{Non-interest expenses} \\ & + \text{Provisions for loan and lease losses} \\ & + \text{Realized gains/losses on securities} - \text{Taxes} \\ & + \text{Other items, adjustments, etc.} \end{aligned}$$



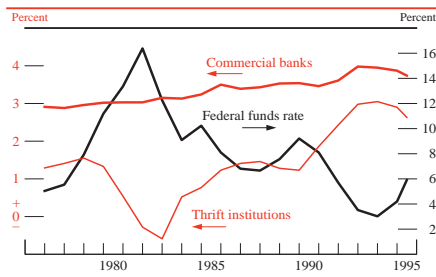
## Why focus on NIMs, continued

- ▶ Projecting profitability is just as important in stress testing as projecting losses
  - ▶ In times of stress, the ability of a bank to remain viable depends just as much on its ability to generate income as it does on its losses on current assets (see Gov. Tarullo, 2012)
- ▶ Interest income accounts for two-thirds of income
- ▶ Interest expenses typically account for 40 percent of expenses (excl. provisions)

# Why focus on NIMs, continued

- ▶ Losses from depressed NII and NIMs can be an important source of risk to banks and the financial sector
- ▶ U.S. savings and loans crisis was associated with NII and NIMs turning negative in the thrift sector

1. Net interest margins of commercial banks and thrift institutions and the federal funds rate, 1976–95

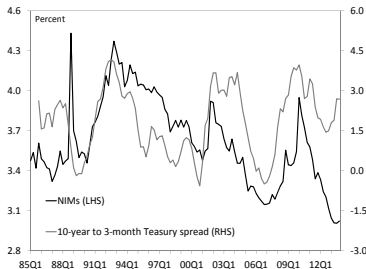


Source: FR Bulletin, February 1996.

# Key variables for modeling NIMs

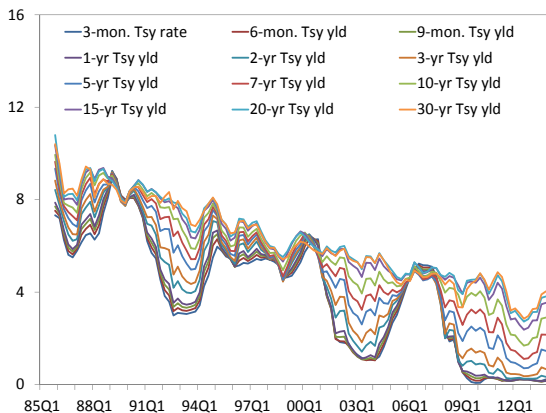
- ▶ Slope of the Treasury yield curve
  - ▶ Reflects banks' return on maturity-transformation services – one of the key services provided by banks
- ▶ Level of short-term interest rates
  - ▶ Indirectly reflects banks' return on transactions services – another key service provided by banks.
  - ▶ Level of the short rate puts an upper limit on how much banks can earn from transactions services
- ▶ 10-year yield less 3-month rate and 3-month rate are commonly used in the macro-banking NIM literature
  - ▶ Hirtle, Kovner, and Vickery (2012)
  - ▶ Covas, Rump, and Zakrajsek (2012)
  - ▶ English (2002)
  - ▶ English, Van den Heuvel, and Zakrajsek (2012)
  - ▶ Alessandri and Nelson (2012)

# Key variables for modeling NIMs, continued



- ▶ NIMs increase when the yield-curve steepens, reflecting the increased return to maturity transformation
- ▶ Changes in short rates generally drive changes in the slope of the yield curve

## Key variables for modeling NIMs, continued



- ▶ We consider other yields in addition to the 3-month and 10-year Treasury yields
- ▶ We use the data derived using the smoothing technique from Gurkaynak et al. (2007)

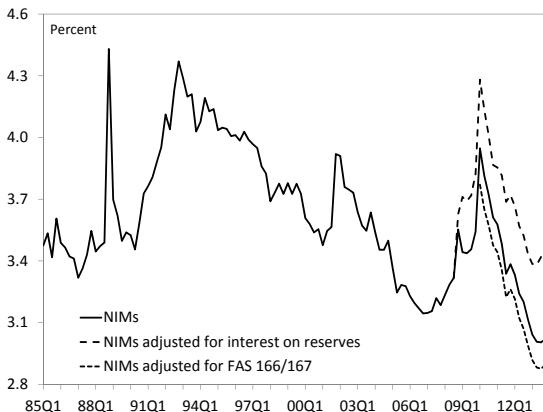
# Other possible variables for modeling NIMs

- ▶ The micro-banking literature emphasizes different variables
  - ▶ The degree of competition faced by banks in loan and deposit markets
  - ▶ The volatility of interest rates
- ▶ Greater competition loan and deposit markets implies
  - ▶ More narrow NIMs set by banks
- ▶ If banks are risk averse, greater interest-rate volatility implies
  - ▶ More compensation for risk required by banks to take deposits and make loans given their imperfect timing
  - ▶ Wider NIMs set by banks
- ▶ At this stage we do not consider these variables

# Aggregate and BHC-level NIMs

- ▶ Aggregate NIM data are from the quarterly “Call Reports” and are an aggregate for the top 25 BHCs, ranked by total assets
  - ▶ This data starts in 1985:Q1
- ▶ BHC-level NIM data are from the Y-9-C
  - ▶ Mergers are accounted for by assuming that all institutions now part of the BHC were always part of it
  - ▶ Merger adjusted data start in 1996:Q1
  - ▶ BHC-level NIM data are not used in this draft

# Aggregate NIMs: Some issues



- ▶ The spike in 1988q4 reflects overdue interest from Brazil
  - ▶ We delay the start of our sample to 1989q1
- ▶ Post 2008 NIMs may be depressed by interest on reserves
- ▶ The jump in 2010q1 reflects FAS 167 going into effect
- ▶ We will adjust for these developments



# Conditional forecasting models for aggregate bank analysis

- ▶ 1. No change forecast (*i.e.*, a random walk without a drift)
- ▶ 2. Observed factors with forecast combination
- ▶ 3. DFM with forecast combination
- ▶ 4. PCR with forecast combination
- ▶ 5. PLS
- ▶ 6. Yields with forecast combination
- ▶ 7. 3-month & 10-year yields with forecast combination
- ▶ 8. Vector autoregression model with 3-month & 10-year yields

# Variants of our models

- ▶ NIMs and interest rates or yield-curve factors in levels but with lags
  - ▶ Iterative forecasts
  - ▶ Direct forecasts (VAR not included)
  
- ▶ NIMs and interest rates or yield-curve factors in first differences
  - ▶ Iterative forecasts

## 6. Yields with forecast combination

- ▶ Regress NIMs on two lags of each yield  $r(\tau)$  separately

$$NIM_t = c_\tau + \rho_\tau NIM_{t-1} + \gamma_{\tau,1} r(\tau)_{t-1} + \gamma_{\tau,2} r(\tau)_{t-2} + \eta_{\tau,t}$$

- ▶ Use each regression to generate an iterative  $s$ -step ahead forecast of NIMs conditional on Treasury yields with maturity  $\tau$  observed through period  $t + s - 1$
- ▶ Denote the forecast by  $NIM_{\tau,t+s/t}$
- ▶ The simple forecast combination is then given by

$$NIM_{t+s/t} = \sum_{\tau} \frac{NIM_{\tau,t+s/t}}{N},$$

where  $N$  is the number of maturities considered (equal to 12)

- 7. 3-month & 10-year yields with forecast combination and
- 8. VAR with 3-month & 10-year yields

### 7. 3-month & 10-year yields with forecast combination

- ▶ Similar to “6. Yields with forecast combination”
- ▶ Uses only forecasts implied by the 3-mon. & 10-year equations

$$NIM_{t+s/t} = \frac{NIM_{3-mon.,t+s/t} + NIM_{10-year,t+s/t}}{2}$$

### 8. VAR with 3-month & 10-year yields

- ▶ Forecasts generated from a 2-lag, 3-variable VAR model of:
  - ▶ Aggregate NIMs
  - ▶ 3-month Treasury yield
  - ▶ 10-year Treasury yield
- ▶ NIM forecasts, conditional on the yields, obtained using the Kalman filter (following, Clarida and Coyle, 1984)

## Models 2 to 4: Using factors to summarize yields

- ▶ Models 2 to 4 use factors that *summarize* yields, rather than all the yields themselves
  - ▶ These factors summarize the yield curve in terms of its level ( $L$ ), slope ( $S$ ), and curvature ( $C$ )
- ▶ Regress NIMs on two lags of each factor – *i.e.*,  $F \in \{L, S, C\}$  – separately

$$NIM_{f,t} = c_f + \rho_f NIM_{t-1} + \gamma_{f,1} F_{t-1} + \gamma_{f,2} F_{t-2} + \eta_{i,t},$$

- ▶ Use each regression to generate a recursive  $s$ -step ahead forecast of NIMs, conditional on lags of the factor
- ▶ Forecasts from each separate regression,  $NIM_{f,t+s/t}$ , are aggregated as

$$NIM_{t+s/t} = \sum_f \frac{NIM_{f,t+s/t}}{N}, \text{ where } N = 3$$

2. Observed factors with forecast combination,
3. DFM with forecast combination, and
4. PCR with forecast combination

## 2. Observed factors with forecast combination

- ▶ Simple “observed” factors as in Diebold and Li (2006)

$$\text{Level: } L = \frac{r(3m) + r(2yr) + r(10yr)}{3}$$

$$\text{Slope: } S = r(3m) - r(10yr)$$

$$\text{Curvature: } C = [r(2yr) - r(10yr)] - [r(3m) - r(2yr)]$$

## 3. DFM with forecast combination

- ▶  $L$ ,  $S$ , and  $C$  factors obtained using Nelson-Siegel framework as in Diebold et al. (2007)

## 4. PCR with forecast combination

- ▶  $L$ ,  $S$ , and  $C$  factors based on principal components

## 5. Partial least squares with 2nd-step regression

- ▶ PLS is a data compression technique analogous to PCA
  - ▶ PCA factors describe the variance of yields but nothing guarantees that these factors will be relevant for NIMs
  - ▶ PLS factors incorporate information about the dependent variable (NIMs)
- ▶ We use the algorithm of Groen & Kapetanios (2009) to get our PLS factors (which addresses lagged NIMs in our model)
- ▶ We generate our forecasts from the multivariate equation

$$NIM_t = c + \rho NIM_{t-1} + \sum_{i=1}^3 \gamma_i PLS_{i,t-1}$$

# Out-of-sample (and in-sample) forecasts

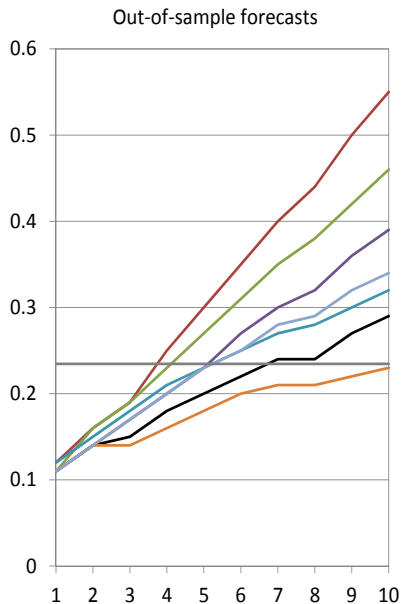
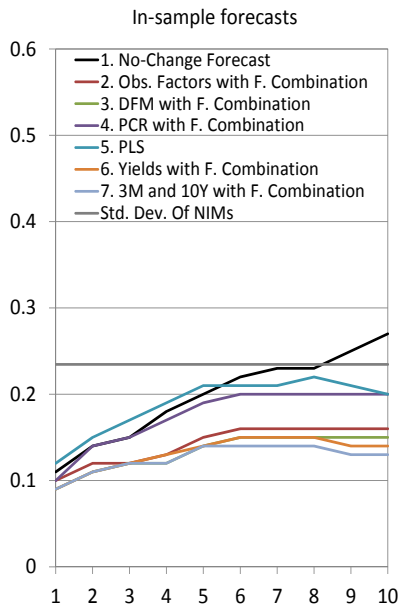
- ▶ Estimation period starts in 1989q2 to avoid the spike from the Latin American debt crisis
- ▶ 10-year rolling window estimation
  - ▶ Recursive windows imply similar results
- ▶ First (and preferred) evaluation window is 2000q1 to 2008q3
  - ▶ Also consider an evaluation window of 2000q1 to 2012q3
- ▶ We focus on root mean squared (forecast) errors:

$$RMSE_{model,steps} = \sqrt{\sum_{t=2000q1}^{2008q3} \left( NIM_t - \widehat{NIM}_{model,t|t-steps} \right)^2}$$

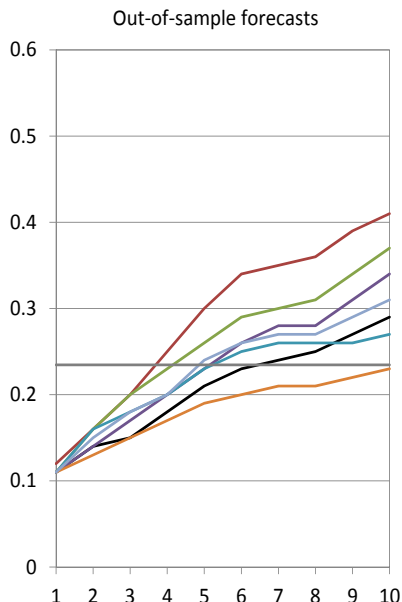
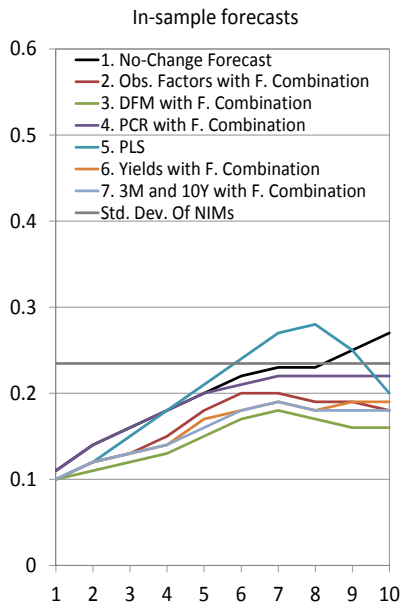
- ▶ In-sample RMSEs are calculated right at the end of the rolling-window sample (as in Rossi and Sekhposyan, 2011)



# RMSEs: Iterative levels forecasts, 00q1-08q3 evaluation



# RMSEs: Direct levels forecasts, 00q1-08q3 evaluation



# Understanding relative performance

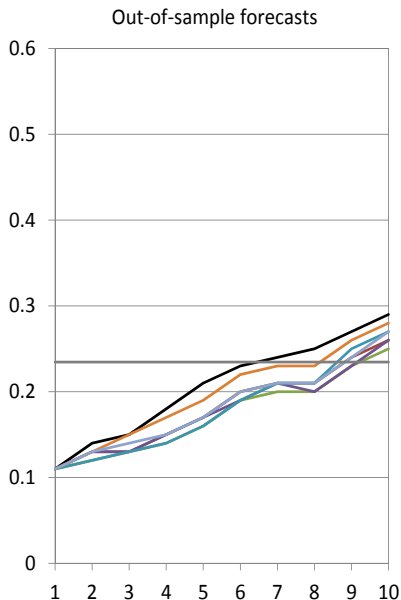
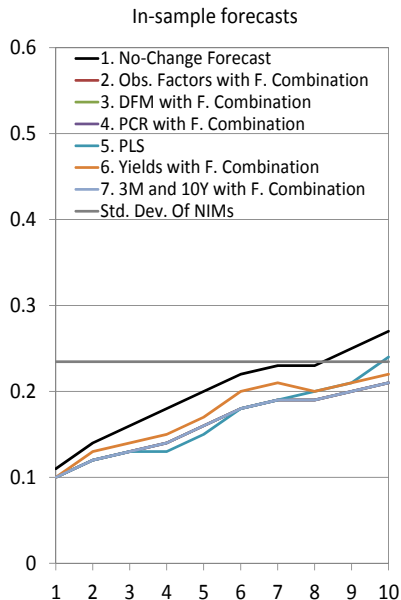
- ▶ Rossi and Sekhposyan (2011) develop methods to understand differences in forecast performance between two models
- ▶ Their method examines whether the relative predictive content between two models is
  - ▶ Constant over the forecast evaluation period
  - ▶ Attributable to one model's better in-sample fit, which is then predictive for out-of-sample forecasting ability
  - ▶ Attributable to one model being over-fit in-sample
- ▶ Rossi and Sekhposyan's method is only applicable to direct forecasts
- ▶ Most of the time the model that forecasts better does so because it is less overfit

# Understanding relative performance: 00q1-08q3

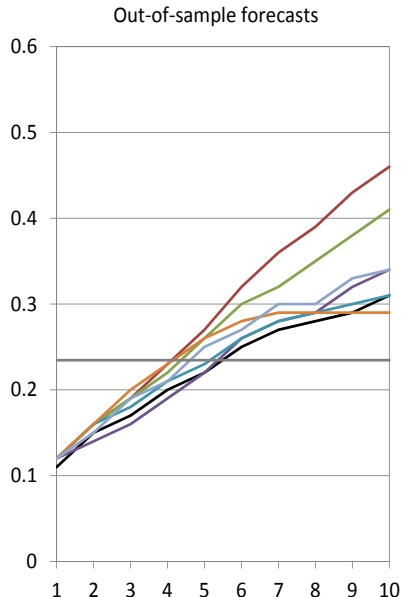
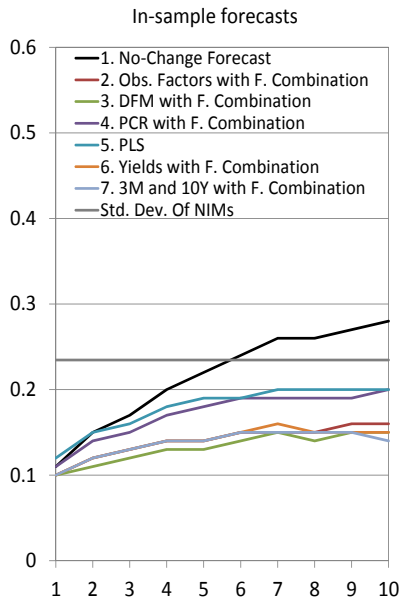
- Forecasts are relative to the yields with combination forecast

		2. Obs.	3. DFM	4. PCR	5. PLS	7. 3M,10Y
"4 steps" ahead	DMW	1.777	1.677	1.036	0.816	2.948*
Time variation	$\Gamma_P^{(A)}$	7.095	4.765	6.471	6.125	5.086
Predictive content	$\Gamma_P^{(B)}$	-0.266	-0.647	3.632*	1.349	1.642
Overfitting	$\Gamma_P^{(U)}$	1.851	1.692	0.302	0.770	2.453*
"6 steps" ahead	DMW	2.976*	1.816	1.772	1.013	3.366*
Time variation	$\Gamma_P^{(A)}$	5.402	5.948	5.653	6.625	6.619
Predictive content	$\Gamma_P^{(B)}$	1.229	-0.793	3.573*	1.764	1.028
Overfitting	$\Gamma_P^{(U)}$	2.887*	2.033*	1.729	0.344	3.228*
"8 steps" ahead	DMW	3.410*	2.924*	2.193*	0.886	2.929*
Time variation	$\Gamma_P^{(A)}$	6.617	5.516	6.488	6.851	5.623
Predictive content	$\Gamma_P^{(B)}$	0.482	-0.556	3.074*	1.800	-0.788
Overfitting	$\Gamma_P^{(U)}$	3.399*	3.690*	1.631	0.303	3.335*

# RMSEs: Iterative changes forecasts, 00q1-08q3 evaluation

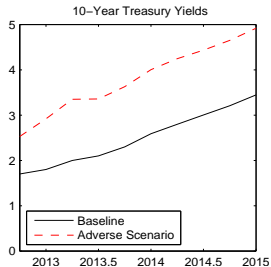
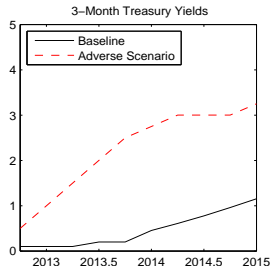
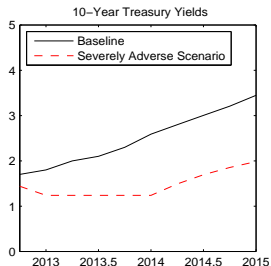
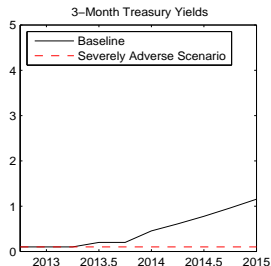


# RMSEs: Iterative levels forecasts, 00q1-12q3 evaluation



- ▶ What do our best performing models imply for the paths of NIMs under different CCAR/Dodd-Frank Act stress test (DFAST) scenarios?
- ▶ We use as our best performing models
  - ▶ Yields with forecast combination in the iterative, levels specification
  - ▶ PLS in the iterative, first-differences specification
- ▶ We focus on the 2013 CCAR/DFAST scenarios because on balance they seem more stressful to bank NIMs

# 2013 CCAR/DFAST scenario rate-paths



- ▶ The severely adverse scenario was a “down and flatter” shift in the yield curve

- ▶ Lower for longer
- ▶ Associated with a severe recession

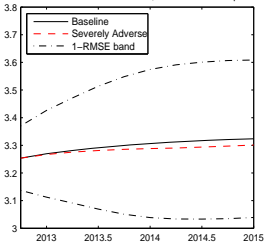
- ▶ The adverse scenario featured an “up and flatter” shift in the yield curve

- ▶ Associated with a moderate recession and a spike in inflation

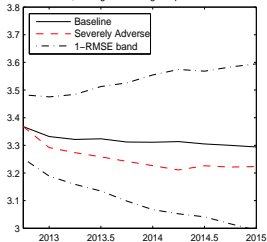


# 2013 CCAR/DFAST scenario model-implied NIMs

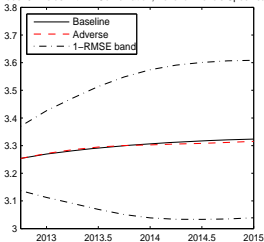
Forecast of NIMs Conditional on Severely Adverse Scenario,  
Model 6. Yields with F. Combination, Level on Levels Specification



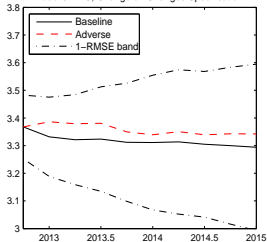
Forecast of NIMs Conditional on Severely Adverse Scenario,  
Model 5. PLS, Change on Changes Specification



Forecast of Nims Conditional on Adverse Scenario,  
Model 6. Yields with F. Combination, Level on Levels Specification



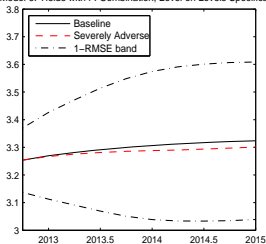
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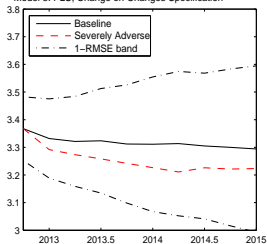
- ▶ Directions for the point forecasts seem reasonable
- ▶ Differences between paths of NIMs under different scenarios are small
  - ▶ This is especially relative to the forecast errors

# 2013 CCAR/DFAST scenario model-implied NIMs, contd.

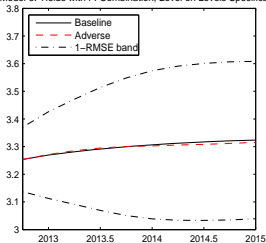
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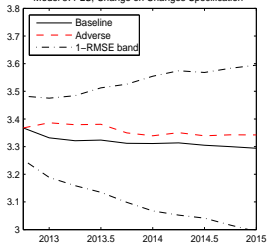
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Forecast of Nims Conditional on Adverse Scenario,  
Model 6. Yields with F. Combination, Level on Levels Specification



Forecast of NIMs Conditional on Adverse Scenario,  
Model 5. PLS, Change on Changes Specification



- ▶ Concern that stress-test results cannot assess forward-looking bank-capital adequacy in a way that creditors and counterparties would find credible

# Summing up

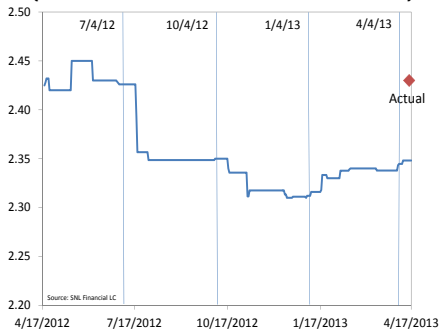
- ▶ In forecasting aggregate NIMs, a few models perform better than the no-change forecast
- ▶ In an absolute sense these models perform poorly
  - ▶ Their RMSEs are large given the variability of NIMs
- ▶ Given the size of RMSEs, NIMs the 2013 CCAR/DFAST stress scenarios are little different to NIMs in the baseline scenario
- ▶ Stress tests and capital planning form the basis of forward-looking *pro forma* bank capital ratios
- ▶ Stress tests are a widely used tool to maintain confidence in future bank capital adequacy during periods of financial stress
- ▶ Poor conditional forecast performance raises concerns as to whether stress-test results can credibly assess and maintain confidence in forward-looking bank capital ratios

- ▶ Other possible variables for aggregate NIM analysis
  - ▶ Variables from micro-banking literature: Competition faced by banks and volatility of interest rates
  - ▶ Other plausible variables: Mortgage originations
  - ▶ All 16 domestic CCAR/DFAST scenario variables
- ▶ BHC-level NIM analysis using similar models to the aggregate analysis

# Motivation for BHC-level NIM analysis

- ▶ To investigate whether poor aggregate large-bank NIM forecast performance also applies to BHCs that are part of the stress tests
- ▶ To compare performance of NIM model-based forecasts to performance of bank-analyst forecasts
  - ▶ SNL Financial LC reports average bank-analyst forecasts
  - ▶ Average is across 20-plus bank-analysts
  - ▶ Bank-analyst forecasts only date back to 2007q4
  - ▶ To give NIM model forecasts the same information as analysts' forecasts, must condition on Blue Chip financial forecasts

**Example:  
Bank of America, 2013q1 NIMs,  
(averaged across all analysts)**



- ▶ Results for 1-quarter ahead forecasts suggests that model forecasts are competitive with averaged bank-analyst forecasts