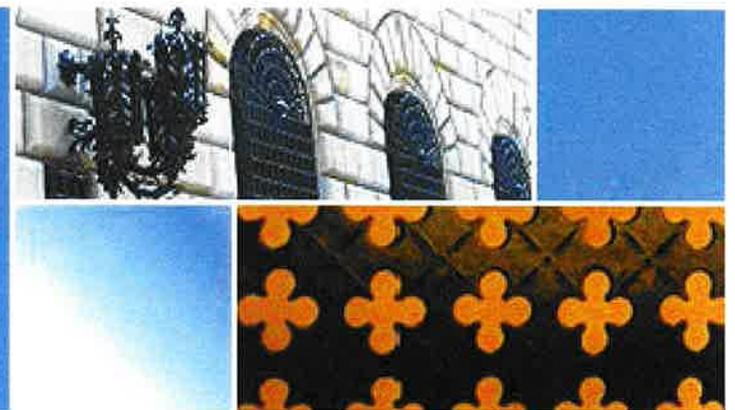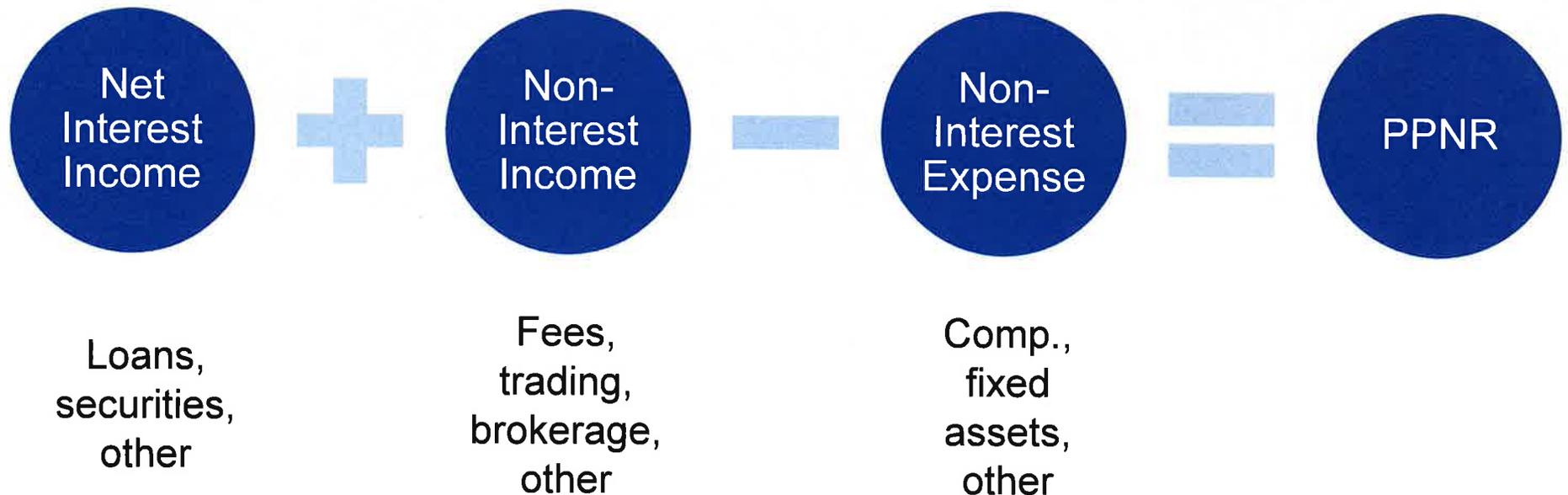# PPNR Modelling Approaches and Development

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Views expressed in this presentation are my own, and do not reflect the opinions of the Federal Reserve Bank of New York or the Federal Reserve System.

Supervisory Approach to Modelling PPNR

- PPNR is modelled with a collection of 26+ models of components of PPNR

Net Interest Income + Non-Interest Income − Non-Interest Expense = PPNR

Loans, securities, other

Fees, trading, brokerage, other

Comp., fixed assets, other

Types of PPNR Models

- **Models of revenues and non-credit-related expenses** expressed as a share of relevant asset or liability balances, and combined with balance forecasts that reflect continued credit intermediation

- Current modelling approaches differ among components:

  - **Instrument level** models calculate ratios from granular information on yields and maturities

  - **Autoregressive models** relate PPNR component ratios to historical ratios, BHC characteristics and macroeconomic variables

  - **Simple models** based on recent firm level performance

Instrument Level Models

- **Long term goal is security / instrument level models**

- For example, subordinated debt:

$$\text{Interest}_{i,t} = \Sigma(\text{Contractual Rate}_{i,t,n})(\text{Balance})_{i,t,n}$$
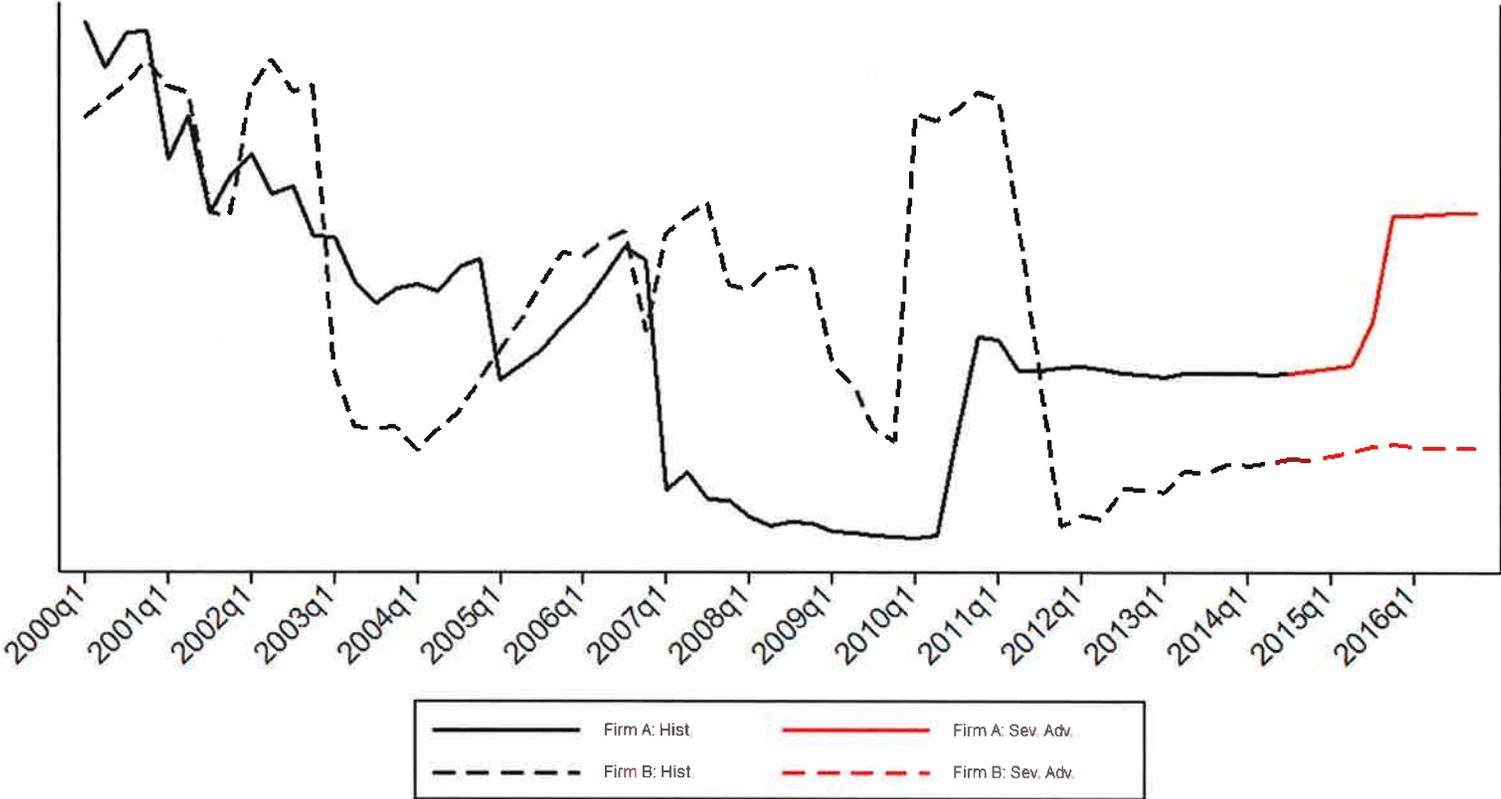
  where *t* indexes time, *i* indexes firms, and the firm has *n* securities:

  - *Contractual Rate$_{i,t,n}$* : contractual interest rate on security *n* at time *t*

  - *Balance$_{i,t,n}$* : balance of security *n* at time *t*

- However, still need to model price and maturity of maturing securities and new issuance as well as swaps

Instrument Level Models - Example

- Forecasts now reflect characteristics of current securities and scenarios

Interest Expense on Sub Debt / Sub Debt

——————	Firm A: Hist.	——————	Firm A: Sev. Adv.
- - - - - -	Firm B: Hist.	- - - - - -	Firm B: Sev. Adv.

Autoregressive Models

- Many components of PPNR models modelled with autoregressive (AR) models:

$$\text{Ratio}_{i,t} = \alpha + \beta_{[1,n]} \, \text{ratio}_{i,t-n} + \beta_2 \, \text{macro}_t + \beta_3 \, X_{i,t} + \varepsilon_t$$

where t indexes time and i indexes banks, and the model has n lags:

- *Ratio*$_{i,t}$: financial ratio of interest and *ratio*$_{t-n}$ is an AR term.
- *Macro*$_t$: macroeconomic variables
- *X*$_{i,t}$: includes bank characteristics

- BHC-specific indicator variables (fixed effects) in a limited number of cases

AR Models – Interest Income Component Example

- Forecasts without fixed effects reflect convergence to mix weighted industry average and scenarios

Interest Income on Loans/ Loans

	History		Sev. Adv.
- - - -	Peer Group History	- - - -	Peer Group Sev. Adv.
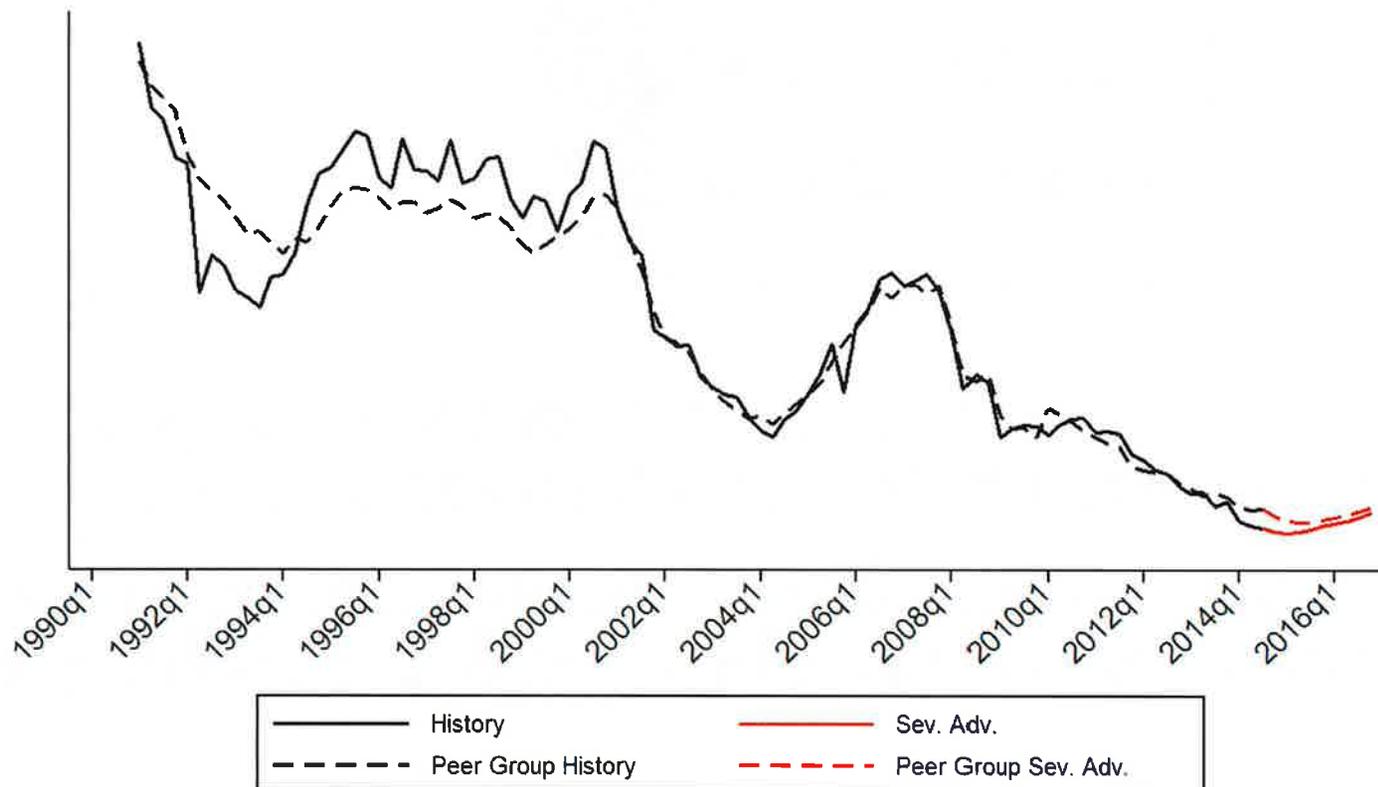
Good, Better, Best?

- Goal is to reflect differences in macroeconomic sensitivity among firms' business models and risk exposures

- However, PPNR inevitably involves modelling new loans and new liabilities as well as existing ones

Instrument level

Autoregressive

Simple
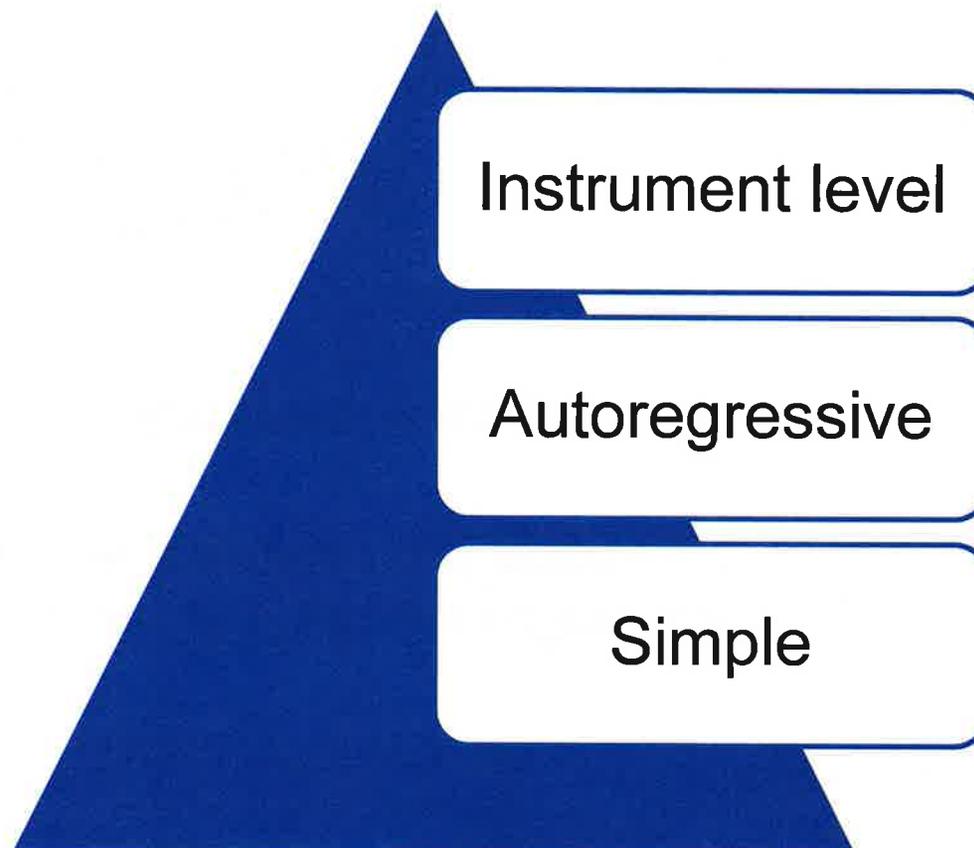
The Long Run Future of Supervisory PPNR Modelling

- Tradeoffs between better data and a rich historical time series of data

Components of net interest income:

- Goal is to move to instrument / security level models as appropriate

Other components:

- Goal is to combine Y-14 data with other sources that provide a longer time series

- Noninterest income and expense will continue to be modelled in a more "top down" way

Model Enhancements Currently Under Development

- Should firms converge to their own past performance or that of all firms in the industry?
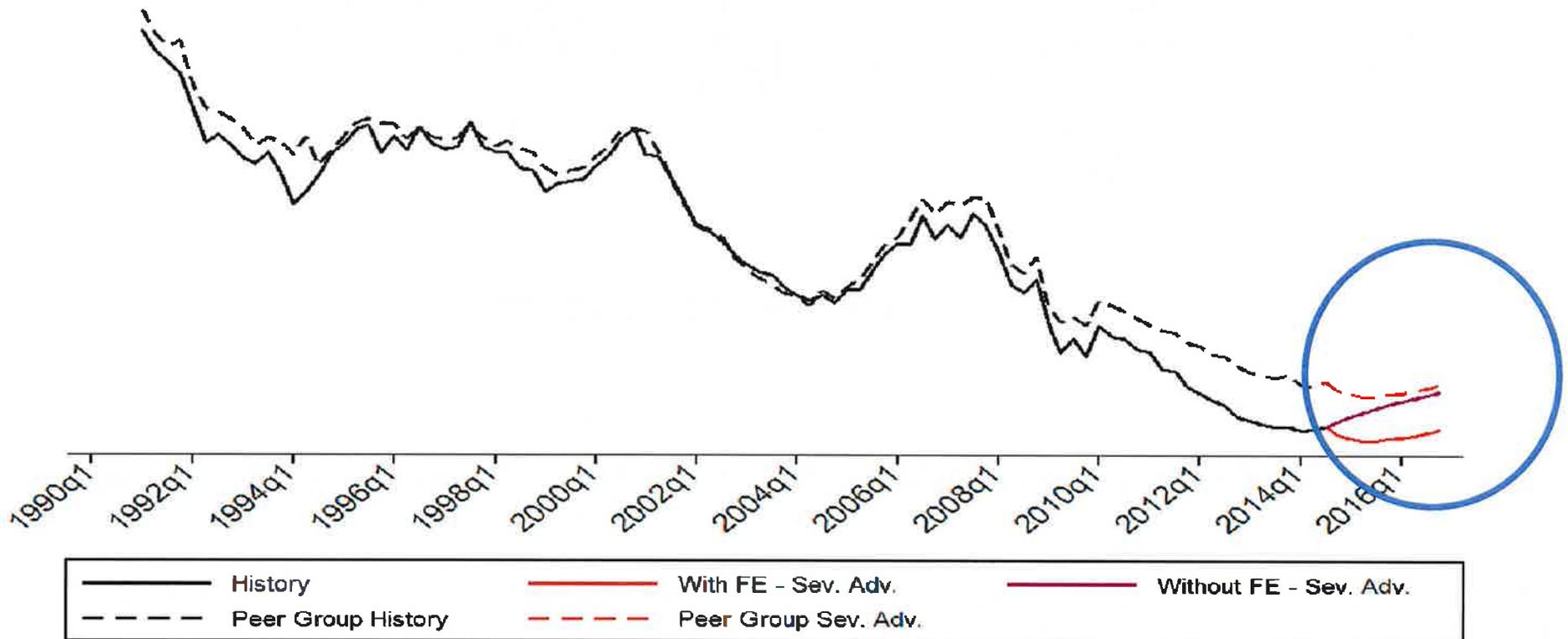
Impact of different approach on projections:

- Generally adding fixed effects produces models more consistent with firms' overall performance

- However, autoregressive coefficients are reduced
  - Reduces impact of very recent performance on forecasts

- Estimating models with fixed effects increases the estimated coefficients on the macro variables
  - Consequently, median forecast with fixed effects models is lower than forecasts without fixed effects in severely adverse scenario (but not necessarily in all scenarios)

Fixed Effects Impact Varies with Firm Performance

- Without fixed effects, firms converge up (or down) to meet the mix weighted industry average

Interest Income on Loans/ Loans

——— History	——— With FE – Sev. Adv.	——— Without FE – Sev. Adv.
- - - Peer Group History	- - - Peer Group Sev. Adv.	

Fixed Effects Reduce Autoregressive Coefficient

- Recent performance has a smaller effect on forecast

Illustrative Revenue / Assets

—— History		—— With FE - Sev. Adv.
—— Without FE - Sev. Adv.		
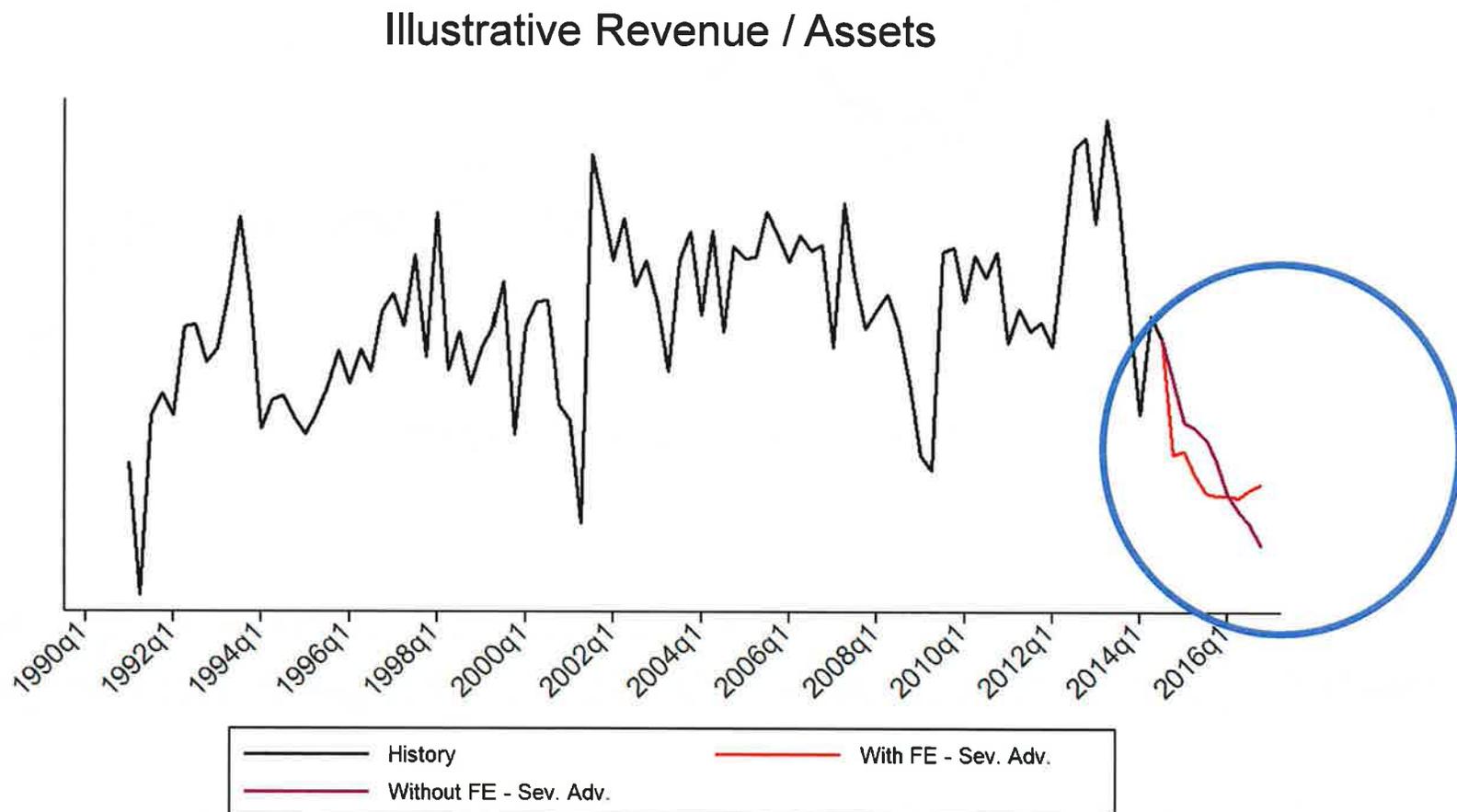
PPNR Component Models with Fixed Effects

- Median effect is negative for industry, but variable for individual BHCs

Illustrative Revenue / Assets

—— History	—— With FE - Sev. Adv.
—— Without FE - Sev. Adv.	—— 25th percentile - Hist.
– – – 25th percentile - With FE Sev. Adv.	– – – 25th percentile - Without FE Sev. Adv.
—— 75th percentile - Hist.	– – – 75th percentile - With FE Sev. Adv.
– – – 75th percentile - Without FE Sev. Adv.	
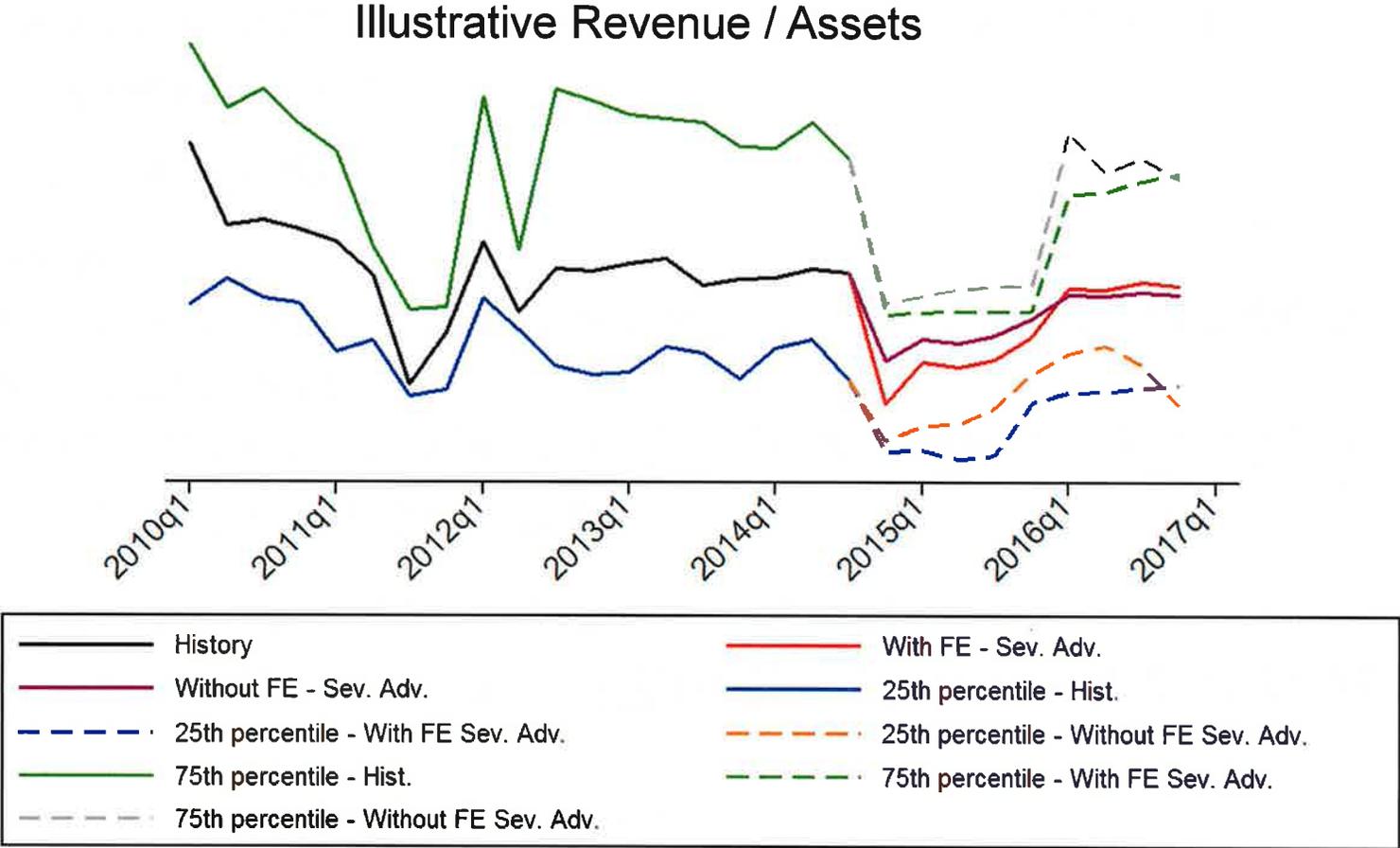
Criteria for Evaluating Models

- Root mean squared error (RMSE) – How does a forecast perform, on average, relative to actual?

- In-sample and out-of-sample
  - In sample criteria are easy to calculate and program, but easy to overfit limited data
  - Finite number of out-of-sample tail realizations of macroeconomic variables

- Forecast horizon
  - Up to 9 quarters ahead
  - Models may perform misleadingly well over short horizons

- Out-of-sample 9Q is intuitively the right metric, but drops many observations in the crisis time period

Other Metrics

- **Different subsets of forecast errors (in- and out-of-sample)**
  - Macroeconomic environment: recession quarters, financial crisis quarters
  - Recent quarters

- **Distribution of errors across firms**
  - How does a model perform for 75 percentile firm or worst firm?

- **"Stability"**
  - Estimate model with data through time t and calculate forecast with constant starting point data (for example, beginning in 2010:Q1, 19 estimated model coefficients through 2014:Q3)
  - Calculate standard deviation of forecasts

- **Sensitivity to macro scenarios**
  - Compare forecasts of different scenarios

Using These Metrics to Inform Model Development

- Use differences between metrics to inform analysis and use judgment

- New models should outperform on multiple dimensions
  - Models should improve performance for most firms without decreasing performance for the worst firms

- Errors calculated for components of revenue and in aggregate