

# How Long Do Markets Need to Fully React to Monetary Policy Announcements?

Paul L. Tran\*

University of Texas at Austin

This version: 28 November, 2025

[[Click here for the latest version](#)]

---

\*Email: pltran@utexas.edu. Website: <https://paulletran.com/>.

# Motivation

- ▶ News is released → Financial markets react to news
  - If change in price  $\approx$  change in expectations → **Unanticipated news**

# Motivation

- ▶ News is released → Financial markets react to news
- ▶ Useful for empirical macro: Obtain shocks from news to infer causal effects
  - Ex: Monetary policy (MP) announcements

# Motivation

- ▶ News is released → Financial markets react to news
- ▶ Useful for empirical macro: Obtain shocks from news to infer causal effects
- ▶ Method: High-frequency Identification of MP surprises
  - Measure price change **within event window** around MP announcement
  - Most popular choice in literature: **30 minutes**

# Motivation

- ▶ News is released → Financial markets react to news
- ▶ Useful for empirical macro: Obtain shocks from news to infer causal effects
- ▶ Method: High-frequency Identification of MP surprises
- ▶ **Research Q:** What size should the window length around MP announcements be?
  - Too short: Markets might **not fully react** to policy news yet
  - Too long: Change in price  $\approx$  MP shocks w/ **unrelated news, confounding factors**
  - **Just right:** Change in price  $\approx$  MP shocks with **minimised noise**

# Motivation

- ▶ News is released → Financial markets react to news
- ▶ Useful for empirical macro: Obtain shocks from news to infer causal effects
- ▶ Method: High-frequency Identification of MP surprises
- ▶ **Research Q:** What size should the window length around MP announcements be?
  - Too short: Markets might **not fully react** to policy news yet
  - Too long: Change in price  $\approx$  MP shocks w/ **unrelated news, confounding factors**
  - **Just right:** Change in price  $\approx$  MP shocks with **minimised noise**
- ▶ **Wrong A:** Contributes to MP shocks lacking precision because of noise

# This Paper

UAT + Layers

- ▶ **This Paper:** Estimate optimal window size for FOMC statements by:
  - Natural language processing (NLP) to combine price dynamics with text-based signal

# This Paper

UAT + Layers

- ▶ **This Paper:** Estimate optimal window size for FOMC statements by:
  - Natural language processing (NLP) to combine price dynamics with text-based signal
  - Approximating underlying relationship  $f(\text{FOMC statement}) = \Delta\text{Asset prices}$

# This Paper

UAT + Layers

- ▶ **This Paper:** Estimate optimal window size for FOMC statements by:
  - Natural language processing (NLP) to combine price dynamics with text-based signal
  - Approximating underlying relationship  $f(\text{FOMC statement}) = \Delta\text{Asset prices}$
  - NLP approximation → Text-based signal =  $\widehat{\Delta\text{Asset prices}}$  within given event window

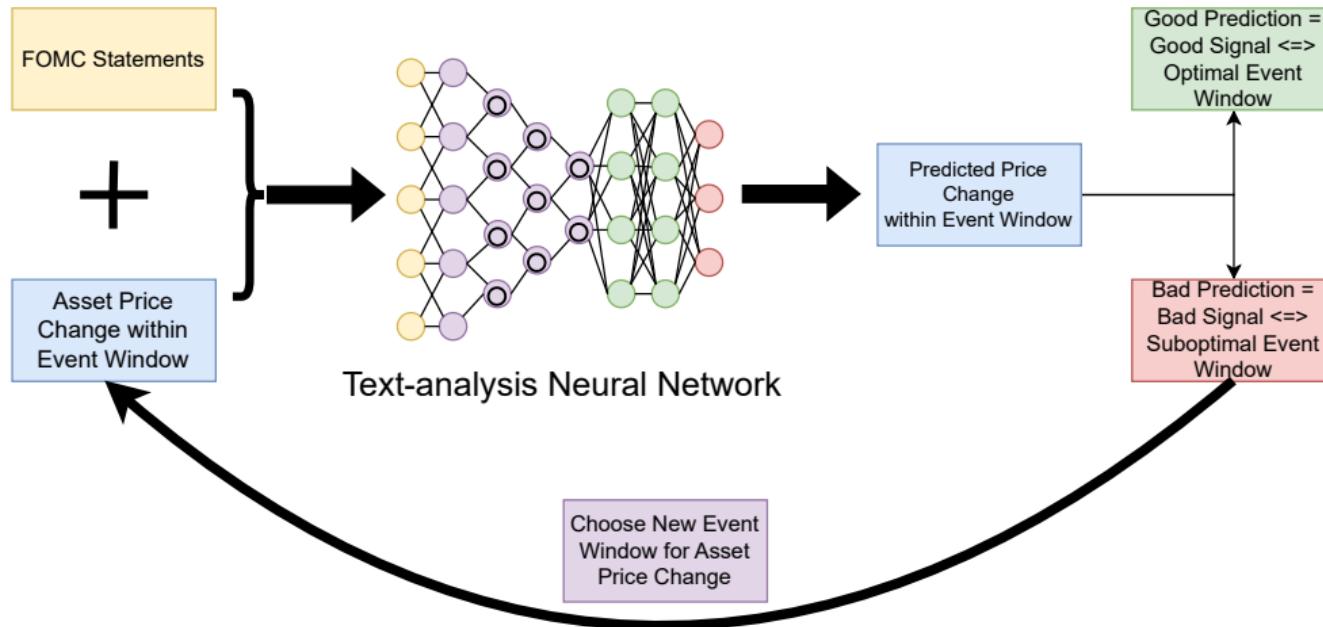
# This Paper

- ▶ **This Paper:** Estimate optimal window size for FOMC statements by:
  - Natural language processing (NLP) to combine price dynamics with text-based signal
  - Approximating underlying relationship  $f(\text{FOMC statement}) = \Delta\text{Asset prices}$
  - NLP approximation → Text-based signal =  $\widehat{\Delta\text{Asset prices}}$  within given event window
- 1. **Optimal window only:** Noise has min average impact on  $\Delta\text{asset prices}$
- 2. **Optimal window only:** NLP text-based signal has highest precision
- 3. **Any other window:** Bad approximation by NLP → Bad signal

# This Paper

UAT + Layers

- ▶ **This Paper:** Estimate optimal window size for FOMC statements using NLP



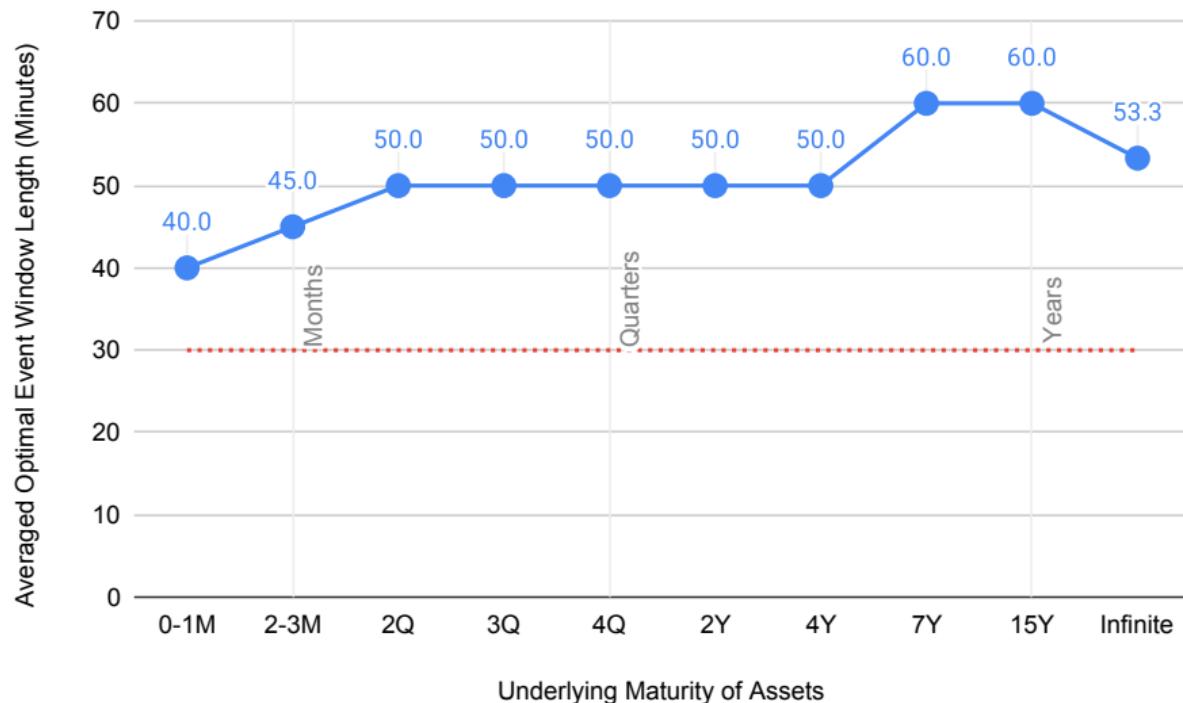
# Previous of Results: Summary

- ▶ **How Long?** Longer than literature standard of 30 minutes:
  - On avg, markets fully react within window 10 min before and 30+ min after
  - Underlying maturity of assets ↑, then average optimal window length ↑
  - Underlying maturity of asset at least 2 quarters out → 50- to 60-min window
  - Complex/dissimilar/dissent statements → Relatively longer windows

# Previous of Results: Summary

- ▶ **How Long?** Longer than literature standard of 30 minutes:
  - On avg, markets fully react within window 10 min before and 30+ min after
  - Underlying maturity of assets ↑, then average optimal window length ↑
  - Underlying maturity of asset at least 2 quarters out → 50- to 60-min window
  - Complex/dissimilar/dissent statements → Relatively longer windows
- ▶ **Effects on MP:** By changing only event window choice:
  - Underlying maturity of assets ↑, then correlation ↓ between MP surprise sets
  - MP shocks about forward guidance have ↑ impact on yields, inflation, and stock prices
  - MP shocks about forward guidance are ↑ precise on macroeconomic variables

# Preview of Results: Visual

[Summary Text](#)[Summary Table](#)[Recap](#)[Liquidity](#)

# Related Literature and Contributions

## 1. Measuring Appropriate Event Window Lengths

- Hillmer and Yu (1979); Chang and Chen (1989); Krivin et al. (2003); Das and King (2021); An et al. (2025); Boehm and Kroner (2025); and others...
- Contributions: (1) If news = text → Method can estimate optimal window; (2) Introduce noise min. approach

# Related Literature and Contributions

## 1. Measuring Appropriate Event Window Lengths

## 2. Text Analysis in Monetary Policy Communication

- Lucca and Trebbi (2009); Hansen and McMahon (2016); Hansen, McMahon, and Prat (2017); Cieslak and Vissing-Jorgensen (2020); Husted et al. (2020); Handlan (2022a); Handlan (2022b); Acosta (2023); Doh et al. (2023); Cieslak and McMahon (2023); Cieslak, Hansen, et al. (2023); Gorodnichenko et al. (2023); Aruoba and Drechsel (2024); Gáti and Handlan (2025a); Gáti and Handlan (2025b); Piller et al. (2025); and others...
- **Contributions:** ↑ adoption of NLP to quantify dimensions of MP communication

# Related Literature and Contributions

- 1. Measuring Appropriate Event Window Lengths**
- 2. Text Analysis in Monetary Policy Communication**
- 3. Event Window Lengths in Monetary Policy**

- Examples: Gürkaynak, Sack, et al. (2005); Nakamura and Steinsson (2018); Swanson and Jayawickrema (2023); An et al. (2025); Boehm and Kroner (2025); and others...
- **Contributions:** (1) Optimal window length around FOMC statements  $>$  30-min; (2) different markets, different window lengths; (3) MP effects less dampened

# Presentation Roadmap

- ① Introduction
- ② Motivating Framework
- ③ Optimal Event Windows
- ④ MP Surprises & Shocks
- ⑤ Conclusion

# Motivating Framework of Asset Market Prices

$$\{P_t = P_t^f + \varepsilon_t^c + \varepsilon_t^n | t \geq 0\}, \quad (1)$$

- ▶ **Fundamental Price Component:** Constant  $\rightarrow P_t^f = P^f \in \mathbb{R}$ 
  - Price because of news

# Motivating Framework of Asset Market Prices

$$\{P_t = P_t^f + \varepsilon_t^c + \varepsilon_t^n | t \geq 0\}, \quad (1)$$

- ▶ **Fundamental Price Component:** Constant  $\rightarrow P_t^f = P^f \in \mathbb{R}$ 
  - Price because of news

- ▶ **Cognitive Noise:** Decaying AR(1)  $\rightarrow \varepsilon_t^c = \rho_c \varepsilon_{t-1}^c + e^{-\mathcal{D}t} \nu_t^c$

Interpretations

- $\nu_t^c \sim \mathcal{N}(0, \sigma_c^2)$
- $|\rho_c| < 1$
- Decay:  $\mathcal{D} \in \mathbb{R}^+$
- $|\frac{\rho_c}{\mathcal{D}}| < 1$
- Assumption:  $\text{Var}(\varepsilon_0^c) = \sigma_c^2$

# Motivating Framework of Asset Market Prices

$$\{P_t = P_t^f + \varepsilon_t^c + \varepsilon_t^n | t \geq 0\}, \quad (1)$$

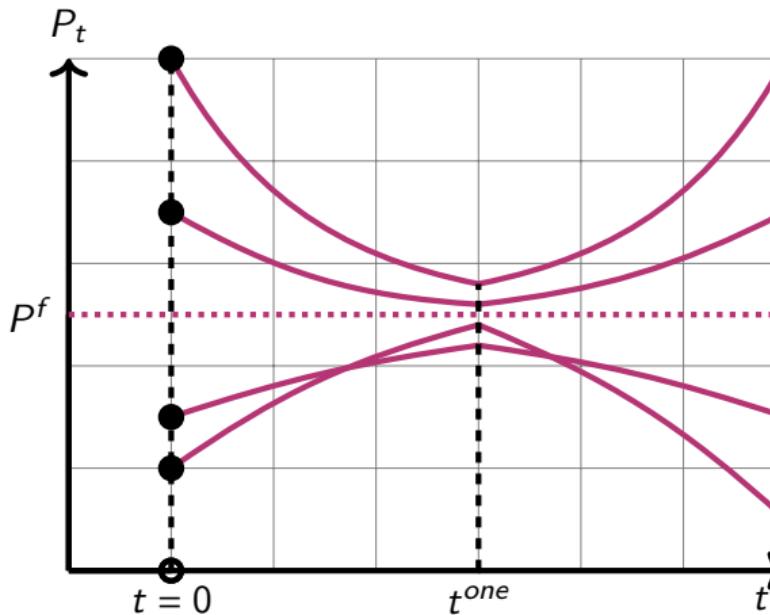
- ▶ **Fundamental Price Component:** Constant →  $P_t^f = P^f \in \mathbb{R}$ 
  - Price because of news
- ▶ **Cognitive Noise:** Decaying AR(1) →  $\varepsilon_t^c = \rho^c \varepsilon_{t-1}^c + e^{-\mathcal{D}t} \nu_t^c$  Interpretations
- ▶ **Unrelated News:** Background shocks as random walk →  $\varepsilon_t^n = \varepsilon_{t-1}^n + \nu_t^n$ 
  - $\nu_t^n \sim \mathcal{N}(0, \sigma_n^2)$
  - Assumption:  $\text{Var}(\varepsilon_0^n) = 0$

# Visualising How Noise Components Affect Prices

[Other Scenarios](#)

Presence of both Cognitive Noise and Unrelated News

- ▶ **Too Short:**
  - Cognitive noise dominates
- ▶ **Too Long:**
  - Unrelated news dominates
- ▶ **“Just Right”:**
  - Noises have minimal impact



# Single News: Effects of Noise Components on $t^{one}$

[Derivation](#)

1. News arrival moves  $P^f$
  2.  $\text{Var}(P_t | t \geq 0)$  evolves
- **Goal:** Find **minimising time  $t^{one}$**

---

† I numerically verify the dynamics of the  $t^{one}$  for various values of  $\sigma_c^2$  and  $\sigma_n^2$  in its indirect expression, holding the other parameters constant.

# Single News: Effects of Noise Components on $t^{one}$

[Derivation](#)

1. News arrival moves  $P^f$

2.  $\text{Var}(P_t | t \geq 0)$  evolves

→ **Goal:** Find **minimising time  $t^{one}$**

► **Result:**  $t^{one}$  moves by noise components:  $\frac{\partial t^{one}}{\partial \sigma_n^2} < 0, \frac{\partial t^{one}}{\partial \sigma_c^2} > 0$ †

---

†I numerically verify the dynamics of the  $t^{one}$  for various values of  $\sigma_c^2$  and  $\sigma_n^2$  in its indirect expression, holding the other parameters constant.

# Single News: Effects of Noise Components on $t^{one}$

Derivation

1. News arrival moves  $P^f$

2.  $\text{Var}(P_t | t \geq 0)$  evolves

→ **Goal:** Find **minimising time  $t^{one}$**

- ▶ **Result:**  $t^{one}$  moves by noise components:  $\frac{\partial t^{one}}{\partial \sigma_n^2} < 0, \frac{\partial t^{one}}{\partial \sigma_c^2} > 0$  †
- ▶ **Conclusion:** Always short, always long window → **Bad idea**

---

† I numerically verify the dynamics of the  $t^{one}$  for various values of  $\sigma_c^2$  and  $\sigma_n^2$  in its indirect expression, holding the other parameters constant.

# Multiple News: Estimator Form

- ▶ **Problem:**  $N$  announcements and  $P_{i,t}^f$  is **unobservable**
- ▶ **Solution:** Observe noisy signal  $s_i = P_i^f + \xi_i$ 
  - Observed by econometrician;  $\xi_i \sim \mathcal{N}(0, \sigma_s^2)$
- ▶ **Goal:** Find  $t^*$  to minimise MSE across  $N$  events:

$$t^* : \min_t \frac{1}{N} \sum_{i=1}^N (P_{i,t} - s_i)^2 \implies \min_t \left[ \frac{1}{N} \sum_{i=1}^N (\varepsilon_{i,t}^c + \varepsilon_{i,t}^n)^2 + \sigma_s^2 \right] \quad (2)$$

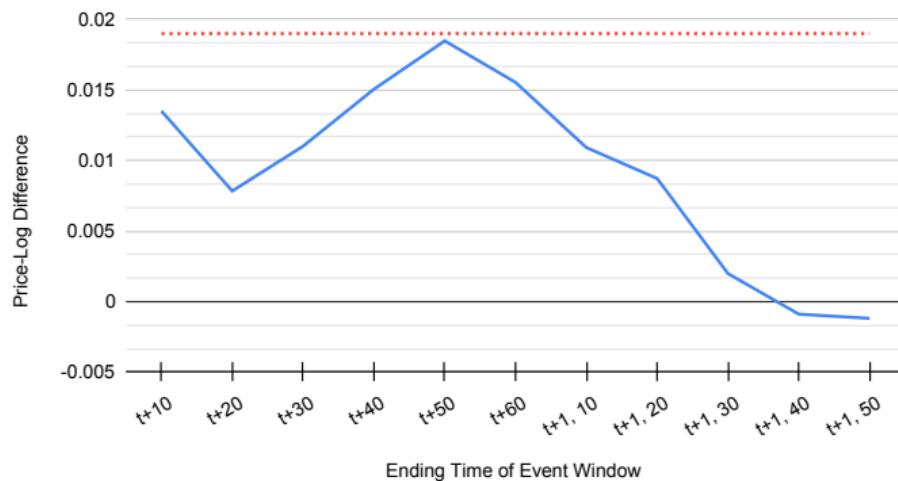
- ▶ Minimising MSE with  $s_i$  the **same** as with  $P_i^f$  (asymptotically)
- ▶ Finite samples → Precision of  $s_i$  ("good" signal) matters
- ⇒ Possible to estimate optimal  $t^*$  with signal  $s_i$

[Derivation](#)

# Multiple News: Example of Signal in Financial Prices

- ▶ **Red Dotted Line:** Signal ( $s_i$ )  $\approx$  Fundamental price change because of news
- ▶ **Blue Line:** Observed price change with varying noise levels
- ▶ **Optimisation:**  $t^*$  is where signal best represents observed price change

Market Price Reactions for S&P 500 Index, 30/01/2008



# Motivating Framework Takeaways

- ▶ **Summary:** Always short, always long window → **Bad idea**
  - “Good” signal → Possible to estimate time horizon reflecting full reactions
- ▶ **Constraint:** MP shocks = **Finite sample** problem → “**Good**” signal matters

# Motivating Framework Takeaways

- ▶ **Summary:** Always short, always long window → **Bad idea**
  - “Good” signal → Possible to estimate time horizon reflecting full reactions
- ▶ **Constraint:** MP shocks = **Finite sample** problem → “**Good**” signal matters
- ▶ **Reality:** **Do not know** noise processes
  - Framework uses strong assumptions to illustrate points
- ▶ **Solution:** NLP method estimates optimal window **without knowing**
  - NLP method can approximate **underlying relationship**

# Presentation Roadmap

- ① Introduction
- ② Motivating Framework
- ③ Optimal Event Windows
- ④ MP Surprises & Shocks
- ⑤ Conclusion

# Estimating Optimal Event Windows: Method

- ▶ **Objective:** Isolate  $\Delta$ asset prices **within given window** to “full” FOMC statements

# Estimating Optimal Event Windows: Method

- ▶ **Objective:** Isolate Δasset prices **within given window** to “full” FOMC statements
- ▶ **Input:** Full text of **scheduled** FOMC statements
  - 165 statements from May 1999–October 2019

FOMC Statement Text Prep

FOMC Statement Ex

Why FOMC Statements?

# Estimating Optimal Event Windows: Method

- ▶ **Objective:** Isolate  $\Delta$ asset prices **within given window** to “full” FOMC statements
- ▶ **Input:** Full text of **scheduled** FOMC statements
  - 165 statements from May 1999–October 2019
- ▶ **Output:**  $DP_{t+n} = \ln\left(\frac{P_{t+n}}{P_{t-10}}\right)$  for interest-rate and equity futures

FOMC Statement Text Prep

FOMC Statement Ex Why FOMC Statements?

Futures List

# Estimating Optimal Event Windows: Method

- ▶ **Objective:** Isolate  $\Delta$ asset prices **within given window** to “full” FOMC statements
- ▶ **Input:** Full text of **scheduled** FOMC statements
  - 165 statements from May 1999–October 2019
- ▶ **Output:**  $DP_{t+n} = \ln\left(\frac{P_{t+n}}{P_{t-10}}\right)$  for interest-rate and equity futures
- ▶ **Model:** XLNet-Base fine-tuned to approx  $f(\text{FOMC Statement}) = \Delta\text{Asset prices}$ 
  - Approach
  - Input/Output Visual
  - Nonparametric regression approximated by many linear + non-linear combinations
  - Neural network approximation → Text-based signal =  $\widehat{\Delta\text{Asset prices}}$

[FOMC Statement Text Prep](#)[FOMC Statement Ex](#) [Why FOMC Statements?](#)[Futures List](#)

# Estimating Optimal Event Windows: Method

- ▶ **Objective:** Isolate  $\Delta$ asset prices **within given window** to “full” FOMC statements

- ▶ **Input:** Full text of **scheduled** FOMC statements

- 165 statements from May 1999–October 2019

FOMC Statement Text Prep

FOMC Statement Ex Why FOMC Statements?

- ▶ **Output:**  $DP_{t+n} = \ln\left(\frac{P_{t+n}}{P_{t-10}}\right)$  for interest-rate and equity futures

Futures List

- ▶ **Model:** XLNet-Base fine-tuned to approx  $f(\text{FOMC Statement}) = \Delta$ Asset prices

Approach Input/Output Visual

- Nonparametric regression approximated by many linear + non-linear combinations
- Neural network approximation → Text-based signal =  $\widehat{\Delta}$ Asset prices

- ▶ **Strategy:** Regress  $\Delta$ asset prices in **different** event windows on FOMC statements

CV Strategy CV Visual Estimation Loop

- Pick event window where neural network has ↑ avg predictive performance :=  $R^2_{oos}$
- **Optimal window only:** Noise components have min average impact on  $\Delta$ asset prices  
⇒ “Jointly” estimate optimal window and “good” signal

# Optimal Event Windows: Main Results

## ▶ How Long?

Summary Visual

- On avg, markets fully react within window 10 min before and 30+ min after FF3
- Underlying maturity of assets increases → Avg optimal window length increases  
Other Assets
- Underlying maturity of asset at least 2 quarters out → 50–60-min window USc2

# Optimal Event Windows: Main Results

## ▶ How Long?

Summary Visual

- On avg, markets fully react within window 10 min before and 30+ min after FF3
- Underlying maturity of assets increases → Avg optimal window length increases  
Other Assets
- Underlying maturity of asset at least 2 quarters out → 50–60-min window USc2

## ▶ How Much Better?

Summary Table

- $\overline{R^2_{OOS}}$  ↑ by 2–17% when event window ↑ to 40+ min
- All event windows → Positive  $\overline{R^2_{OOS}}$  → XLNet-Base can approx underlying relationship

# Optimal Event Windows: Main Results

## ▶ How Long?

[Summary Visual](#)

- On avg, markets fully react within window 10 min before and 30+ min after FF3
- Underlying maturity of assets increases → Avg optimal window length increases  
Other Assets
- Underlying maturity of asset at least 2 quarters out → 50–60-min window USc2

## ▶ How Much Better?

[Summary Table](#)

- $\overline{R^2_{OOS}}$  ↑ by 2–17% when event window ↑ to 40+ min
- All event windows → Positive  $\overline{R^2_{OOS}}$  → XLNet-Base can approx underlying relationship

## ▶ Why?

[FF3 Scatter](#) [USc2 Scatter](#)

- On avg, markets under-react, ex-post, to FOMC statement within standard windows
- “Soft” information = Longer to process → Info asymmetry to resolve  
[FOMC Statement Ex](#)
  - Indriawan et al. (2021); Brooks et al. (2023)

# Presentation Roadmap

① Introduction

② Motivating Framework

③ Optimal Event Windows

④ MP Surprises & Shocks

⑤ Conclusion

# Monetary Policy Surprises: Overview

- ▶ Found optimal event window lengths: 40-, 50-, 60-minutes
- 1. Pick an interest-rate futures contract

# Monetary Policy Surprises: Overview

- ▶ Found optimal event window lengths: 40-, 50-, 60-minutes
- 1. Pick an interest-rate futures contract
- 2. Construct MP surprises within 30-minute and optimal windows
  - $mp1, mp2, \Delta ed2, \Delta ed3, \Delta ed4, \Delta t2, \Delta t5, \Delta t10, \Delta t30$

*DP → Surprise*

# Monetary Policy Surprises: Overview

- ▶ Found optimal event window lengths: 40-, 50-, 60-minutes
- 1. Pick an interest-rate futures contract
- 2. Construct MP surprises within 30-minute and optimal windows
  - $mp1, mp2, \Delta ed2, \Delta ed3, \Delta ed4, \Delta t2, \Delta t5, \Delta t10, \Delta t30$
- 3. Calculate correlations between MP surprise sets

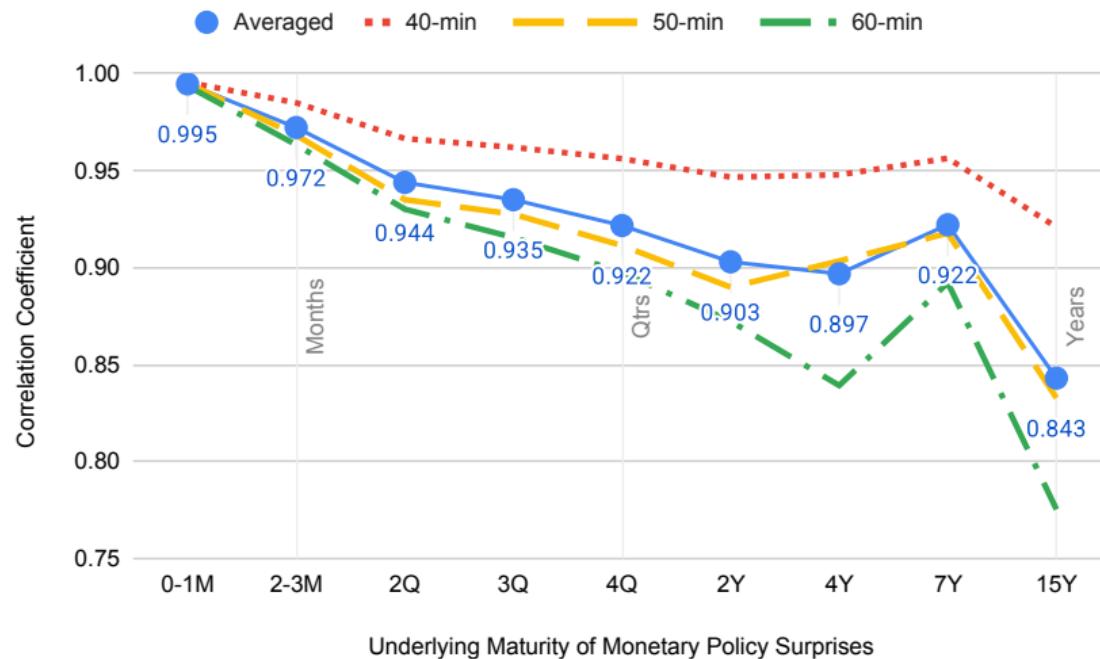
*DP → Surprise*

# Monetary Policy Surprises: Overview

- ▶ Found optimal event window lengths: 40-, 50-, 60-minutes
- 1. Pick an interest-rate futures contract
- 2. Construct MP surprises within 30-minute and optimal windows
  - $mp1, mp2, \Delta ed2, \Delta ed3, \Delta ed4, \Delta t2, \Delta t5, \Delta t10, \Delta t30$
- 3. Calculate correlations between MP surprise sets
- 4. Back to step 1

*DP → Surprise*

# Monetary Policy Surprises: Correlations Along the Yield Curve



→ Changing only window length has ↑ effect at **further horizons**

# Monetary Policy Shocks: Construction Methods

- ▶ Focus on median optimal event window length: 50 minutes

# Monetary Policy Shocks: Construction Methods

- ▶ Focus on **median** optimal event window length: **50 minutes**
- ▶ Use **full set** of MP surprises as instruments
  - Prevent dampening of MP during ELB period (Brennan et al., 2024; An et al., 2025)

# Monetary Policy Shocks: Construction Methods

- ▶ Focus on median optimal event window length: 50 minutes
  - ▶ Use full set of MP surprises as instruments
  - ▶ Construct MP shocks using diff methods within 30-minutes and optimal windows:  
[PCA](#) [MP Shock Visuals](#) [Summary Stats](#)
1. Gürkaynak, Sack, et al. (2005):
    - $GSS_T$  → 1<sup>st</sup> Principal component rotated to drive  $mp1$
    - $GSS_P$  → 2<sup>nd</sup> Principal component rotated to have no effect on  $mp1$
  2. Nakamura and Steinsson (2018):
    - $NS_{MP}$  → 1<sup>st</sup> Principal component of MP surprises
  3. Jarociński and Karadi (2020):
    - $JK_{MP}$  → 1<sup>st</sup> Principal component of MP surprises w/  $SPX$  + co-movement
    - $JK_{CBI}$  → 1<sup>st</sup> Principal component of MP surprises w/  $SPX$  + co-movement

# Monetary Policy Shocks: Construction Methods

- ▶ Focus on median optimal event window length: 50 minutes
- ▶ Use full set of MP surprises as instruments
- ▶ Construct MP shocks using diff methods within 30-minutes and optimal windows:  
[PCA](#) [MP Shock Visuals](#) [Summary Stats](#)
- 1. Gürkaynak, Sack, et al. (2005):
  - $GSS_T$  → 1<sup>st</sup> Principal component rotated to drive  $mp1$
  - $GSS_P$  → 2<sup>nd</sup> Principal component rotated to have no effect on  $mp1$
- 2. Nakamura and Steinsson (2018):
  - $NS_{MP}$  → 1<sup>st</sup> Principal component of MP surprises
- 3. Jarociński and Karadi (2020):
  - $JK_{MP}$  → 1<sup>st</sup> Principal component of MP surprises w/  $SPX$  + co-movement
  - $JK_{CBI}$  → 1<sup>st</sup> Principal component of MP surprises w/  $SPX$  + co-movement
- ▶ All shocks scaled: 1bp ↑ in shock → 1bp ↑ in nominal 1-year Treasury yield

# MP Shocks: Effects on Interest Rates, Break-even Inflation, Equities (1/2)

## ► LHS Variables:

1.  $\Delta TY^i$  = Daily change in nominal Treasury yields,  $i \in \{1, 2, 5, 10\}$
2.  $\Delta TIPS^i$  = Daily change in Treasury Inflation-Protected Security yields,  $i \in \{2, 5, 10\}$
3.  $\Delta BEI^i$  = Daily change in end-of-day break-even inflation,  $i \in \{2, 5, 10\}$
4.  $DP_{SPX}$  = Price log-difference of *SPX* within 30-minute and optimal windows
5.  $DP_{ESc1}$  = Price log-difference of *ESc1* within 30-minute and optimal windows
6.  $DP_{ESc2}$  = Price log-difference of *ESc2* within 30-minute and optimal windows

## ► Specification:

$$y^j = \beta_0^{j,k,l} + \beta_1^{j,k,l} (\text{Shock})^{k,l} + \varepsilon^{j,k,l}, \quad (3)$$

- Shock  $k \in \{GSS_T, GSS_P, NS_{MP}, JK_{MP}, JK_{CBI}\}$
- Event window  $l \in \{30 \text{ minutes, optimal}\}$

# MP Shocks: Effects on Interest Rates, Break-even Inflation, Equities (2/2)

- ▶ **Using Optimal Windows:** MP shocks about forward guidance have ↑ effects on:
  - Nominal interest rates [Reg Table](#)
  - Real interest rates [Reg Table](#)
  - Break-even inflation [Reg Table](#)
  - Stock prices and E-mini futures [Reg Table](#)
- ▶ Using non-optimal windows → Attenuated MP shock effects

# MP Shocks: Impulse Responses from Local Projection Approach (1/2)

- ▶ **LHS Variables:** Monthly variables  $i$  from FRED [Summary Stats](#)
  - Log Consumer Price Index (CPI)
  - Log Industrial Production (IP)
  - Nominal 2-year Treasury yield
  - Excess Bond Premium (EBP) (Gilchrist and Zakrajšek, 2012)
- ▶ **Specification:** Lag-augmented local projections (Olea and Plagborg-Møller, 2021)

$$y_{t+h}^{i,I} = \theta^{i,k,I} (\text{Shock})_t^{k,I} + \text{controls} + \eta^{i,k,I} \quad (4)$$

- ▶ Shock  $k \in \{GSS_T, GSS_P, NS_{MP}, JK_{MP}, JK_{CBI}\}$ 
  - All shocks converted to monthly frequency (No meeting → Zero shock) [Summary Stats](#)
- ▶ Event window  $I \in \{30 \text{ minutes, optimal}\}$
- ▶ **All shocks scaled:** 100bp ↑ shock → Contractionary shock

# MP Shocks: Impulse Responses from Local Projection Approach (2/2)

- ▶ Calculate confidence interval (CI) widths under 30-minute and optimal windows
  - Average ratio of CI widths: 0.9173
  - Median ratio of CI widths: 0.9410
- **Using Optimal Windows:** Impulse responses have ↑ precision LP Visuals
- ▶ Using non-optimal windows → Attenuated MP shock effects on macro variables

# Extensions: How do Statement Characteristics Affect Window Length?

- ▶ **Question:** Do FOMC statement **characteristics** affect **optimal** window length?
- ▶ **Approach:** Condition estimation on specific statement features under “**One Signal**”  
One Signal Approach
- ▶ **Findings:** On average, longer windows associated with:
  - More **semantically complex** statements (Reading Level ↑)  
Complexity
  - Statements **less similar** to previous statement (Cosine Similarity ↓)  
Similarity
  - Statements with presence of **dissents** in the voting record  
Dissents

# Presentation Roadmap

① Introduction

② Motivating Framework

③ Optimal Event Windows

④ MP Surprises & Shocks

⑤ Conclusion

# Conclusion

- ▶ **This Paper:** Estimate optimal window size for FOMC statements using NLP:
  - By combining **text-based signal** with observed price dynamics
  - Approximating **underlying** relationship  $f(\text{FOMC statement}) = \Delta\text{Asset prices}$
- ▶ **How Long?** **Longer** than literature standard of 30 minutes:
  - On avg, markets fully react within window 10 min before and **30+ min after**
  - Underlying maturity of assets ↑, then average optimal window length ↑
  - Underlying maturity of asset at least 2 quarters out → **50- to 60-min window**
  - Complex/dissimilar/dissent statements → Relatively **longer** windows
- ▶ **Effects on MP:** By changing only event window choice:
  - Underlying maturity of assets ↑, then **correlation ↓** between MP surprise sets
  - MP shocks about forward guidance have ↑ **impact** on yields, inflation, and stock prices
  - MP shocks about forward guidance are ↑ **precise** on macroeconomic variables

# Next Steps

## ► Next steps:

1. Estimate optimal event window lengths for other MP communication
  - Ex: Fed Chair and Vice-chair **speeches** (Swanson and Jayawickrema, 2023)
2. Analyse how deeper changes in MP communication affect optimal windows
  - **Conceptual** complexity effect > semantic complexity effect?
3. Different optimal window lengths for **different states**?
  - Ex: High/low inflationary periods

# Thank you!

pltran@utexas.edu

<https://paulletran.com/>

# References I

- Acosta, Miguel (2023). "The Perceived Causes of Monetary Policy Surprises". Published manuscript.
- Acosta, Miguel and Ellen E. Meade (2015). *Hanging on Every Word: Semantic Analysis of the FOMC's Postmeeting Statement*. Tech. rep. FEDS Notes. Board of Governors of the Federal Reserve System.
- An, Phillip, Karlye Dilts Stedman, and Amaze Lusompa (2025). *How High Does High Frequency Need to Be? A Comparison of Daily and Intradaily Monetary Policy Surprises*. Tech. rep. Research Working Paper no. 25-03. Federal Reserve Bank of Kansas City.
- Antweiler, Werner and Murray A. Frank (2022). "Do US Stock Markets Typically Overreact to Corporate News Stories?" SSRN Working Paper No 878091.
- Aruoba, S. Boragan and Thomas Drechsel (2024). *Identifying Monetary Policy Shocks: A Natural Language Approach*. Working Paper 32417. National Bureau of Economic Research.
- Bazzana, Flavio and Andrea Collini (2020). "How does HFT activity impact market volatility and the bid-ask spread after an exogenous shock? An empirical analysis on S&P 500 ETF". In: *The North American Journal of Economics and Finance* 54, p. 101240.
- Ben Ammar, Imen and Slaheddine Hellara (2022). "High-frequency trading, stock volatility, and intraday crashes". In: *The Quarterly Review of Economics and Finance* 84, pp. 337–344.
- Ben-David, Itzhak, Francesco Franzoni, Byungwook Kim, and Rabih Moussawi (2022). "Competition for Attention in the ETF Space". In: *The Review of Financial Studies* 36.3, pp. 987–1042. eprint: <https://academic.oup.com/rfs/article-pdf/36/3/987/49288527/hhac048.pdf>.
- Bernard, Victor L. and Jacob K. Thomas (1989). "Post-Earnings-Announcement Drift: Delayed Price Response or Risk Premium?" In: *Journal of Accounting Research* 27, pp. 1–36.
- Bianchi, Francesco, Sydney C Ludvigson, and Sai Ma (2024). *What Hundreds of Economic News Events Say About Belief Overreaction in the Stock Market*. Working Paper 32301. National Bureau of Economic Research.
- Bloomfield, Robert, Maureen O'Hara, and Gideon Saar (2009). "How Noise Trading Affects Markets: An Experimental Analysis". In: *The Review of Financial Studies* 22.6, pp. 2275–2302.
- Bobrov, Anton, Rupal Kamdar, and Mauricio Ulate (2025). "Regional Dissent: Do Local Economic Conditions Influence FOMC Votes?" In: *American Economic Review: Insights* 7.2, pp. 268–84.
- Boehm, Christoph E and T Niklas Kröner (2025). "Monetary Policy without Moving Interest Rates: The Fed Non-Yield Shock". SSRN Working Paper No 3812524.
- Boguth, Oliver, Adlai J. Fisher, Vincent Gregoire, and Charles Martineau (2023). "Noisy FOMC Returns? Information, Price Pressure, and Post-Announcement Reversals". SSRN Working Paper No 878091.
- Bordalo, Pedro, Nicola Gennaioli, Rafael La Porta, and Andrei Shleifer (2019). "Diagnostic Expectations and Stock Returns". In: *The Journal of Finance* 74.6, pp. 2839–2874. eprint: <https://onlinelibrary.wiley.com/doi/pdf/10.1111/jofi.12833>.

# References II

- Bordalo, Pedro, Nicola Gennaioli, Yueran Ma, and Andrei Shleifer (2020). "Overreaction in Macroeconomic Expectations". In: *American Economic Review* 110.9, pp. 2748–82.
- Brennan, Connor M., Margaret M. Jacobson, Christian Matthes, and Todd B. Walker (2024). *Monetary Policy Shocks: Data or Methods?* Tech. rep. Finance and Economics Discussion Series 2024-011r1. Board of Governors of the Federal Reserve System.
- Brooks, Jordan, Michael Katz, and Hanno Lustig (2023). *Post-FOMC Announcement Drifts in U.S. Bond Markets*. Working Paper 25127. National Bureau of Economic Research.
- Caivano, Valeria (2015). "The Impact of High-Frequency Trading on Volatility. Evidence from the Italian Market". CONSOB Working Papers No 80.
- Chan, Louis K. C., Narasimhan Jegadeesh, and Josef Lakonishok (1996). "Momentum Strategies". In: *The Journal of Finance* 51.5, pp. 1681–1713. eprint: <https://onlinelibrary.wiley.com/doi/pdf/10.1111/j.1540-6261.1996.tb05222.x>.
- Chan, Wesley S. (2003). "Stock price reaction to news and no-news: drift and reversal after headlines". In: *Journal of Financial Economics* 70.2, pp. 223–260.
- Chang, Son J and Son-Nan Chen (1989). "Stock-price adjustment to earnings and dividend surprises". In: *Quarterly Review of Economics and Business* 29.1, pp. 68–81.
- Cieslak, Anna, Stephen Hansen, Michael McMahon, and Song Xiao (2023). *Policymakers' Uncertainty*. Working Paper 31849. National Bureau of Economic Research.
- Cieslak, Anna and Michael McMahon (2023). "Tough Talk: The Fed and the Risk Premium". SSRN Working Paper No 4560220.
- Cieslak, Anna and Annette Vissing-Jorgensen (2020). "The Economics of the Fed Put". In: *The Review of Financial Studies* 34.9, pp. 4045–4089.
- Da, Zhi, Joseph Engelberg, and Pengjie Gao (2011). "In Search of Attention". In: *The Journal of Finance* 66.5, pp. 1461–1499. eprint: <https://onlinelibrary.wiley.com/doi/pdf/10.1111/j.1540-6261.2011.01679.x>.
- Das, Somnath and Alexander Z. King (2021). "Measuring the informativeness of earnings announcements: The role of event windows". In: *The Quarterly Review of Economics and Finance* 82, pp. 350–367.
- De Bondt, Werner F. M. and Richard Thaler (1985). "Does the Stock Market Overreact?" In: *The Journal of Finance* 40.3, pp. 793–805. eprint: <https://onlinelibrary.wiley.com/doi/pdf/10.1111/j.1540-6261.1985.tb05004.x>.
- De Pooter, Michiel (2021). *Questions and Answers: The Information Content of the Post-FOMC Meeting Press Conference*. Tech. rep. FEDS Notes. Board of Governors of the Federal Reserve System.
- Doh, Taeyoung, Dongho Song, and Shu-Kuei Yang (2023). "Deciphering Federal Reserve Communication via Text Analysis of Alternative FOMC Statements". Federal Reserve Bank of Kansas City Working Paper.
- Fleming, Michael J. and Monika Piazzesi (2005). *Monetary Policy Tick-by-Tick*. Tech. rep. Working Paper. Federal Reserve Bank of New York.

# References III

- Gáti, Laura and Amy Handlan (2025a). "Monetary Communication Rules". ECB Working Paper No. 2022/2759.
- Gáti, Laura and Amy Handlan (2025b). "Reputation for Confidence". Working Paper.
- Gentzkow, Matthew, Bryan Kelly, and Matt Taddy (2019). "Text as Data". In: *Journal of Economic Literature* 57.3, pp. 535–74.
- Gider, Jasmin, Simon Schmickler, and Christian Westheide (2019). "High-Frequency Trading and Price Informativeness". SAFE Working Paper No 248.
- Gilchrist, Simon and Egon Zakrajšek (2012). "Credit Spreads and Business Cycle Fluctuations". In: *American Economic Review* 102.4, pp. 1692–1720.
- GORODNICHENKO, YURIY, THO PHAM, and OLEKSANDR TALAVERA (2023). "The Voice of Monetary Policy". In: *American Economic Review* 113.2, pp. 548–84.
- Gürkaynak, Refet S., Burçin Kisacikoglu, and Jonathan H. Wright (2020). "Missing Events in Event Studies: Identifying the Effects of Partially Measured News Surprises". In: *American Economic Review* 110.12, pp. 3871–3912.
- Gürkaynak, Refet S., Brian Sack, and Eric T. Swanson (2005). "Do Actions Speak Louder Than Words? The Response of Asset Prices to Monetary Policy Actions and Statements". In: *International Journal of Central Banking* 1.1.
- Haldane, Andrew and Michael McMahon (2018). "Central Bank Communications and the General Public". In: *AEA Papers and Proceedings* 108, pp. 578–83.
- Handlan, Amy (2022a). "FedSpeak Matters: Statement Similarity and Monetary Policy Expectations". Published manuscript.
- Handlan, Amy (2022b). "Text Shocks and Monetary Surprises: Text Analysis of FOMC Statements with Machine Learning". Published manuscript.
- Hansen, Stephen and Michael McMahon (2016). "Shocking language: Understanding the macroeconomic effects of central bank communication". In: *Journal of International Economics* 99. 38th Annual NBER International Seminar on Macroeconomics, S114–S133.
- Hansen, Stephen, Michael McMahon, and Andrea Prat (2017). "Transparency and Deliberation Within the FOMC: A Computational Linguistics Approach". In: *The Quarterly Journal of Economics* 133.2, pp. 801–870. URL: <https://doi.org/10.1093/qje/qjx045>.
- Hawinkel, Stijn, Willem Waegeman, and Steven Maere (2024). "Out-of-Sample R2: Estimation and Inference". In: *The American Statistician* 78.1, pp. 15–25.
- Hernandez-Murillo, Ruben and Hannah Shell (2014). "The Rising Complexity of the FOMC Statement". In: *Economic Synopses* 23.
- Hervé, Fabrice, Mohamed Zouaoui, and Bertrand Belvaux (2019). "Noise traders and smart money: Evidence from online searches". In: *Economic Modelling* 83, pp. 141–149.
- Hillmer, S.C. and P.L. Yu (1979). "The market speed of adjustment to new information". In: *Journal of Financial Economics* 7.4, pp. 321–345.
- Hornik, Kurt, Maxwell Stinchcombe, and Halbert White (1989). "Multilayer feedforward networks are universal approximators". In: *Neural Networks* 2.5, pp. 359–366.
- Husted, Lucas, John Rogers, and Bo Sun (2020). "Monetary policy uncertainty". In: *Journal of Monetary Economics* 115, pp. 20–36.

# References IV

- Indriawan, Ivan, Feng Jiao, and Yiuman Tse (2021). "The FOMC announcement returns on long-term US and German bond futures". In: *Journal of Banking & Finance* 123, p. 106027.
- Jarociński, Marek and Peter Karadi (2020). "Deconstructing Monetary Policy Surprises—The Role of Information Shocks". In: *American Economic Journal: Macroeconomics* 12.2, pp. 1–43.
- Kriven, Dmitry, Robert Patton, Erica Rose, and David Tabak (2003). "Determination of the Appropriate Event Window Length in Individual Stock Event Studies". SSRN Working Paper No 466161.
- Kroner, T. Niklas (2025). "How Markets Process Macro News: The Importance of Investor Inattention". Working paper.
- La Porta, Rafael (1996). "Expectations and the Cross-Section of Stock Returns". In: *The Journal of Finance* 51.5, pp. 1715–1742.
- Lucca, David O and Francesco Trebbi (2009). *Measuring Central Bank Communication: An Automated Approach with Application to FOMC Statements*. Working Paper 15367. National Bureau of Economic Research.
- Lucca, David O. and Emanuel Moench (2015). "The Pre-FOMC Announcement Drift". In: *The Journal of Finance* 70.1, pp. 329–371.
- McMahon Naylor, Matthew (2023). *Getting Through: Communicating Complex Information*. Tech. rep. Staff Working Paper No. 1047. Bank of England.
- Nakamura, Emi and Jón Steinsson (2018). "High-Frequency Identification of Monetary Non-Neutrality: The Information Effect". In: *The Quarterly Journal of Economics* 133.3, pp. 1283–1330.
- Olea, José Luis Montiel and Mikkel Plagborg-Møller (2021). "Local Projection Inference is Simpler and More Robust Than You Think". In: *Econometrica* 89.4, pp. 1789–1823. eprint: <https://onlinelibrary.wiley.com/doi/pdf/10.3982/ECTA18756>.
- Piller, Alexander, Marc Schranz, and Larissa Schwaller (2025). "Using Natural Language Processing to Identify Monetary Policy Shocks". Working Paper.
- Riboni, Alessandro and Francisco Ruge-Murcia (2014). "Dissent in monetary policy decisions". In: *Journal of Monetary Economics* 66, pp. 137–154.
- Sarkar, Suproteem and Keyon Vafa (2024). "Lookahead Bias in Pretrained Language Models". SSRN Working Paper No 4754678.
- Smales, L.A. and N. Apergis (2017). "Does more complex language in FOMC decisions impact financial markets?" In: *Journal of International Financial Markets, Institutions and Money* 51, pp. 171–189.
- Swanson, Eric T. and Vishuddhi Jayawickrema (2023). "Speeches by the Fed Chair Are More Important than FOMC Announcements: An Improved High-Frequency Measure of U.S. Monetary Policy Shocks". Unpublished manuscript.
- Tsang, Kwok Ping and Zichao Yang (2024). *Agree to Disagree: Measuring Hidden Dissent in FOMC Meetings*. arXiv: 2308.10131 [econ.GN].
- Weller, Brian M. (2017). "Does Algorithmic Trading Reduce Information Acquisition?" In: *The Review of Financial Studies* 31.6, pp. 2184–2226. eprint: <https://academic.oup.com/rfs/article-pdf/31/6/2184/24833081/hhx137.pdf>.

# References V

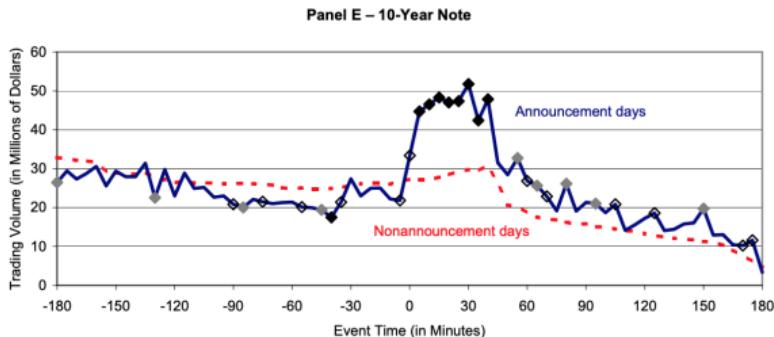
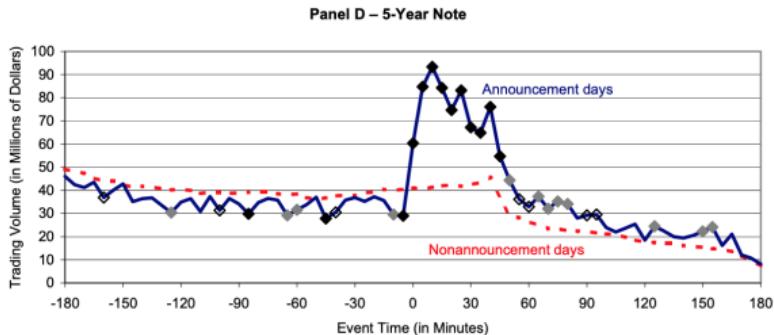
Yang, Zhilin, Zihang Dai, Yiming Yang, Jaime G. Carbonell, Ruslan Salakhutdinov, and Quoc V. Le (2019). "XLNet: Generalized Autoregressive Pretraining for Language Understanding". In: *CoRR* abs/1906.08237. arXiv: 1906.08237.

# Liquidity: Related Symptom for Longer Event Windows (1/2)

[Back to Summary Visual](#)

- ▶ Do not currently have data access **BUT**:
  - Fleming and Piazzesi, 2005: ↑ asset horizon, then ↑ time length of abn trading volume
  - Kroner, 2025: Within asset types, futures maturity ↑, then ↓ change in trading volume
- ▶ **Both papers**: Document ↑ trading volume on macro news for longer times
- Assets with ↑ underlying maturities might need **more time to fully react**

# Liquidity: Related Symptom for Longer Event Windows (2/2)

[Back to Summary Visual](#)

► Fleming and Piazzesi, 2005

# Cognitive Noise Interpretations

[Back to Framework](#)[Back to Framework Components](#)

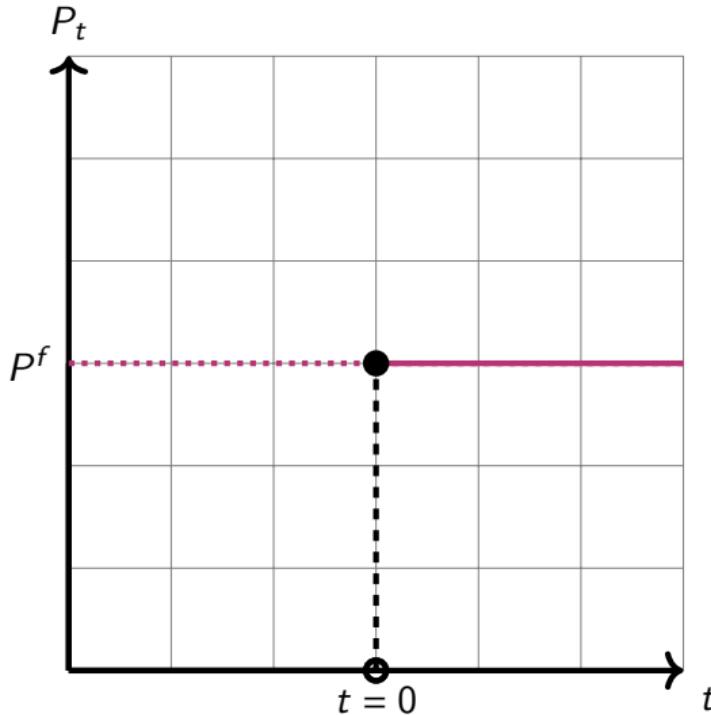
1. **Over-reaction**: De Bondt and Thaler (1985); La Porta (1996); Antweiler and Frank (2022); Da et al. (2011); Bordalo, Gennaioli, La Porta, et al. (2019); Bordalo, Gennaioli, Ma, et al. (2020); Boguth et al. (2023); Bianchi et al. (2024)
2. **Under-reaction**: Bernard and Thomas (1989); LKC Chan et al. (1996); WS Chan (2003); Lucca and Moench (2015); Boguth et al. (2023); Bianchi et al. (2024)
3. **Noise trading**: Bloomfield et al. (2009); Hervé et al. (2019); Ben-David et al. (2022)
4. **Algorithmic trading**: Caivano (2015); Weller (2017); Gider et al. (2019); Bazzana and Collini (2020); Ben Ammar and Hellara (2022)

# Visualising How Noise Components Affect Prices (1/3)

[Back to Framework IRF](#)

No cognitive noise + No unrelated news

- ▶  $P_t \rightarrow P^f$  because of no cognitive noise
- ▶  $P_t$  moves anywhere over time because of unrelated news
- Choose shortest event window



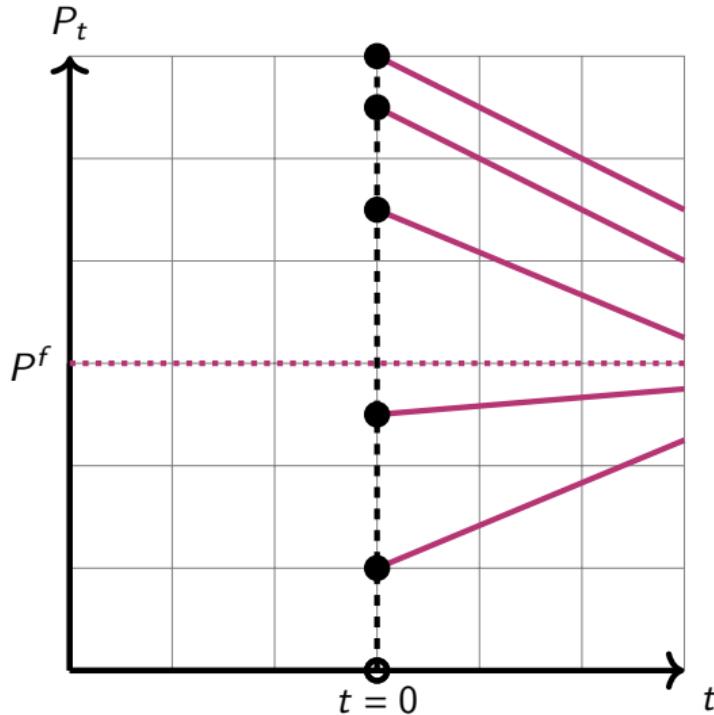
# Visualising How Noise Components Affect Prices (2/3)

[Back to Framework IRF](#)

Cognitive noise + No unrelated news

[Interpretations](#)

- ▶  $P_t$  jumps anywhere because of cognitive noise
- ▶  $P_t \rightarrow P^f$  because of no unrelated news
- Choose long event window

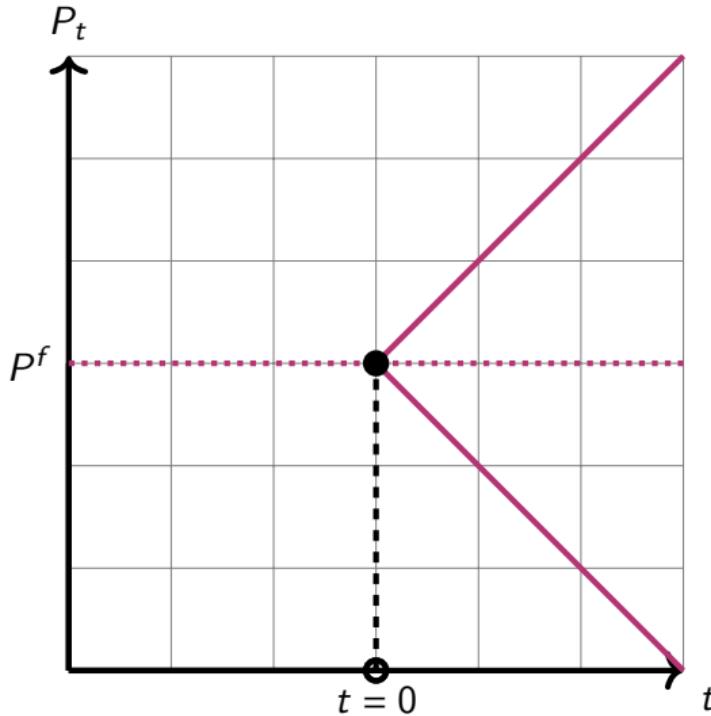


# Visualising How Noise Components Affect Prices (3/3)

[Back to Framework IRF](#)

No cognitive noise + Unrelated news

- ▶  $P_t \rightarrow P^f \because$  no cognitive noise
- ▶  $P_t$  moves anywhere over time  $\because$  unrelated news
- ▶  $\therefore$  Choose short event window



# Derivation of $\text{Var}(P_t|t \geq 0)$ and $\frac{\partial \text{Var}(P_t|t \geq 0)}{\partial t}$ (1/3)

$$\begin{aligned}\text{Var}(P_0) &= \text{Var}(\varepsilon_0^c) + \text{Var}(\varepsilon_0^n) \\ &= \sigma_c^2\end{aligned}$$

$$\begin{aligned}\text{Var}(P_1) &= \text{Var}(\varepsilon_1^c) + \text{Var}(\varepsilon_1^n) \\ &= \sigma_c^2(\rho_c^2 + e^{-2\mathcal{D}}) + \sigma_n^2\end{aligned}$$

$$\begin{aligned}\text{Var}(P_2) &= \text{Var}(\varepsilon_2^c) + \text{Var}(\varepsilon_2^n) \\ &= \sigma_c^2(\rho_c^4 + \rho_c^2 e^{-2\mathcal{D}} + e^{-4\mathcal{D}}) + 2\sigma_n^2\end{aligned}$$

⋮

$$\text{Var}(P_t|t \geq 0) = \left[ \sum_{i=0}^t \rho_c^{2(t-i)} e^{-2\mathcal{D}i} \right] \sigma_c^2 + t\sigma_n^2$$

$$\implies \text{Var}(P_t|t \geq 0) = \left[ \frac{\rho_c^{2(t+1)} - e^{-2(t+1)\mathcal{D}}}{\rho_c^2 - e^{-2\mathcal{D}}} \right] \sigma_c^2 + t\sigma_n^2$$

# Derivation of $\text{Var}(P_t|t \geq 0)$ and $\frac{\partial \text{Var}(P_t|t \geq 0)}{\partial t}$ (2/3)

$$\text{Var}(P_t|t \geq 0) = \left[ \frac{\rho_c^{2(t+1)} - e^{-2(t+1)\mathcal{D}}}{\rho_c^2 - e^{-2\mathcal{D}}} \right] \sigma_c^2 + t\sigma_n^2$$

$$\frac{\partial \text{Var}(P_t|t \geq 0)}{\partial t} = \left\{ \frac{2 \left[ \ln(\rho_c) \rho_c^{2(t+1)} + \mathcal{D} \left[ (e^{-2(t+1)\mathcal{D}}) \right] \right]}{\rho_c^2 - e^{-2\mathcal{D}}} \right\} \sigma_c^2 + \sigma_n^2$$

# Derivation of $\text{Var}(P_t|t \geq 0)$ and $\frac{\partial \text{Var}(P_t|t \geq 0)}{\partial t}$ (3/3)

$$\text{Var}(P_t|t \geq 0) = \overbrace{\left[ \frac{\rho_c^{2(t+1)} - e^{-2(t+1)\mathcal{D}}}{\rho_c^2 - e^{-2\mathcal{D}}} \right] \sigma_c^2 + t\sigma_n^2}^{\text{lim}_{t \rightarrow \infty} \text{ is } 0} \quad (5)$$

# Derivation of $\text{Var}(P_t|t \geq 0)$ and $\frac{\partial \text{Var}(P_t|t \geq 0)}{\partial t}$ (3/3)

$$\text{Var}(P_t|t \geq 0) = \overbrace{\left[ \frac{\rho_c^{2(t+1)} - e^{-2(t+1)\mathcal{D}}}{\rho_c^2 - e^{-2\mathcal{D}}} \right] \sigma_c^2 + t\sigma_n^2}^{\text{lim}_{t \rightarrow \infty} \text{ is } 0} \quad (5)$$

$$\implies t^{\text{one}} : \mathcal{D} [e^{-2(t+1)\mathcal{D}}] + \ln(\rho_c) \rho_c^{2(t+1)} = \left[ \frac{(e^{-2\mathcal{D}} - \rho_c^2)}{2} \right] \frac{\sigma_n^2}{\sigma_c^2} \quad (6)$$

# Derivation of $\text{Var}(P_t|t \geq 0)$ and $\frac{\partial \text{Var}(P_t|t \geq 0)}{\partial t}$ (3/3)

$$\text{Var}(P_t|t \geq 0) = \overbrace{\left[ \frac{\rho_c^{2(t+1)} - e^{-2(t+1)\mathcal{D}}}{\rho_c^2 - e^{-2\mathcal{D}}} \right]}^{\text{lim}_{t \rightarrow \infty} \text{ is } 0} \sigma_c^2 + t\sigma_n^2 \quad (5)$$

$$\implies t^{\text{one}} : \mathcal{D} [e^{-2(t+1)\mathcal{D}}] + \ln(\rho_c) \rho_c^{2(t+1)} = \left[ \frac{(e^{-2\mathcal{D}} - \rho_c^2)}{2} \right] \frac{\sigma_n^2}{\sigma_c^2} \quad (6)$$

$$\implies \frac{\partial t^{\text{one}}}{\partial \sigma_n^2} < 0, \frac{\partial t^{\text{one}}}{\partial \sigma_c^2} > 0^{\ddagger}$$

---

<sup>†</sup>Because Equation 3 is unable to have  $t$  isolated on one side, I numerically verify the dynamics of the  $t^{\text{one}}$  for various values of  $\sigma_c^2$  and  $\sigma_n^2$  in the indirect expression whilst holding the other parameters constant.

# Derivation of MSE Minimisation Problem with Signal

$$\begin{aligned}
 t^* : \min_t \frac{1}{N} \sum_{i=1}^N (P_{i,t} - s_i)^2 &= \min_t \frac{1}{N} \sum_{i=1}^N (P_i^f + \varepsilon_{i,t}^c + \varepsilon_{i,t}^n - P_i^f - \xi_i)^2 \\
 &= \min_t \frac{1}{N} \sum_{i=1}^N (\varepsilon_{i,t}^c + \varepsilon_{i,t}^n - \xi_i)^2 \\
 &= \min_t \frac{1}{N} \sum_{i=1}^N \left[ (\varepsilon_{i,t}^c + \varepsilon_{i,t}^n)^2 + \xi_i^2 - 2\xi_i (\varepsilon_{i,t}^c + \varepsilon_{i,t}^n) \right] \\
 &= \min_t \left\{ \mathbb{E} \left[ (\varepsilon_{i,t}^c + \varepsilon_{i,t}^n)^2 \right] + \mathbb{E} [\xi_i^2] - 2 \mathbb{E} [\xi_i] \mathbb{E} \left[ (\varepsilon_{i,t}^c + \varepsilon_{i,t}^n) \right] \right\} \\
 \implies t^* : \min_t \frac{1}{N} \sum_{i=1}^N (P_{i,t} - s_i)^2 &= \min_t \left[ \frac{1}{N} \sum_{i=1}^N (\varepsilon_{i,t}^c + \varepsilon_{i,t}^n)^2 + \sigma_s^2 \right]
 \end{aligned} \tag{7}$$

# Simulation Setup (1/3): Initial Conditions

- ▶  $t = 0$ : Release of **one** FOMC announcement

- $P_{t,i}^f = P_i^f \in [-100, 100]$
- $\varepsilon_{i,0}^c \in [-100, 100]$
- $\varepsilon_{i,0}^n = 0$
- $\sigma_s \in \mathbb{R}$

## Simulation Setup (2/3): MSEs

- ▶ For single news  $i \in N = 10,000$ :
  - Simulate  $P_{i,t}$  (and components) and  $s_i$  up to  $t = 100$
  - Calculate  $(P_{i,t} - P_{i,t}^f)^2$  and  $(P_{i,t} - s_i)^2$
- ▶ Across all  $N$  news:
  - Calculate MSEs  $\sum_{i=1}^N \frac{1}{N} (P_{i,t} - P_{i,t}^f)^2$  and  $\sum_{i=1}^N \frac{1}{N} (P_{i,t} - s_{i,t})^2$
  - Calculate  $t^*$  and  $\hat{t}$

## Simulation Setup (3/3): Market Scenarios

- ▶ Calculate  $t^*, \hat{t}$  under 3 asset market scenarios:

	Scenario 1	Scenario 2	Scenario 3
$P_i^f$	$\in [-100, 100]$	$\in [-100, 100]$	$\in [-100, 100]$
$\varepsilon_{i,0}^c$	$\in [-100, 100]$	$\in [-100, 100]$	$\in [-100, 100]$
$\varepsilon_{i,0}^n$	0	0	0
$\sigma_c$	100	0.1	50
$\mathcal{D}$	0.5	1	0.75
$\sigma_n$	0.1	10	1
$\rho_c$	0.47	0.47	0.47
$\sigma_s$	$\in \mathbb{R}$	$\in \mathbb{R}$	$\in \mathbb{R}$

Table 1: Framework Parameters for Simulations

- ▶ Scenario 1 ~ High presence of cognitive noise, little unrelated news
- ▶ Scenario 2 ~ Little cognitive noise, high presence of unrelated news
- ▶ Scenario 3 ~ Presence of both cognitive noise and unrelated news

# Simulation Results

	Scenario 1	Scenario 2	Scenario 3
<i>Simulation Parameters</i>			
$P_i^f$	$\in [-100, 100]$	$\in [-100, 100]$	$\in [-100, 100]$
$\varepsilon_{i,0}^c$	$\in [-100, 100]$	$\in [-100, 100]$	$\in [-100, 100]$
$\varepsilon_{i,0}^n$	0	0	0
$\sigma_c$	100	0.1	50
$\mathcal{D}$	0.5	1	0.75
$\sigma_n$	0.1	10	1
$\rho_c$	0.47	0.47	0.47
$\sigma_s$	$\in \mathbb{R}$	$\in \mathbb{R}$	$\in \mathbb{R}$
<i>Simulation Results</i>			
$t^*$	16	2	10
$\hat{t}$	15	2	10

Table 2: Framework Parameters and Results from 10,000 Simulations

# Preprocessing FOMC Statement Text

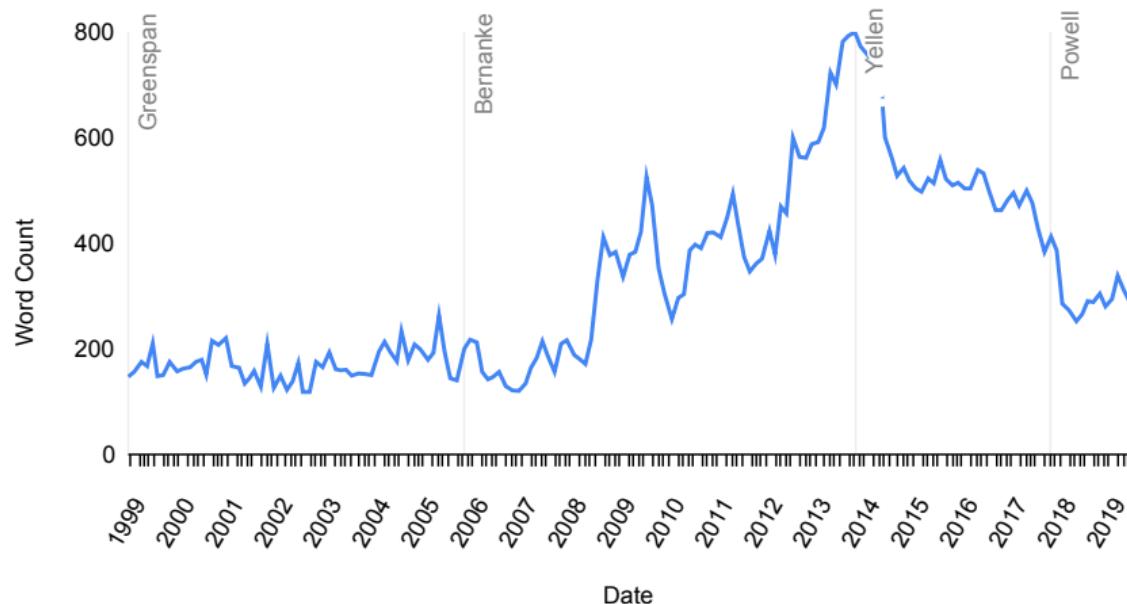
[Back to Method](#)

- ▶ Remove:
  - URLs and hyperlinks from statement's HTML file
  - FOMC member voting record from end of statement
  - List of regional bank request approvals
  - Release timestamp (e.g., "For immediate release")
- ▶ Change:
  - Statement file type to text
  - Text coding into standardised UTF-8 format (e.g., change length of "-")
  - Spacing between words to be one space

# Preprocessed FOMC Statement Length

[Back to Method](#)

Number of Words in FOMC Statements



# Cleaned FOMC Statement (08/2011) (1/3)

[Results](#)[Preview](#)[Method](#)[Summary Text](#)[Extensions](#)

1. Information received since the Federal Open Market Committee met in June indicates that economic growth so far this year has been considerably slower than the Committee had expected.
2. Indicators suggest a deterioration in overall labor market conditions in recent months, and the unemployment rate has moved up.
3. Household spending has flattened out, investment in nonresidential structures is still weak, and the housing sector remains depressed.
4. However, business investment in equipment and software continues to expand.
5. Temporary factors, including the damping effect of higher food and energy prices on consumer purchasing power and spending as well as supply chain disruptions associated with the tragic events in Japan, appear to account for only some of the recent weakness in economic activity.
6. Inflation picked up earlier in the year, mainly reflecting higher prices for some commodities and imported goods, as well as the supply chain disruptions.
7. More recently, inflation has moderated as prices of energy and some commodities have declined from their earlier peaks. Longer-term inflation expectations have remained stable.

# Cleaned FOMC Statement (08/2011) (2/3)

[Results Preview](#)[Method](#)[Summary Text](#)[Extensions](#)

1. Consistent with its statutory mandate, the Committee seeks to foster maximum employment and price stability.
2. The Committee now expects a somewhat slower pace of recovery over coming quarters than it did at the time of the previous meeting and anticipates that the unemployment rate will decline only gradually toward levels that the Committee judges to be consistent with its dual mandate.
3. Moreover, downside risks to the economic outlook have increased.
4. The Committee also anticipates that inflation will settle, over coming quarters, at levels at or below those consistent with the Committee's dual mandate as the effects of past energy and other commodity price increases dissipate further.
5. However, the Committee will continue to pay close attention to the evolution of inflation and inflation expectations.
6. To promote the ongoing economic recovery and to help ensure that inflation, over time, is at levels consistent with its mandate, the Committee decided today to keep the target range for the federal funds rate at 0 to 1/4 percent.

# Cleaned FOMC Statement (08/2011) (3/3)

[Results Preview](#)[Method](#)[Summary Text](#)[Extensions](#)

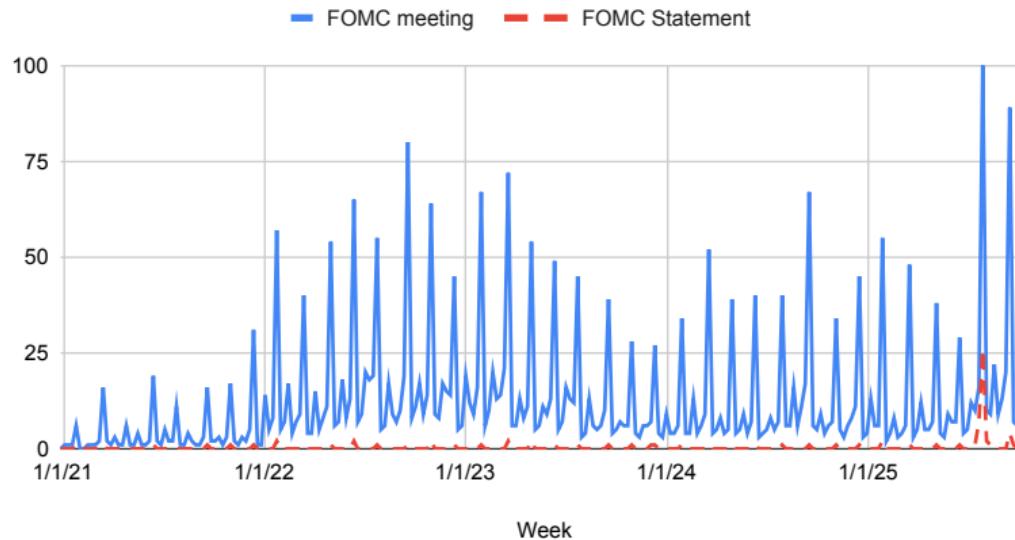
1. The Committee currently anticipates that economic conditions—including low rates of resource utilization and a subdued outlook for inflation over the medium run—are likely to warrant exceptionally low levels for the federal funds rate at least through mid-2013.
2. The Committee also will maintain its existing policy of reinvesting principal payments from its securities holdings.
3. The Committee will regularly review the size and composition of its securities holdings and is prepared to adjust those holdings as appropriate.
4. The Committee discussed the range of policy tools available to promote a stronger economic recovery in a context of price stability.
5. It will continue to assess the economic outlook in light of incoming information and is prepared to employ these tools as appropriate.

# Why FOMC Statements?

[Back to Method](#)

- ▶ FOMC statements = Initial + Primary communication of MP
  - FOMC statement website = 1<sup>st</sup> – 3<sup>rd</sup> query on search engines

Google Trends for FOMC Meeting Terms



# Output: Interest-rate and Equity Futures

[Back to Method](#)

► **Output:**  $DP_{t+n} = \ln\left(\frac{P_{t+n}}{P_{t-10}}\right)$  for interest-rate and equity futures

[Futures Overview](#)

- Price levels at 10-min-intervals: 10 min before to 18 hours after statement release
- Fed Fund Futures:  $FF1, FF2, FF3, FF4$
- Eurodollar Futures:  $EDcm2, EDcm3, EDcm4$
- 2-Year Treasury Futures:  $TUc1, TUc2$
- 5-Year Treasury Futures:  $FVc1, FVc2$
- 10-Year Treasury Futures:  $TYc1, TYc2$
- 30-year Treasury Futures:  $USc1, USc2$
- S&P 500 Index and E-mini Futures:  $SPX, ESc1, ESc2$

# Futures Contract Overview (1/2)

[Back to Futures List](#)

- ▶ Federal Fund futures: For a given expiry month, on last day of expiry month, contract pays out 100 minus the average federal funds rate over the final month
- ▶ Eurodollar futures: Quarterly contracts which pay out 100 minus the 3-month US dollar British Banks Association London Interbank Offered Rate (BBA LIBOR) interest rate at the time of expiry month (i.e., March, June, September, and December).
- ▶ 2-year Treasure futures: Quarterly contracts that obligate seller to deliver Treasury notes within a range of maturities up to 2 years on the last day of the expiry month to the buyer (i.e., March, June, September, and December). Average maturity is 2 years (Gürkaynak, Kisacikoglu, et al., 2020)
- ▶ 5-year Treasure futures: Quarterly contracts that obligate seller to deliver Treasury notes within a range of maturities up to 5 years on the last day of the expiry month to the buyer (i.e., March, June, September, and December). Average maturity is 4 years (Gürkaynak, Kisacikoglu, et al., 2020)

# Futures Contract Overview (2/2)

[Back to Futures List](#)

- ▶ 10-year Treasure futures: Quarterly contracts that obligate seller to deliver Treasury notes within a range of maturities up to 10 years on the last day of the expiry month to the buyer (i.e., March, June, September, and December). Average maturity is 7 years (Gürkaynak, Kisacikoglu, et al., 2020)
- ▶ 30-year Treasure futures: Quarterly contracts that obligate seller to deliver Treasury notes within a range of maturities up to 30 years on the last day of the expiry month to the buyer (i.e., March, June, September, and December). Average maturity is 15 years (Gürkaynak, Kisacikoglu, et al., 2020)
- ▶ S&P 500 E-mini futures: Quarterly contracts that pay out  $50 \text{ USD} \times \text{S\&P 500}$  value on the last day of the expiry month (i.e., March, June, September, and December)

# NN Input/Output Visual

[Back to Method](#)

- ▶ Each FOMC statement is paired with  $DP_{t+n}$  for each asset
- ▶ Input  $X_i = 768 \times j$  matrix: Columns =  $j$  words in order, rows = 768 word-features

## Statement Text

Dec 12, 2006: “The Federal Open Market Committee decided today to keep its target for the federal funds rate at 5 1/4 percent...”

## Input Matrix

768 word-features  
 $\times 512$  words

$$\begin{bmatrix} x_i^1 & x_i^2 & x_i^3 & x_i^4 & x_i^5 & x_i^6 & \dots & x_i^{512} \end{bmatrix}$$

*The Federal Open Market Committee decided .*

- ▶  $x_t^0$  = Dummy vector that gets updated with intermediate layers of X
- ▶ Output =  $DP_{i,t+n}$  for each asset
- ▶ Update XLNet-Base parameters to minimise  $\sum_{i \in N} \frac{1}{N} \left( DP_{i,t+n} - \widehat{DP}_{i,t+n} \right)^2$

# Popular Text Analysis Methods in Macro

[Back to Approach](#)

## 1. Counts of single words

- “employment went up, but inflation did not”
- “inflation went up, but employment did not”
- **Problem:** Method produces same measure from both sentences

## 2. Counts of n-grams

- “economic growth slowed, but is expected to pick up pace later this year”
- **Problem:** Method doesn’t quantify full sentence context

# Estimating Optimal Event Windows: Approach

[Back to Method](#)

- ▶ **At the Core:**  $f(\text{FOMC statement text}) = DP_{t+n}$ : Nonparametric mapping

# Estimating Optimal Event Windows: Approach

[Back to Method](#)

- ▶ **At the Core:**  $f(\text{FOMC statement text}) = DP_{t+n}$ : Nonparametric mapping
- ▶ Popular text analysis methods in empirical macro:
  - “Fitting predictive models on simple counts of text features” (Gentzkow et al., 2019)

# Estimating Optimal Event Windows: Approach

[Back to Method](#)

- ▶ **At the Core:**  $f(\text{FOMC statement text}) = DP_{t+n}$ : Nonparametric mapping
- ▶ Popular text analysis methods in empirical macro:
  - “Fitting predictive models on simple counts of text features” (Gentzkow et al., 2019)
- ▶ Popular methods cannot realistically:
  - Quantify all info. in text (e.g., Word interdependencies, context, long-term memory)  
⇒ Approximate  $f(\text{FOMC statement text}) = DP_{t+n}$

[Popular Method Ex Issues](#)

# Estimating Optimal Event Windows: Approach

[Back to Method](#)

- ▶ **At the Core:**  $f(\text{FOMC statement text}) = DP_{t+n}$ : Nonparametric mapping
  - ▶ Popular methods cannot quantify  $f(\text{FOMC statement text}) = DP_{t+n}$
  - ▶ **Foundation:** Text-analysis neural network XLNet-Base (Yang et al., 2019) can:
    - Transfer learning: Fine-tune pre-trained XLNet-Base on FOMC language
    - Features: Bi-directional learning, recurrent memory, permutation modelling
- [UAT + Layers](#) [XLNet-Base Details](#) [Addressing Look-ahead Bias](#)
- ⇒ “Good” signal based on FOMC statement text within given window length
- ⇒ “Jointly” estimate optimal window and “good” signal

# Universal Approximation Theorem

[Back to This Paper](#)[Back to Approach](#)[Back to NN Training Overview](#)

- ▶ Universal Approximation Theorem (Hornik et al., 1989; and others...) from ML literature:
  - Neural networks with **at least 1 hidden layer** can approximate **any** function
  - Existence theorem → Nothing about finding structure and training
- ▶ In reality, adding more layers:
  - ↓ number of parameters for each node function
  - ↓ computational, data, and training requirements

# Details about XLNet-Base from Yang et al. (2019)

[Hyperparameters](#)[Back to Approach](#)

- ▶ **Overview:** Open-source, pretrained NN for text analysis
  - Paper version: XLNet-Base
- ▶ **Design:** Permutation- and autoregressive-based learning
  - 12 hidden layers (each of size 768)
  - 12 self-attention heads (each of size 64)
  - Vocabulary size of 32,000 word tokens
  - 110 million network parameters
- ▶ **Text Input:** Sequence of numerical vectors representing words and document
- ▶ **Transfer Learning:** “pretrained” parameters = Starting point for new task
  - SOTA status in translation, Q&A, word prediction, classification/regression
- ▶ **Initial Task:** Predict words using all permutations of text
- ▶ **Initial Data:** BookCorpus (11,038 books), English Wikipedia (6 mil articles)
  - Additional data for original, larger-scale NN:
    - Giga5 (9.9 mil news articles), ClueWeb12 (733 mil web pages), Common Crawl (1K+ TB text from web pages)

# Hyperparameters for Fine-tuning XLNet-Base (1/2)

[XLNet-Base Details](#)

Hyperparameter	Value
Number of Layers	12
Hidden Size	768
Number of Attention Heads	12
Attention Head Size	64
Hidden Dropout	0.1
Attention Dropout	0.1
Max Sequence Length	512
Vocab Size	32,000

**Table 3:** The symbol “\*” denotes the hyperparameter that undergoes tuning during the fine-tuning process. The random seed is set as a constant to ensure replicability by always initialising random components (e.g., weights and biases) to the same value. (cont.)

# Hyperparameters for Fine-tuning XLNet-Base (2/2)

[XLNet-Base Details](#)

Hyperparameter	Value
Training Batch Size	8
Evaluation Batch Size	8
Max Num of Steps	2040
Max Num of Epochs	120
Manual Random Seed	47
Learning Rate	*
Warmup Ratio	0.06
Adam Epsilon	1e-8
Learning Rate Decay	Linear

Table 4: The symbol “\*” denotes the hyperparameter that undergoes tuning during the fine-tuning process. The random seed is set as a constant to ensure replicability by always initialising random components (e.g., weights and biases) to the same value.

# Addressing Look-ahead Bias

[Back to Approach](#)[Back to Loop](#)

- ▶ **Sarkar and Vafa (2024)**: NNs predict values in past using info. in the future.
  - NNs for text analysis trained with large amounts of data
  - High probability of future info. used in initial training of NN weights
  - Look-ahead bias addressed for 2 reasons:
    1. XLNet-Base initially trained **only** with BookCorpus and English Wikipedia
      - Very low probability of XLNet-Base initially trained on FOMC statements and futures data
    2. Pre-processed FOMC statements have no references to relevant times  $t$  and  $t + 1$

[XLNet-Base Details](#)

# Estimating Optimal Event Windows: Prepare for Train + Eval XLNet

- ▶ **Goal:** “Good” signal from XLNet-Base for every FOMC statements
  - Method from ML literature: Train XLNet-Base on *splits* of data

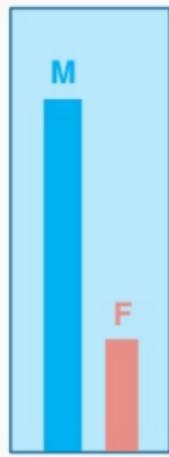
# Estimating Optimal Event Windows: Prepare for Train + Eval XLNet

- ▶ **Goal:** “Good” signal from XLNet-Base for every FOMC statements
  - Method from ML literature: Train XLNet-Base on **splits** of data
- ▶ Split data into training (80%) and testing (20%) samples **5 times**:
  - By **stratified sampling**Why Stratified? Why CV?
  - Conditions: Word count (200-word bins), FFR decision, FOMC chair, pre/post 2007
  - Every testing subsample share **NO** FOMC statements

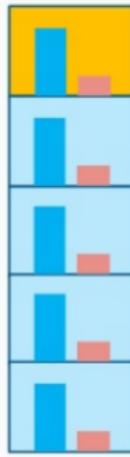
# Estimating Optimal Event Windows: Prepare for Train + Eval XLNet

- ▶ **Goal:** “Good” signal from XLNet-Base for every FOMC statements
  - Method from ML literature: Train XLNet-Base on **splits** of data
- ▶ Split data into training (80%) and testing (20%) samples **5 times**:
  - By **stratified sampling**Why Stratified? Why CV?
  - Conditions: Word count (200-word bins), FFR decision, FOMC chair, pre/post 2007
  - Every testing subsample share **NO** FOMC statements
- ▶ **Result:** XLNet-Base learns  $f(\text{FOMC statement text}) = DP_{t+n}$  for each fold:
  - With **equal distribution** of FOMC statements based on characteristics

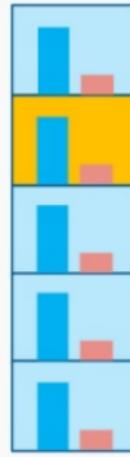
# Estimating Optimal Event Windows: Stratified CV Visual

[Back to Method](#)

Class Distributions



Round 1



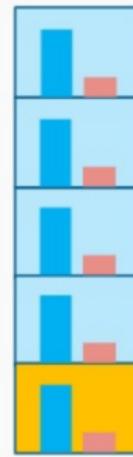
Round 2



Round 3



Round 4



Round 5

# Estimating Optimal Event Windows: Loop “Diagram”

[Back to Method](#)

For each interest-rate and equity futures contract:

# Estimating Optimal Event Windows: Loop “Diagram”

[Back to Method](#)

For each interest-rate and equity futures contract:

- ▶ For each  $DP_{t+n}$  up to  $t + 60$ :

# Estimating Optimal Event Windows: Loop “Diagram”

[Back to Method](#)

For each interest-rate and equity futures contract:

- ▶ For each  $DP_{t+n}$  up to  $t + 60$ :
  - For each split:
    1. Fine-tune NN parameters and **hyperparameters** to fit training data  
[NN Training Overview](#)   [Hyperparameter Tuning](#)   [Addressing Look-ahead Bias](#)
    2. Evaluate NN on testing data → Choose hyperparameters that yield highest  $R^2_{OOS}$

# Estimating Optimal Event Windows: Loop “Diagram”

Back to Method

For each interest-rate and equity futures contract:

- ▶ For each  $DP_{t+n}$  up to  $t + 60$ :
  - For each split:
    1. Fine-tune NN parameters and **hyperparameters** to fit training data  
[NN Training Overview](#)   [Hyperparameter Tuning](#)   [Addressing Look-ahead Bias](#)
    2. Evaluate NN on testing data → Choose hyperparameters that yield highest  $R^2_{OOS}$
    3. **Final Output:**  $\overline{R^2_{OOS}} := R^2_{OOS}$  averaged across 5 splits
      - Other  $R^2_{OOS}$  metrics: Min, max, 75<sup>th</sup>, 25<sup>th</sup> percentiles

# NN Training Overview

[Back to Loop](#)

- ▶ Train NN → Fine-tune parameters and hyperparameters to fit training data

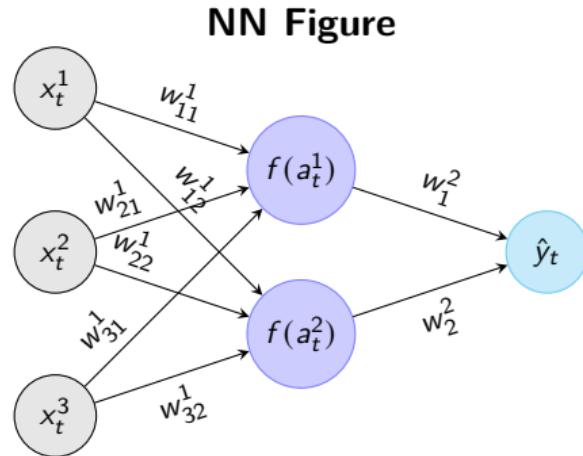
[Small NN Ex](#)

1. Fix network structure (layers and nodes) + non-tuned hyperparameters [UAT + Layers](#)
2. Choose value for hyperparameter that will be tuned [Hyperparameter Tuning](#)
3. Iteratively update parameters to  $\downarrow \widehat{MSE}_{IS}$
4. Evaluate NN → Judge based on  $R^2_{OOS}$
5. Poor performance → Go back to step 1

# Small NN Example

[Back to NN Training Overview](#)

- ▶ **Data:** 4 variables  $x_t^1, x_t^2, x_t^3, y_t$
- ▶ **Goal:** Predict  $y_t$  from  $X \equiv x_t^1, x_t^2, x_t^3$
- ▶ **Example:** 2 layers, 2 “hidden” nodes
- ▶ From  $X_t$  to  $\hat{y}_t$  for observation  $t \in T$ :
  - Linearly combine  $x_t^1, x_t^2, x_t^3 \rightarrow a_t^1, a_t^2$
  - $f$  is a non-linear function
  - $\hat{y}_t$  is predicted output
- ▶ **Training** prediction error → update weights  $w$
- ▶ **Testing** prediction error → update network structure



**NN Matrix Algebra**

$$\begin{bmatrix} x_t^1 & x_t^2 & x_t^3 \end{bmatrix} \begin{bmatrix} w_{11}^1 & w_{12}^1 \\ w_{21}^1 & w_{22}^1 \\ w_{31}^1 & w_{32}^1 \end{bmatrix} = \begin{bmatrix} a_t^1 & a_t^2 \end{bmatrix}$$

$$\begin{bmatrix} f(a_t^1) & f(a_t^2) \end{bmatrix} \begin{bmatrix} w_1^2 \\ w_2^2 \end{bmatrix} = \hat{y}_t$$

# Why Stratified Sampling?

[Back to CV](#)

## ► Why stratified over random splitting?

1. Transfer learning → Lower data requirements for NNs **BUT**
2. Large sample size for NNs → Fold  $\approx$  Population for characteristics
  - Can use random  $k$ -fold cross validation
3. Finite sample size for NNs  $\rightarrow$  Fold  $\approx$  Population
  - Create folds **conditioned on class dist** can help
4. Minimises diff between pop and fold distributions of FOMC statement characteristics
5. **Result:** Better learning and predictive performance from NN

# Estimating Optimal Event Windows: Accuracy Metrics

[Back to Method](#)

- ▶ For each split, primary metric to judge NN = generalised  $R^2 := R^2_{OOS}$  R<sup>2</sup> Details
- ▶ Make adjustments from typical definition because:

# Estimating Optimal Event Windows: Accuracy Metrics

[Back to Method](#)

- ▶ For each split, primary metric to judge NN = generalised  $R^2 := R^2_{OOS}$  R<sup>2</sup> Details
- ▶ Make adjustments from typical definition because:
  1. NN is a non-linear regression  $\implies \rho^2 \neq R^2$

# Estimating Optimal Event Windows: Accuracy Metrics

[Back to Method](#)

- ▶ For each split, primary metric to judge NN = generalised  $R^2 := R^2_{OOS}$  R<sup>2</sup> Details
- ▶ Make adjustments from typical definition because:
  1. NN is a non-linear regression  $\implies \rho^2 \neq R^2$
  2. Judging out-of-sample (OOS) performance, not in-sample

# Estimating Optimal Event Windows: Accuracy Metrics

[Back to Method](#)

- ▶ For each split, primary metric to judge NN = generalised  $R^2 := R^2_{OOS}$   $R^2$  Details
- ▶ Make adjustments from typical definition because:
  1. NN is a non-linear regression  $\implies \rho^2 \neq R^2$
  2. Judging out-of-sample (OOS) performance, not in-sample
- ▶ **Other Tracked Metrics:**  $\rho_{OOS}$ ,  $\widehat{MAE}_{OOS}$ ,  $\widehat{MSE}_{IS}$

# Estimating Optimal Event Windows: Accuracy Metrics

- ▶ For each fold, primary metric to judge NN from Hawinkel et al. (2024):

$$R^2_{OOS} = 1 - \frac{\widehat{MSE}}{\widehat{MST}} = 1 - \frac{T^{-1} \sum_{i=1}^T (y_i - \hat{y}_i)^2}{\frac{T+1}{T(T-1)} \sum_{i=1}^T (y_i - \overline{y}_{IS})^2}, \quad (8)$$

# Estimating Optimal Event Windows: Accuracy Metrics

- ▶ For each fold, primary metric to judge NN from Hawinkel et al. (2024):

$$R^2_{OOS} = 1 - \frac{\widehat{MSE}}{\widehat{MST}} = 1 - \frac{T^{-1} \sum_{i=1}^T (y_i - \hat{y}_i)^2}{\frac{T+1}{T(T-1)} \sum_{i=1}^T (y_i - \overline{y}_{IS})^2}, \quad (8)$$

- ▶ **Definition:** Comparison between two models: NN and **null model**
  - Null model:  $\overline{y}_{IS}$  as prediction

# Estimating Optimal Event Windows: Accuracy Metrics

- ▶ For each fold, primary metric to judge NN from Hawinkel et al. (2024):

$$R^2_{OOS} = 1 - \frac{\widehat{MSE}}{\widehat{MST}} = 1 - \frac{T^{-1} \sum_{i=1}^T (y_i - \hat{y}_i)^2}{\frac{T+1}{T(T-1)} \sum_{i=1}^T (y_i - \overline{y}_{IS})^2}, \quad (8)$$

- ▶ **Definition:** Comparison between two models: NN and **null model**
  - Null model:  $\overline{y}_{IS}$  as prediction
- ▶ **Interpretation:** % of null model's *MSE* explained by NN
  - NOT % of  $DP_{t+n}$  variance explained by NN ∵ nonlinearity

# Estimating Optimal Event Windows: Accuracy Metrics

- ▶ For each fold, primary metric to judge NN from Hawinkel et al. (2024):

$$R_{OOS}^2 = 1 - \frac{\widehat{MSE}}{\widehat{MST}} = 1 - \frac{T^{-1} \sum_{i=1}^T (y_i - \hat{y}_i)^2}{\frac{T+1}{T(T-1)} \sum_{i=1}^T (y_i - \overline{y}_{IS})^2}, \quad (8)$$

- ▶ **Definition:** Comparison between two models: NN and **null model**
  - Null model:  $\overline{y}_{IS}$  as prediction
- ▶ **Interpretation:** % of null model's *MSE* explained by NN
  - NOT % of  $DP_{t+n}$  variance explained by NN :: nonlinearity
- ▶ **Explicit objective function:** Minimise  $\widehat{MSE}$  during fine-tuning
  - $\min \widehat{MSE} = \max R_{OOS}^2$

# Estimating Optimal Event Windows: Accuracy Metrics

- ▶ For each fold, primary metric to judge NN from Hawinkel et al. (2024):

$$R_{OOS}^2 = 1 - \frac{\widehat{MSE}}{\widehat{MST}} = 1 - \frac{T^{-1} \sum_{i=1}^T (y_i - \hat{y}_i)^2}{\frac{T+1}{T(T-1)} \sum_{i=1}^T (y_i - \overline{y}_{IS})^2}, \quad (8)$$

- ▶ **Definition:** Comparison between two models: NN and **null model**
  - Null model:  $\overline{y}_{IS}$  as prediction
- ▶ **Interpretation:** % of null model's *MSE* explained by NN
  - NOT % of  $DP_{t+n}$  variance explained by NN :: nonlinearity
- ▶ **Explicit objective function:** Minimise  $\widehat{MSE}$  during fine-tuning
  - $\min \widehat{MSE} = \max R_{OOS}^2$
- ▶ **Other tracked metrics:**  $\rho_{OOS}$ ,  $\widehat{MAE}_{OOS}$ ,  $\widehat{MSE}_{IS}$

# Why Cross Validation?

[Back to Stratified CV](#)

- ▶ Purpose in ML Literature: See how well model performs on unseen data whilst addressing overfitting
- ▶ Popular usage: Model selection
- ▶ **One Model:** Reduce prediction variation coming from splits themselves
  1. Allows model to predict for **all** sample observations
  2. Some splits might be ↑ “lucky” than others

# Tuning XLNet-Base Hyperparameters

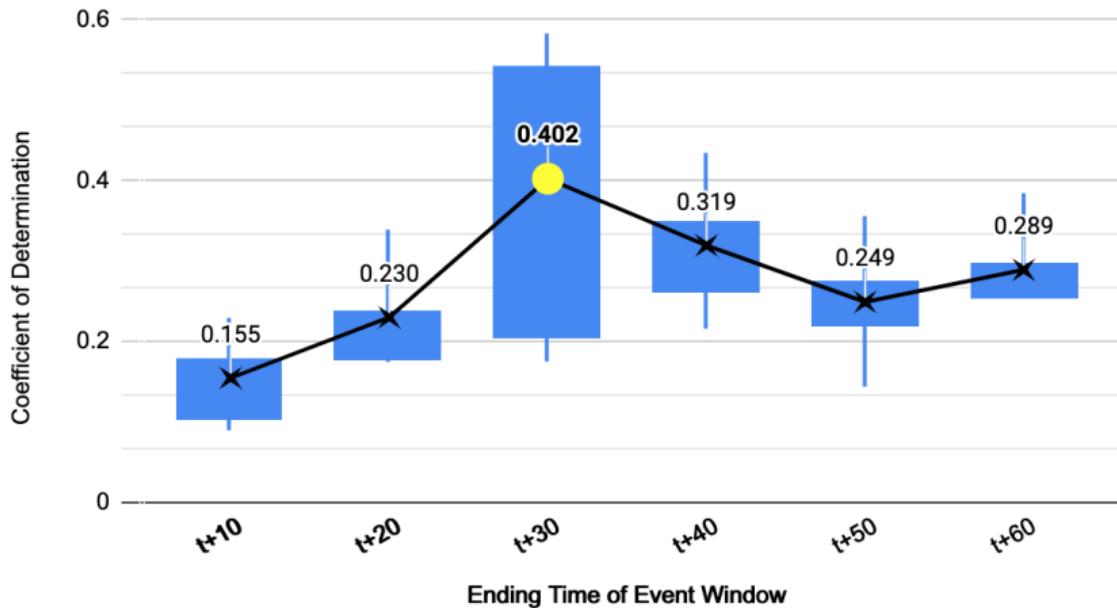
[Back to Loop](#)

- ▶ Hyperparameters: Variables outside NN structure that affect training performance
  - “Tuned” hyperparameter: Learning rate
  - Analogy: CPU & GPU overclocking (e.g., voltage, temperature, clock frequencies)
- ▶ For each 10-minute interval, “tune” learning rate of XLNet:
  - “Best chance” of approximating  $f(\text{FOMC statement text}) = DP_{t+n}$
  - Tuning process takes 1 computation day for each  $DP_{t+n}$

# Optimal Event Windows: FF3

[Summary Visual](#)[Summary Text](#)

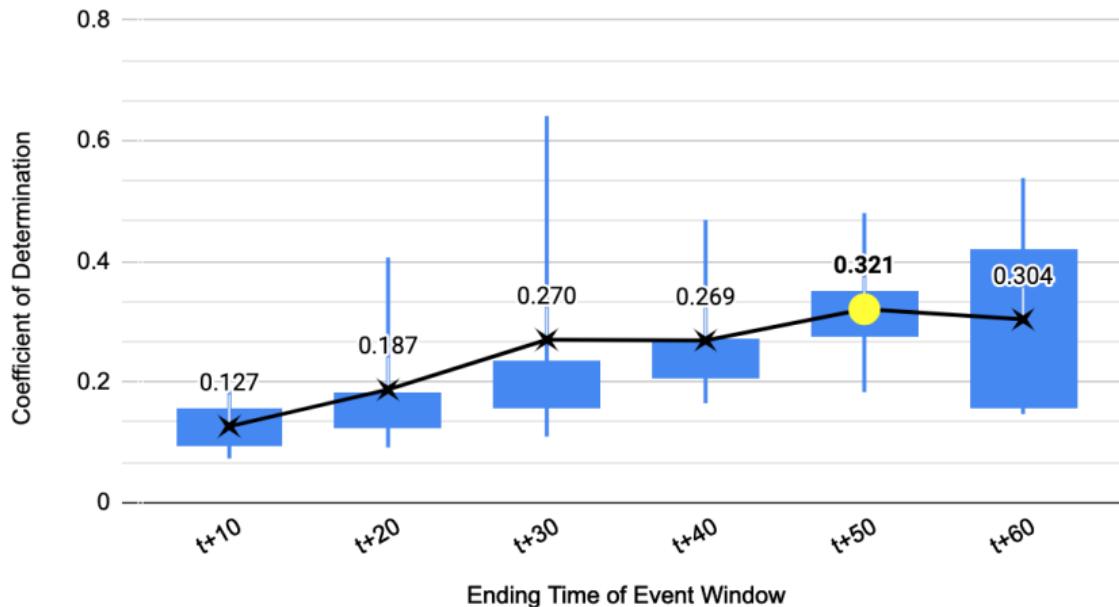
Out-of-sample R<sup>2</sup> for FF3 (Averaged Across Splits)



# Optimal Event Windows: USc2

[Summary Visual](#)[Summary Text](#)

Out-of-sample R<sup>2</sup> for USc2 (Averaged Across Splits)



# Optimal Event Windows: $R^2_{OOS}$ Table (1/2)

[Back to Summary Text](#)

Asset	$\overline{R^2_{OOS}}$ , 30-min	$\overline{R^2_{OOS}}$ , Optimal	Difference
<i>FF1</i>	35.0%	37.2%	+2.2 p.p.
<i>FF2</i>	28.7%	34.5%	+5.8 p.p.
<i>FF3</i>	23.0%	40.2%	+17.2 p.p.
<i>FF4</i>	29.8%	43.3%	+13.5 p.p.
<i>EDcm2</i>	18.3%	23.3%	+5 p.p.
<i>EDcm3</i>	14.0%	18.2%	+4.2 p.p.
<i>EDcm4</i>	11.2%	16.0%	+4.8 p.p.
<i>TUc1</i>	21.3%	24.4%	+3.1 p.p.
<i>TUc2</i>	16.5%	19.4%	+2.9 p.p.

Table 5: Differences of  $\overline{R^2_{OOS}}$  between 30-minute and Optimal Event Windows (cont.)

# Optimal Event Windows: $\overline{R^2_{OOS}}$ Table (2/2)

[Back to Summary Text](#)

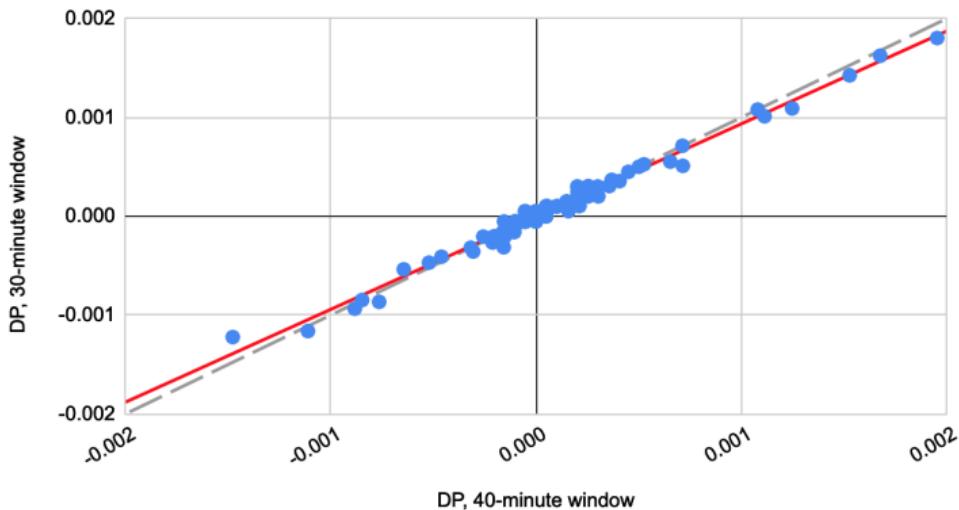
Asset	$\overline{R^2_{OOS}}$ , 30-min	$\overline{R^2_{OOS}}$ , Optimal	Difference
<i>FVc1</i>	11.7%	21.4%	+9.7 p.p.
<i>FVc2</i>	12.7%	19.2%	+6.5 p.p.
<i>TYc1</i>	11.7%	25.5%	+13.8 p.p.
<i>TYc2</i>	11.4%	23.9%	+12.5 p.p.
<i>USc1</i>	15.7%	28.5%	+12.8 p.p.
<i>USc2</i>	18.7%	32.1%	+13.4 p.p.
<i>SPX</i>	18.4%	23.2%	+4.8 p.p.
<i>ESc1</i>	22.9%	27.7%	+4.8 p.p.
<i>ESc2</i>	19.3%	23.5%	+4.2 p.p.

Table 6: Differences of  $\overline{R^2_{OOS}}$  between 30-minute and Optimal Event Windows

# Optimal Event Windows: Diff Windows, Diff Responses (FF3\*\*\*)

[Other Assets](#)

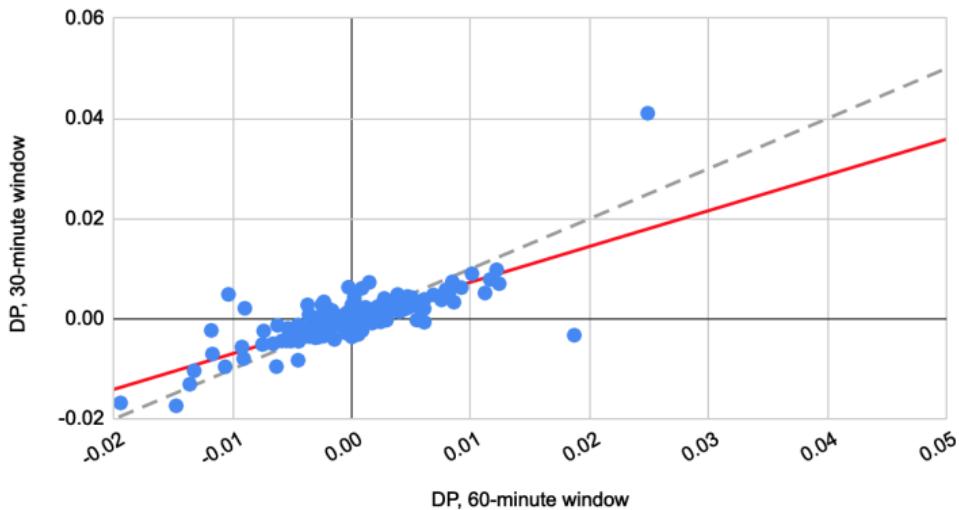
Market Responses in Different Event Windows (FF3)



- ▶ **Takeaway:** On average, markets **under-react**, ex-post, to FOMC statement text
- ▶ **"Soft"** information = Longer to process → Info asymmetry to resolve
  - Indriawan et al. (2021); Brooks et al. (2023)

# Optimal Event Windows: Diff Windows, Diff Responses ( $USc2^{***}$ )

Market Responses in Different Event Windows ( $USc2$ )

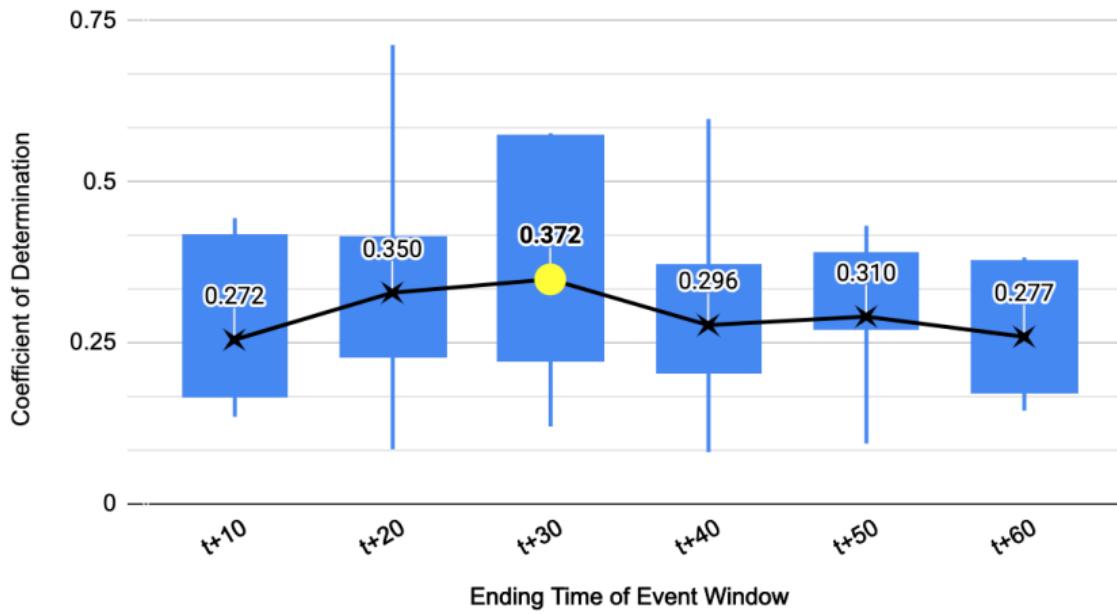


- ▶ **Takeaway:** On average, markets **under-react**, ex-post, to FOMC statement text
- ▶ **"Soft"** information = Longer to process → Info asymmetry to resolve
  - Indriawan et al. (2021); Brooks et al. (2023)

# Optimal Event Windows: FF1

[Back to Summary Text](#)

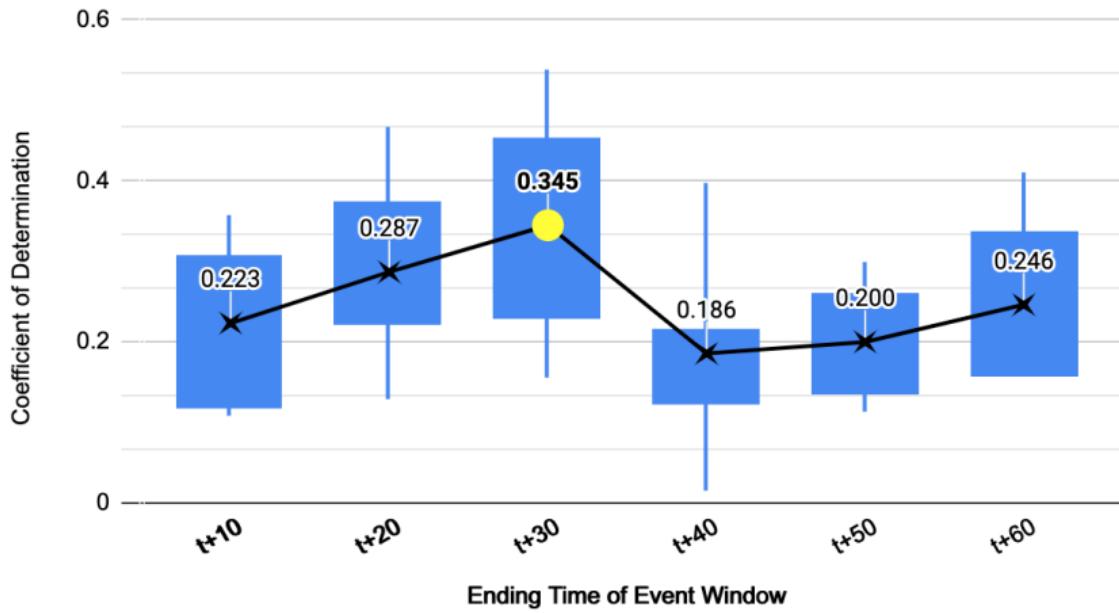
Out-of-sample R<sup>2</sup> for FF1 (Averaged Across Splits)



# Optimal Event Windows: FF2

[Back to Summary Text](#) [One Signal](#)

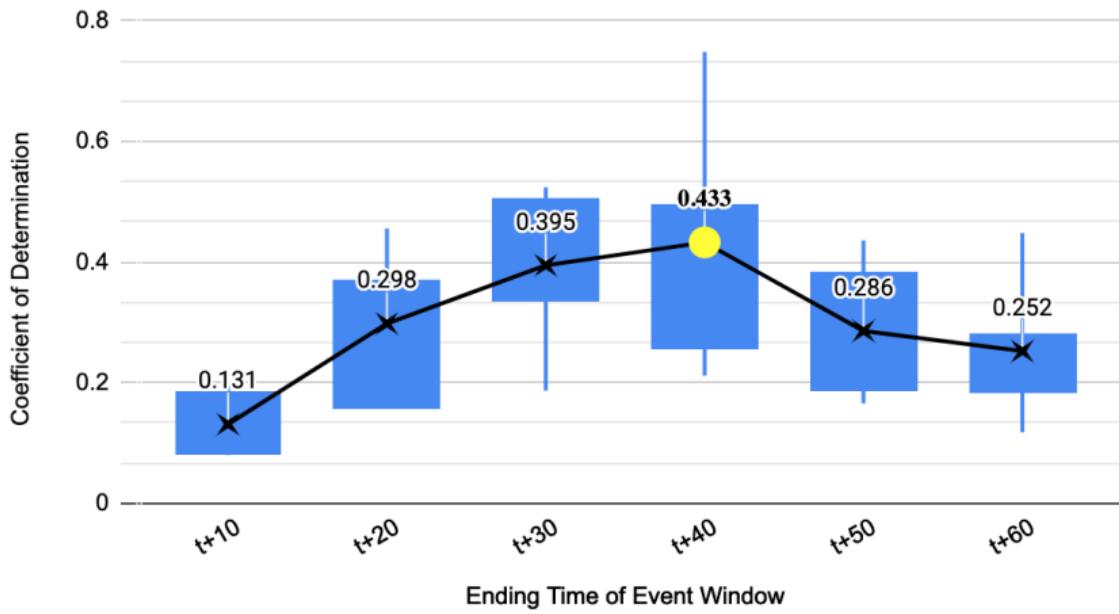
Out-of-sample R<sup>2</sup> for FF2 (Averaged Across Splits)



# Optimal Event Windows: FF4

[Back to Summary Text](#) [One Signal](#)

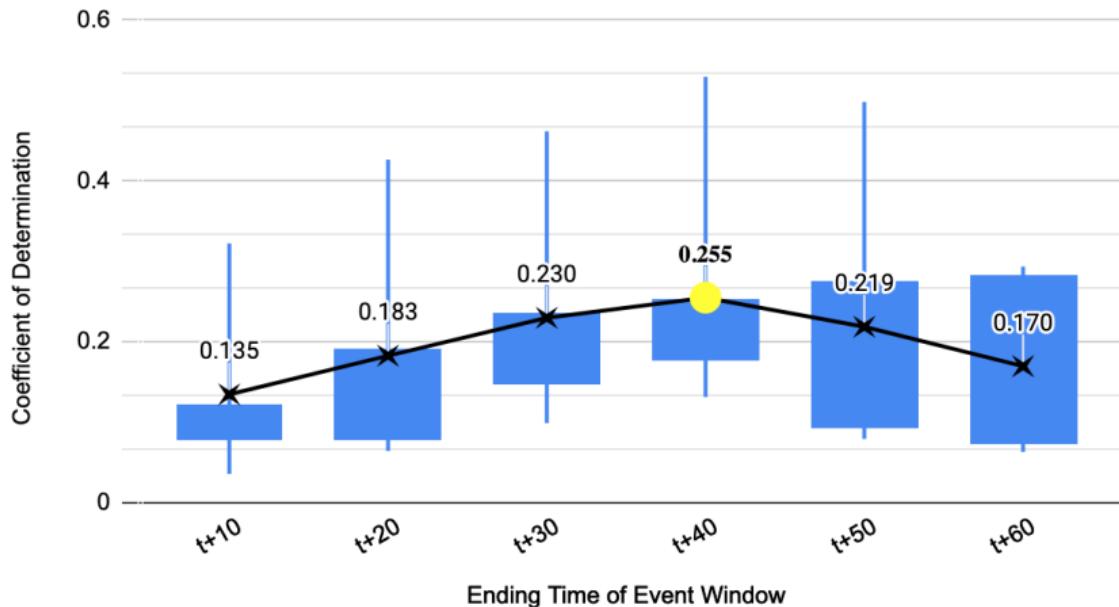
Out-of-sample R<sup>2</sup> for FF4 (Averaged Across Splits)



# Optimal Event Windows: *EDcm2*

[Back to Summary Text](#)

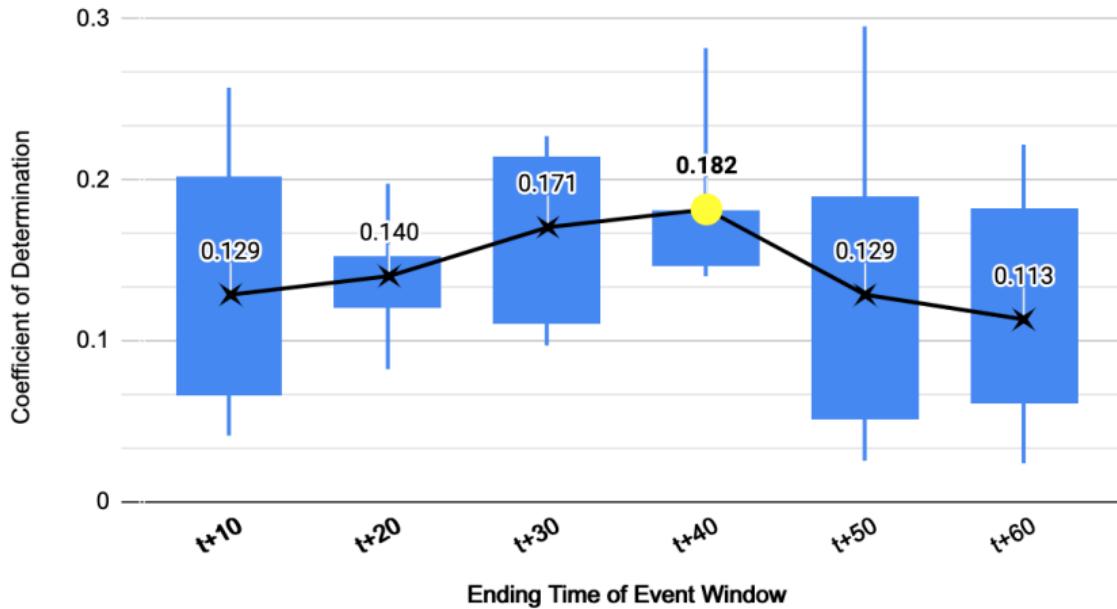
Out-of-sample R<sup>2</sup> for EDcm2 (Averaged Across Splits)



# Optimal Event Windows: *EDcm3*

[Back to Summary Text](#)

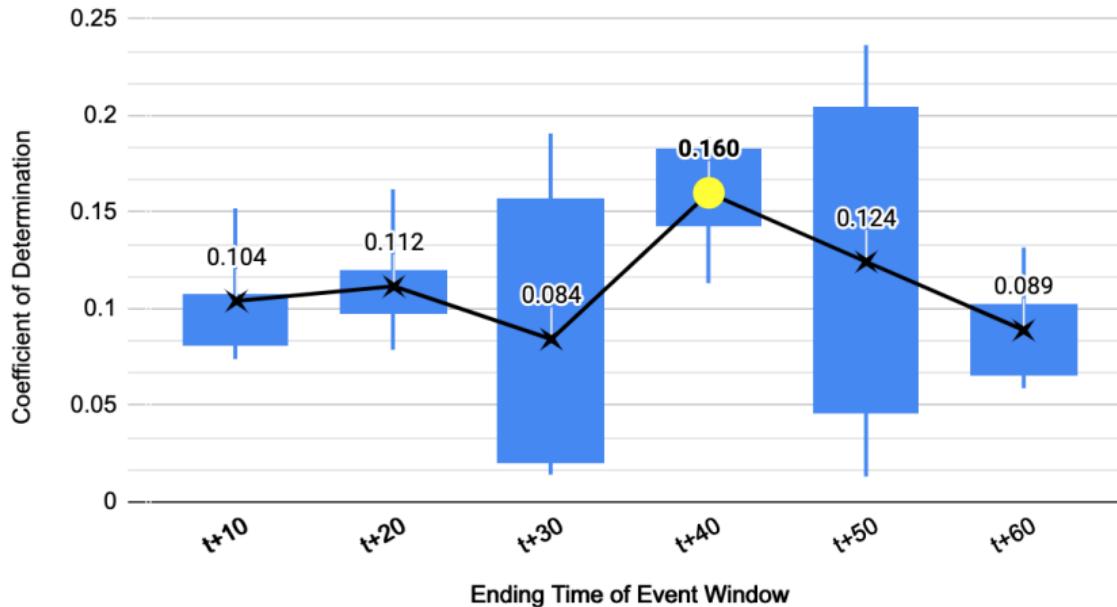
Out-of-sample R<sup>2</sup> for EDcm3 (Averaged Across Splits)



# Optimal Event Windows: *EDcm4*

[Back to Summary Text](#)

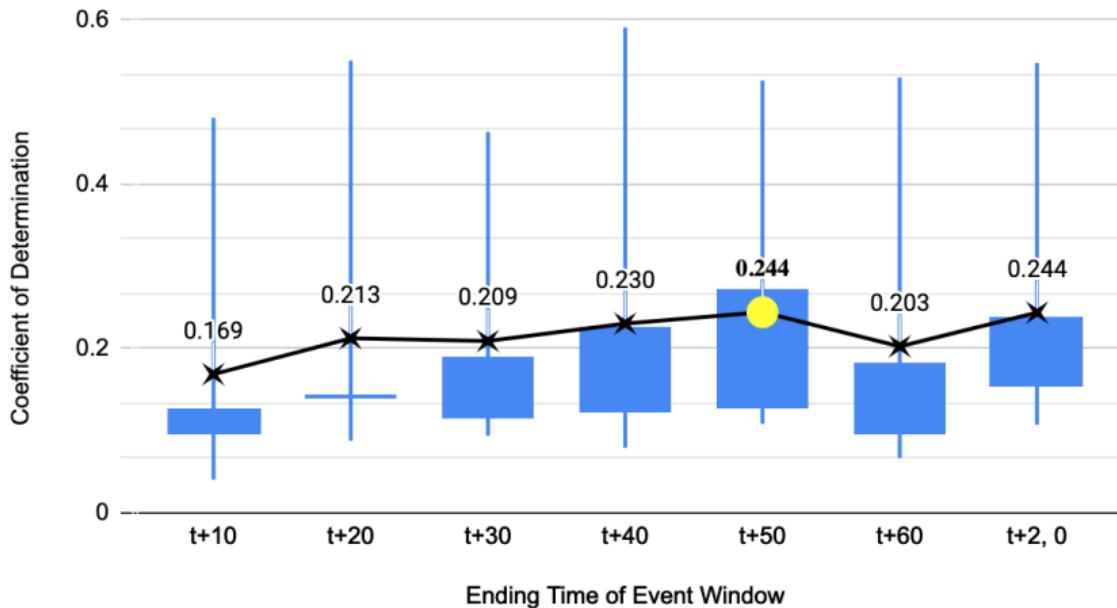
Out-of-sample R<sup>2</sup> for EDcm4 (Averaged Across Splits)



# Optimal Event Windows: $TUc1$

[Back to Summary Text](#) [One Signal](#)

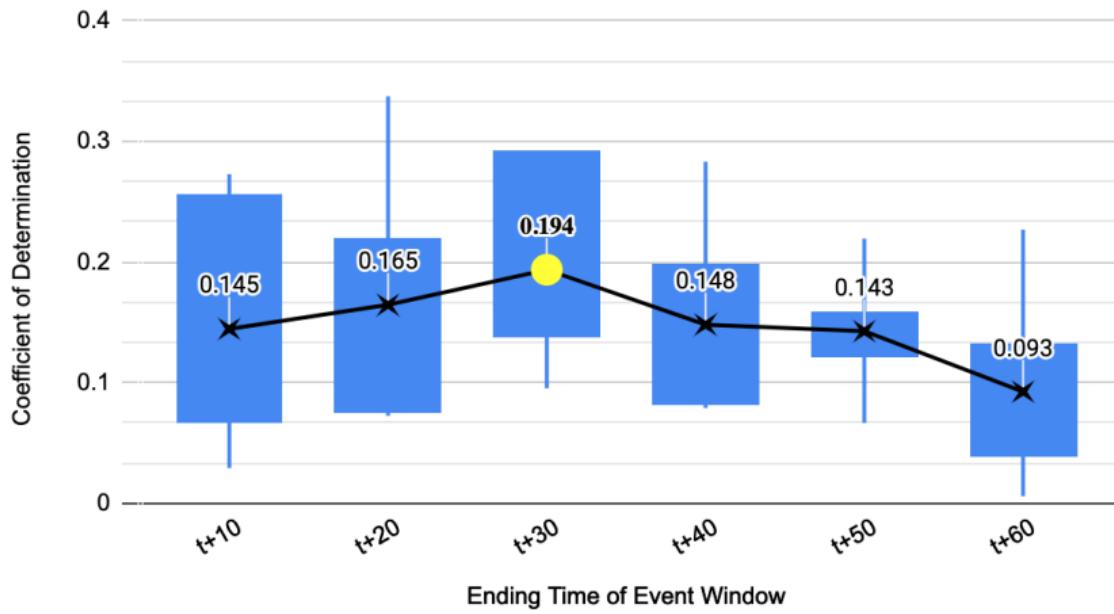
Out-of-sample R<sup>2</sup> for TUc1 (Averaged Across Splits)



# Optimal Event Windows: TUC2

[Back to Summary Text](#)

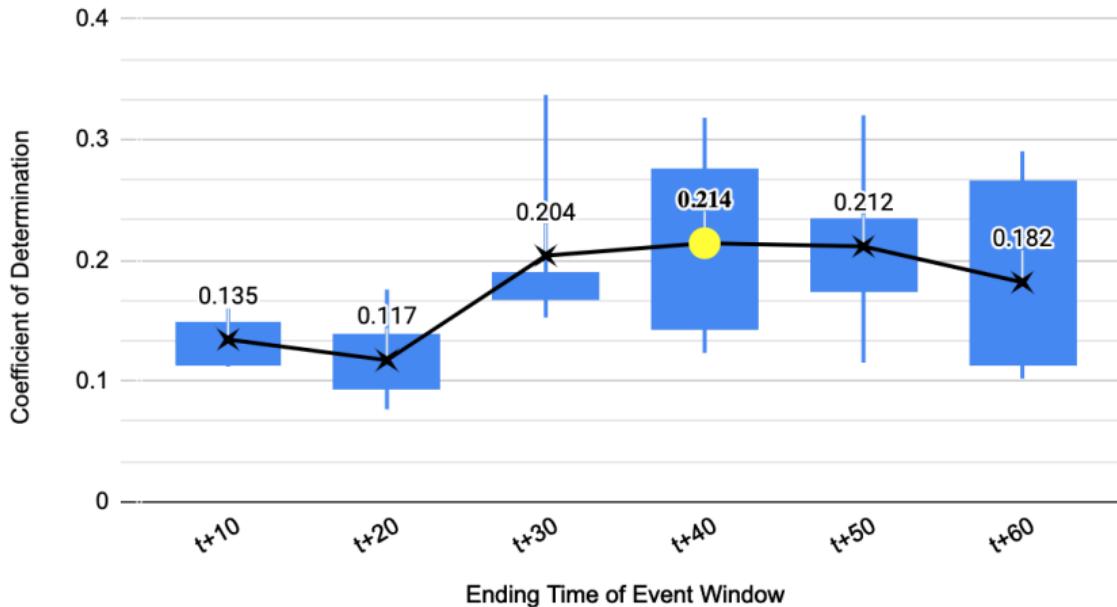
Out-of-sample R<sup>2</sup> for TUC2 (Averaged Across Splits)



# Optimal Event Windows: $FVc1$

[Back to Summary Text](#)

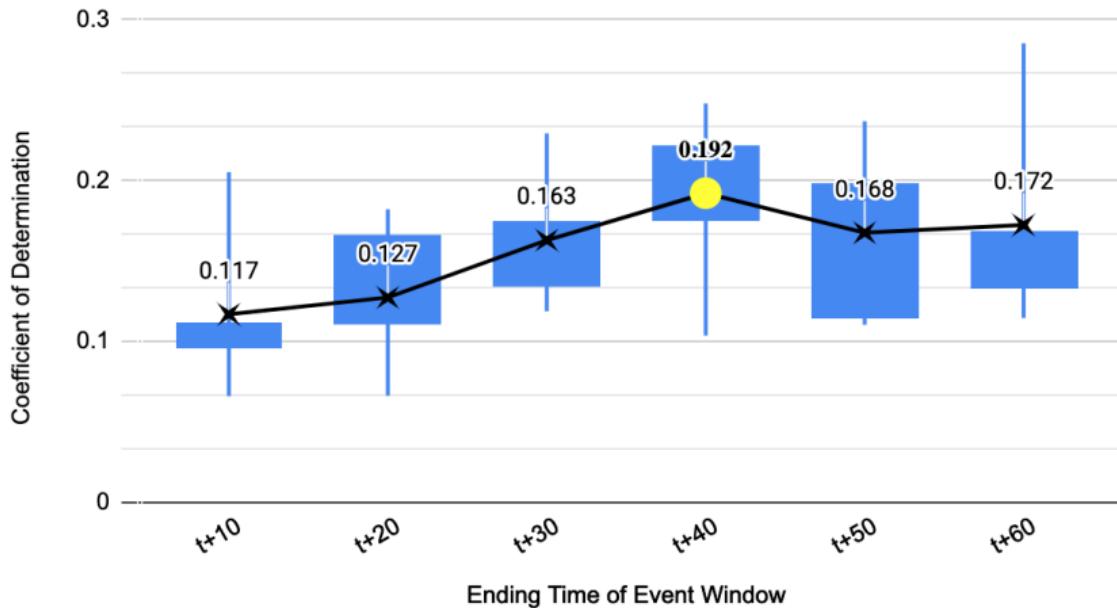
Out-of-sample  $R^2$  for  $FVc1$  (Averaged Across Splits)



# Optimal Event Windows: $FVc2$

[Back to Summary Text](#)

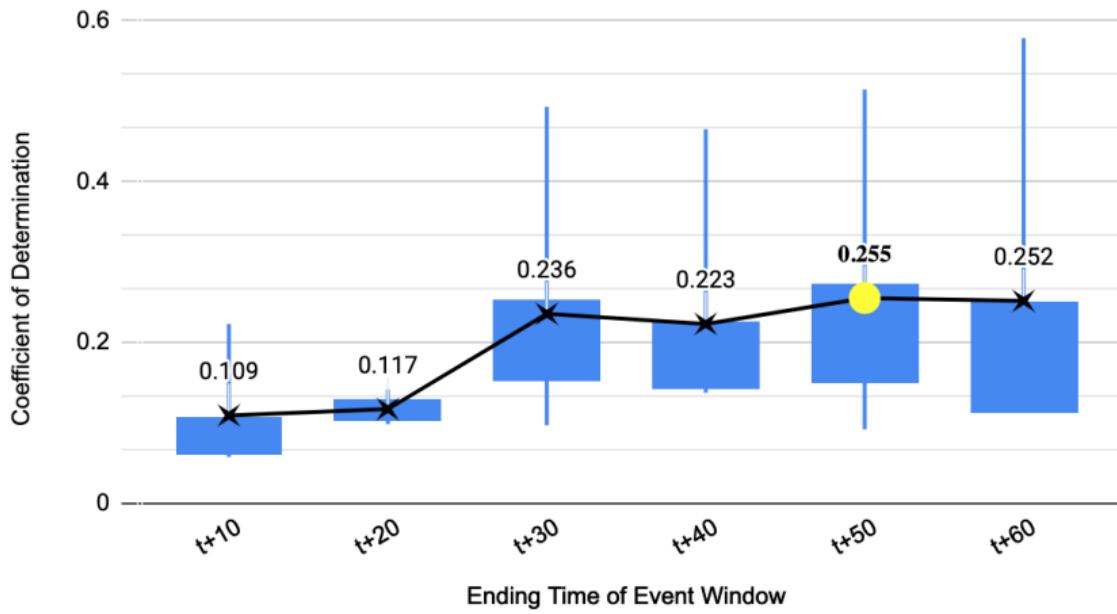
Out-of-sample  $R^2$  for  $FVc2$  (Averaged Across Splits)



# Optimal Event Windows: TYc1

[Back to Summary Text](#)

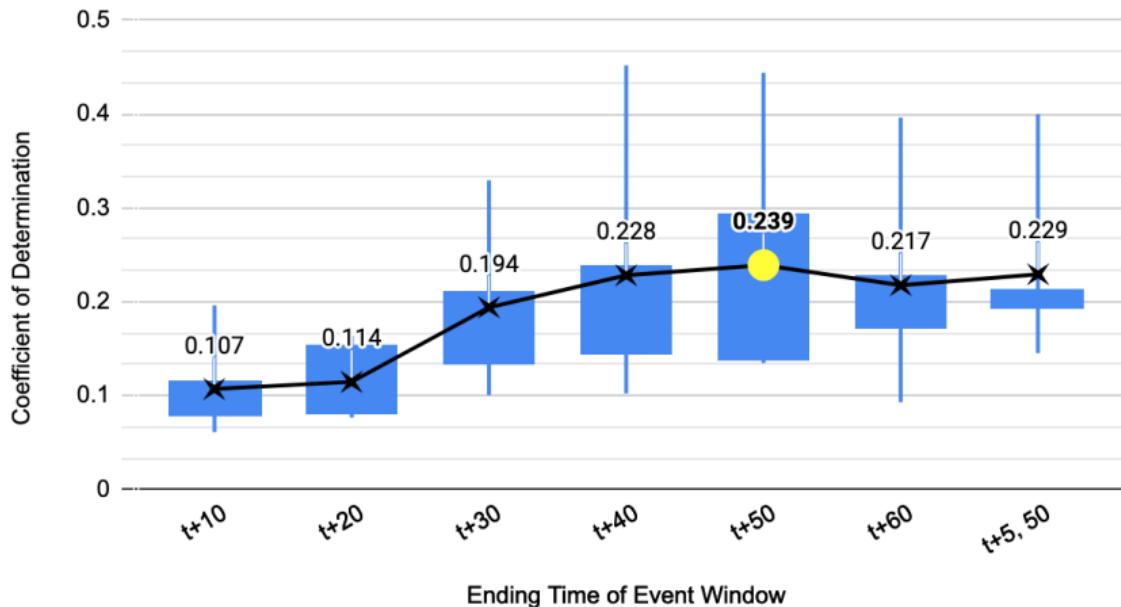
Out-of-sample R<sup>2</sup> for TYc1 (Averaged Across Splits)



# Estimating Optimal Event Windows: TYc2

[Back to Summary Text](#) [One Signal](#)

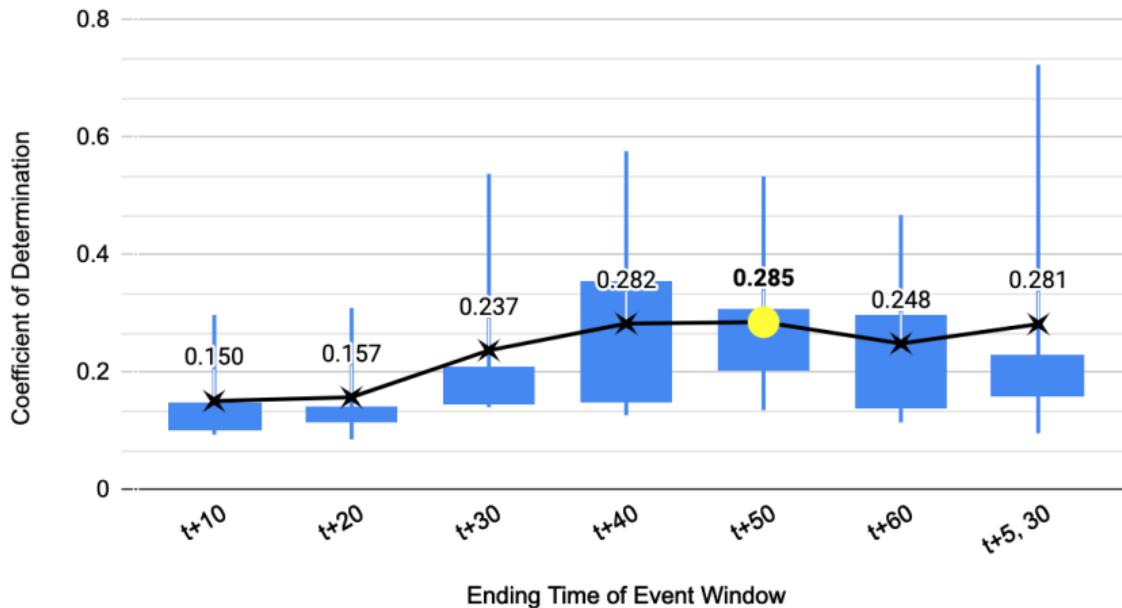
Out-of-sample R<sup>2</sup> for TYc2 (Averaged Across Splits)



# Optimal Event Windows: USc1

[Back to Summary Text](#) [One Signal](#)

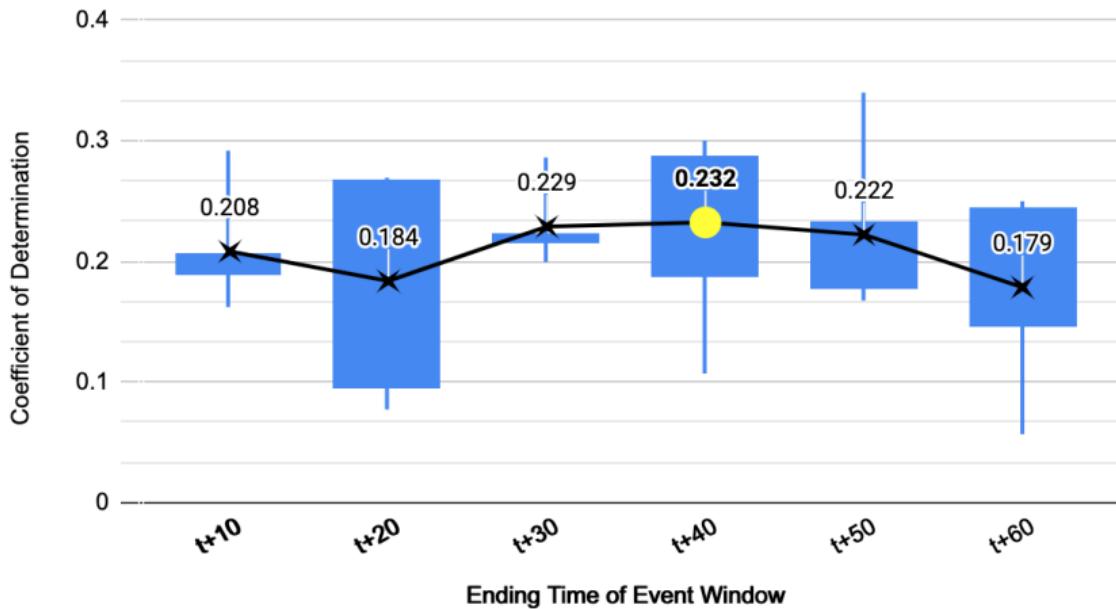
Out-of-sample R<sup>2</sup> for USc1 (Averaged Across Splits)



# Optimal Event Windows: SPX

[Back to Summary Text](#)

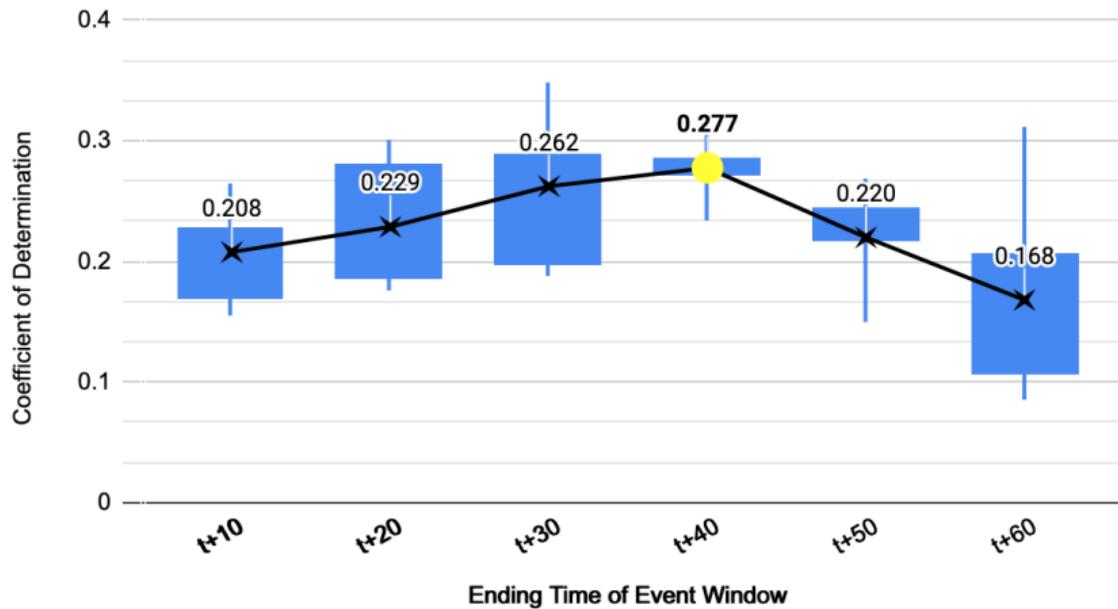
Out-of-sample R<sup>2</sup> for SPX (Averaged Across Splits)



# Optimal Event Windows: ESc1

[Back to Summary Text](#)

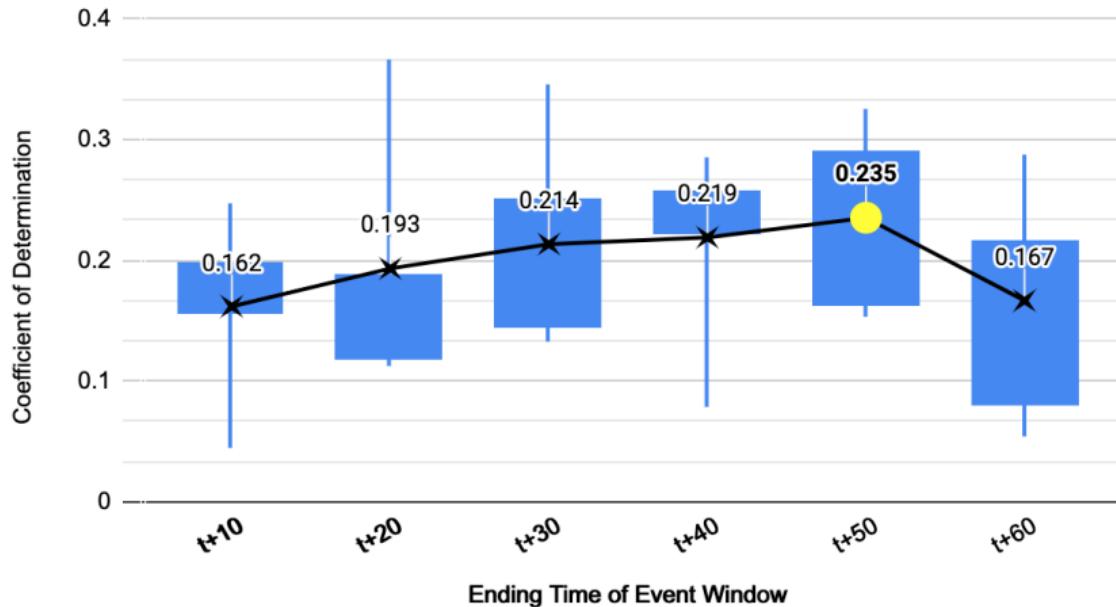
Out-of-sample R<sup>2</sup> for ESc1 (Averaged Across Splits)



# Optimal Event Windows: *ESc2*

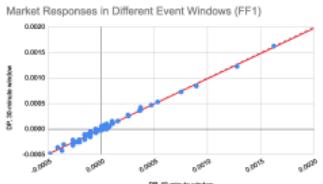
[Back to Summary Text](#)

Out-of-sample R<sup>2</sup> for ESc2 (Averaged Across Splits)

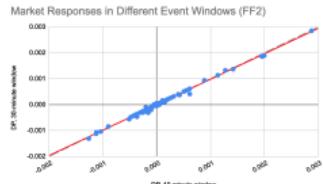


# Optimal Event Windows: Diff Windows, Diff Responses (1/2)

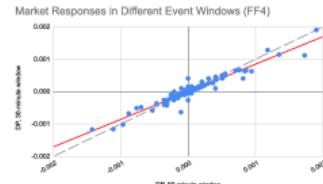
FF3 USc2



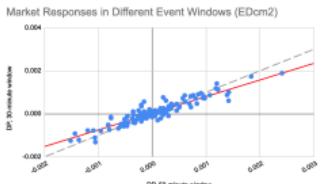
(a) FF1\*\*



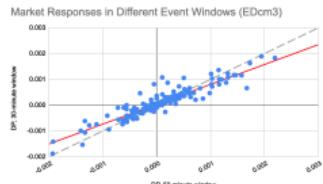
(b) FF2\*\*\*



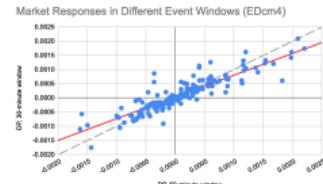
(c) FF4\*\*\*



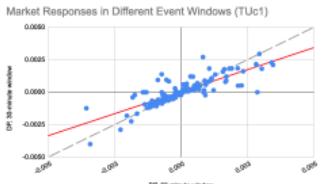
(d) EDcm2\*\*\*



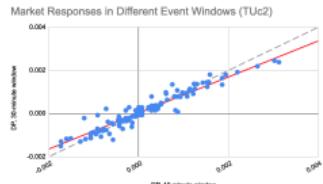
(e) EDcm3\*\*\*



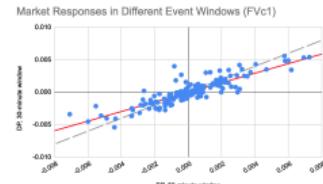
(f) EDcm4\*\*\*



(g) TUC1\*\*\*

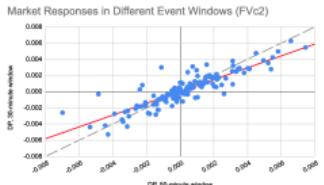
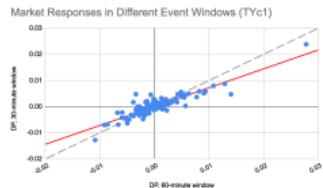
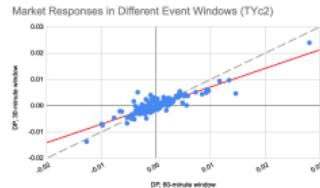
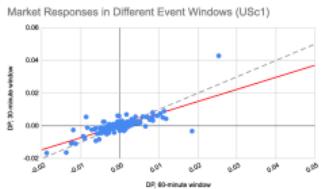
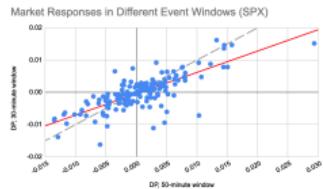
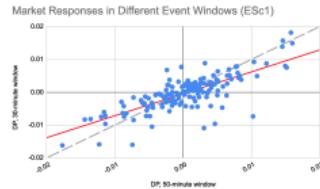
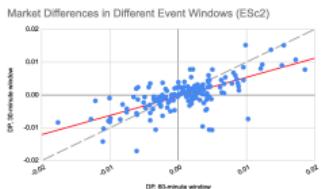


(h) TUC2\*\*\*



(i) FVC1\*\*\*

# Optimal Event Windows: Diff Windows, Diff Responses (2/2)

(a) *FVc2\*\*\**(b) *TYc1\*\*\**(c) *TYc2\*\*\**(d) *USc1\*\*\**(e) *SPX\*\*\**(f) *ESc1\*\*\**(g) *ESc2\*\*\**

# Interest-rate Futures Prices into MP Surprises: $mp1$

[Back to MP surprises](#)

- ▶ For given expiry month, FFF pays out, on last day,  $100 - \text{avg FFR}$
- ▶ Price of  $(1-j)$  month-ahead FFF at time  $t$  for FOMC meeting  $\tau$ :  $p_{\tau,t}^{FFj}$
- ▶ Expected avg FFR at  $t$  for  $\tau$ :  $FFj_{\tau,t} = 100 - p_{\tau,t}^{FFj}$
- Current-meeting FFR surprise  $mp1_{\tau,t+n}$ :

$$mp1_{\tau,t+n} = \frac{m}{m-d} (FF1_{\tau,t+n} - FF1_{\tau,t-10}), \quad (9)$$

- ▶ Day  $d$  of month, days  $m$  in month
- ▶ If  $m-d+1 \leq 7 \implies mp1_{\tau,t+n} = FF2_{\tau,t+n} - FF2_{\tau,t-10}$
- ▶ **Futures Contracts:**  $FF1, FF2$

# Interest-rate Futures Prices into MP Surprises: *mp2*

[Back to MP surprises](#)

- ▶ Number of months out ( $j - 1$ ) containing next meeting
- ▶ Next-meeting FFR surprise  $mp2_{\tau, t+n}$ :

$$mp2_{\tau, t+n} = \frac{m_2}{m_2 - d_2} \left\{ [FFj_{\tau, t+n} - FFj_{\tau, t-10}] - \frac{d_2}{m_2} mp1_{\tau, t+n} \right\}, \quad (10)$$

- ▶ Day  $d_2$  of next-meeting month, days  $m_2$  in next-meeting month
- ▶ If  $m_2 - d_2 + 1 \leq 7 \implies mp2_{\tau, t+n} = FF(j+1)_{\tau, t+n} - FF(j+1)_{\tau, t-10}$
- ▶ **Futures Contracts:**  $FF2, FF3, FF4$

# Interest-rate Futures Prices into MP Surprises: $\Delta edj$

[Back to MP surprises](#)

- ▶ On last day of last quarter, ED pays out 100– 3-month US dollar BBA LIBOR rate
- ▶ Price at time  $t$  of  $j^{th}$  nearest quarterly ED contract for meeting  $\tau$ :  $p_{\tau,t}^{edj}$
- ▶ Implied rate at  $t$  for  $\tau$ :  $edj_{\tau,t} = 100 - p_{\tau,t}^{edj}$
- Implied rate surprise  $j$ -quarters out  $edj_{\tau,t+n}$ :

$$edj_{\tau,t+n} = edj_{\tau,t+n} - edj_{\tau,t-10}, \quad (11)$$

- ▶ Day  $d$  of month, days  $m$  in month
- ▶ **Futures Contracts:**  $EDcm2, EDcm3, EDcm4$

# Interest-rate Futures Prices into MP Surprises: $\Delta tk$

[Back to MP surprises](#)

- ▶ On expiry quarter, Tsy futures obliges seller to deliver bond within maturities range
- ▶ Price at time  $t$  of  $j^{th}$  nearest quarterly  $k$ -year Treasury contract for meeting  $\tau$ :  $p_{\tau,t}^{tk^j}$
- Implied yield surprise for meeting  $\tau$   $tk_{\tau,t+n}$ :

$$tk_{\tau,t+n} = - \left( p_{\tau,t+n}^{tk^j} - p_{\tau,t-10}^{tk^j} \right) / I, \quad (12)$$

- ▶ If  $\tau \in \{\text{Mar, Jun, Sep, Dec}\} \implies tk_{\tau,t+n} = - \left( p_{\tau,t+n}^{tk^{j+1}} - p_{\tau,t-10}^{tk^{j+1}} \right) / I$
- ▶ Approximated maturities  $I \in \{2, 4, 7, 15\}$  by Gürkaynak, Kisacikoglu, et al. (2020)
- ▶ **Futures Contracts:**  $TUc1, TUc2; FVc1, FVc2; TYc1, TYc2; USc1, USc2$

# Principal Component Analysis

- ▶ **Purpose:** Reduces dimensionality without sacrificing data variation
- ▶ **Example:** Variables  $x^1, x^2$ ;  $N$  observations
- ▶  $1^{st}$  Principal component:  $\underbrace{PC1}_{N \times 1} = \underbrace{X}_{N \times 2} \cdot \underbrace{V}_{2 \times 1},$ 
  1.  $X$  = Covariance matrix of variables
  2.  $V$  = Eigenvector of covariance matrix  $X$  that has largest eigenvalue
- ▶ Largest eigenvalue → Captures most common variation in data
- Corresponding eigenvector is “direction” explaining data variation

# Monetary Policy Shocks: Visual Diff from Window Choice (1/2)

[Back to MP Shocks](#)

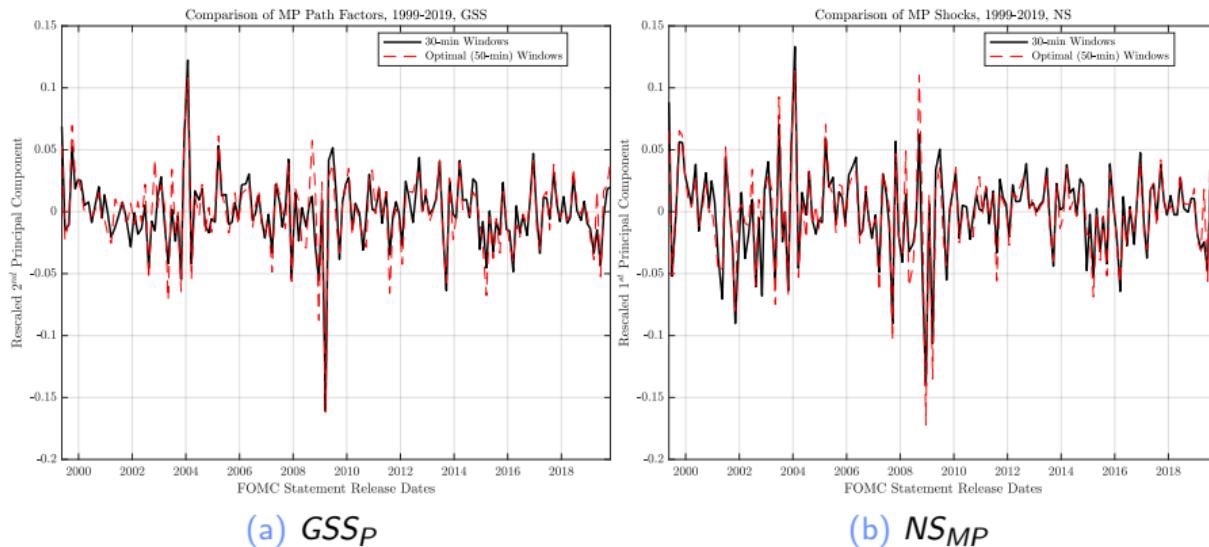


Figure 1: Comparing MP Shock Series Derived from Optimal Window Length v. 30 Minutes

# Monetary Policy Shocks: Visual Diff from Window Choice (2/2)

[Back to MP Shocks](#)

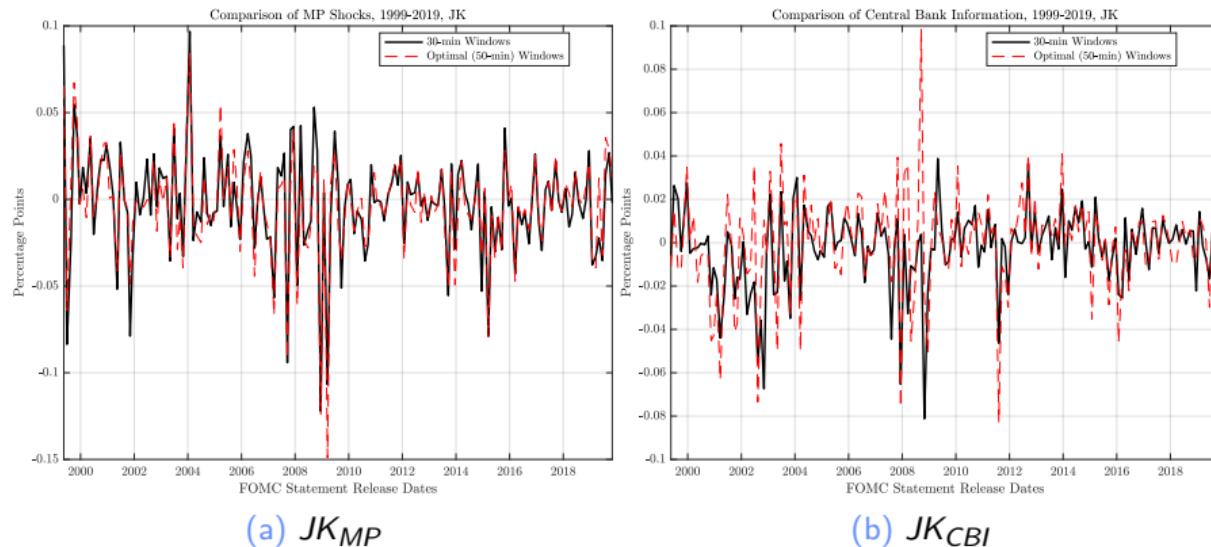


Figure 2: Comparing MP Shock Series Derived from Optimal Window Length v. 30 Minutes

# Monetary Policy Shocks, Statement Frequency: Summary Table

[Back to MP Shocks](#)

Metric	$GSS_T$	$GSS_P$	$NS_{MP}$	$JK_{MP}$	$JK_{CBI}$
Count	165 (165)	165 (165)	165 (165)	165 (165)	165 (165)
Mean	0 (0)	0 (0)	0 (0)	-0.0023 (-0.0035)	-0.0028 (-0.0004)
SD	0.0219 (0.0216)	0.0282 (0.0309)	0.0356 (0.0375)	0.0305 (0.0297)	0.0180 (0.0233)
Max	0.0756 (0.0652)	0.1223 (0.1079)	0.1333 (0.1135)	0.0968 (0.0840)	0.0388 (0.0984)
$75^{th}$	0.0076 (0.0084)	0.0134 (0.0167)	0.0193 (0.0203)	0.0175 (0.0124)	0.0069 (0.0112)
Median	0.0011 (0.0023)	-0.0010 (0.0019)	0.0033 (0.0003)	-0.0017 (-0.0009)	-0.0003 (0.0022)
$25^{th}$	-0.0069 (-0.0077)	-0.0124 (-0.0127)	-0.0187 (-0.0164)	-0.0153 (-0.0138)	-0.0086 (-0.0103)
Min	-0.1038 (-0.1025)	-0.1611 (-0.1618)	-0.1403 (-0.1722)	-0.1222 (-0.1491)	-0.0812 (-0.0828)

**Table 7:** Descriptive Statistics for Monetary Policy Shock Series, FOMC Statement Frequency for 1999–2019

# Impulse Response Variables: Summary Table

[Back to LP](#)

Metric	$\ln(CPI)$	$\ln(IP)$	EBP	$TY_2$
Count	246	246	246	246
Mean	5.356	4.597	0.110	2.210
SD	0.126	0.057	0.715	1.794
Max	5.551	4.706	3.283	6.650
$75^{th}$	5.466	4.642	0.341	3.569
Median	5.381	4.605	-0.108	1.673
$25^{th}$	5.241	4.548	-0.334	0.662
Min	5.112	4.467	-1.140	0.188

Table 8: Descriptive Statistics for Impulse Response Variables, Monthly for 1999–2019

# Monetary Policy Shocks, Monthly Frequency: Summary Table

[Back to LP](#)

- Months without FOMC meeting → Shock values set to zero

Metric	$GSS_T$	$GSS_P$	$NS_{MP}$	$JK_{MP}$	$JK_{CBI}$
Count	165 (165)	165 (165)	165 (165)	165 (165)	165 (165)
Mean	0 (0)	0 (0)	0 (0)	-0.0015 (-0.0024)	-0.0019 (-0.0002)
SD	0.0180 (0.0177)	0.0230 (0.0253)	0.0291 (0.0307)	0.0250 (0.0243)	0.0148 (0.0190)
Max	0.0756 (0.0652)	0.1223 (0.1079)	0.1333 (0.1135)	0.0968 (0.0840)	0.0388 (0.0984)
$75^{th}$	0.0042 (0.0042)	0.0078 (0.0089)	0.0114 (0.0110)	0.0055 (0.0058)	0.0031 (0.0075)
Median	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
$25^{th}$	-0.0021 (-0.0011)	-0.0064 (-0.0052)	-0.0036 (-0.0039)	-0.0073 (-0.0070)	-0.0037 (-0.0035)
Min	-0.1038 (-0.1025)	-0.1611 (-0.1618)	-0.1403 (-0.1722)	-0.1222 (-0.1491)	-0.0812 (-0.0828)

Table 9: Descriptive Statistics for Monetary Policy Shock Series, Monthly Frequency for 1999–2019

[Back to Reg Results](#)

# MP Shocks: Nominal Interest Rates

	30-minute Window				Optimal Window				Difference		
	$\Delta TY_1$	$\Delta TY_2$	$\Delta TY_5$	$\Delta TY_{10}$	$\Delta TY_1$	$\Delta TY_2$	$\Delta TY_5$	$\Delta TY_{10}$	$\Delta TY_2$	$\Delta TY_5$	$\Delta TY_{10}$
$GSS_T$	1.00*** (0.28)	0.82*** (0.34)	0.15 (0.43)	-0.37 (0.41)	1.00*** (0.23)	0.78*** (0.28)	0.08 (0.33)	-0.42 (0.32)	<b>-0.04</b>	<b>-0.07</b>	<b>-0.05</b>
$GSS_P$	1.00*** (0.09)	1.46*** (0.09)	1.89*** (0.25)	1.64*** (0.36)	1.00*** (0.11)	1.51*** (0.10)	1.93*** (0.21)	1.66*** (0.30)	<b>+0.05</b>	<b>+0.04</b>	<b>+0.02</b>
$NS_{MP}$	1.00*** (0.07)	1.24*** (0.09)	1.29*** (0.19)	0.95*** (0.25)	1.00*** (0.09)	1.30*** (0.10)	1.39*** (0.18)	1.06*** (0.24)	<b>+0.06</b>	<b>+0.11</b>	<b>+0.11</b>
$JK_{MP}$	1.00*** (0.11)	1.30*** (0.15)	1.39*** (0.28)	0.99*** (0.36)	1.00*** (0.12)	1.35*** (0.16)	1.52*** (0.32)	1.16*** (0.43)	<b>+0.04</b>	<b>+0.13</b>	<b>+0.17</b>
$JK_{CBI}$	1.00*** (0.25)	1.04*** (0.30)	1.00*** (0.31)	0.82*** (0.29)	1.00*** (0.23)	1.20*** (0.25)	1.14*** (0.27)	0.85*** (0.26)	<b>+0.16</b>	<b>+0.14</b>	<b>+0.03</b>

Table 10: Diff in Responses of Nominal Interest Rates to Shocks from Event Window Choice

→ Using optimal windows → Bigger effects for MP shocks about forward guidance

# MP Shocks: Real Interest Rates

[Back to Reg Results](#)

	30-minute Window			Optimal Window			Difference		
	$\Delta TIPS_2$	$\Delta TIPS_5$	$\Delta TIPS_{10}$	$\Delta TIPS_2$	$\Delta TIPS_5$	$\Delta TIPS_{10}$	$\Delta TIPS_2$	$\Delta TIPS_5$	$\Delta TIPS_{10}$
$GSS_T$	-0.81 (1.44)	0.02 (0.51)	-0.19 (0.45)	-0.90 (1.57)	0.09 (0.46)	-0.16 (0.37)	<b>-0.09</b>	<b>+0.07</b>	<b>+0.03</b>
$GSS_P$	2.21*** (0.49)	1.96*** (0.46)	1.74*** (0.44)	2.20*** (0.37)	2.03*** (0.38)	1.75*** (0.37)	<b>-0.00</b>	<b>+0.06</b>	<b>+0.01</b>
$NS_{MP}$	1.17*** (0.73)	1.29*** (0.36)	1.08*** (0.30)	1.31*** (0.63)	1.47*** (0.31)	1.20*** (0.28)	<b>+0.14</b>	<b>+0.18</b>	<b>+0.13</b>
$JK_{MP}$	1.40*** (0.83)	1.40*** (0.47)	1.15*** (0.41)	1.66*** (0.63)	1.64*** (0.49)	1.38*** (0.46)	<b>+0.26</b>	<b>+0.24</b>	<b>+0.23</b>
$JK_{CBI}$	0.51 (0.85)	0.99*** (0.33)	0.85*** (0.25)	0.60 (0.92)	1.13*** (0.33)	0.84*** (0.25)	<b>+0.09</b>	<b>+0.14</b>	<b>-0.01</b>

Table 11: Diff in Responses of Real Interest Rates to Shocks from Event Window Choice

→ Using optimal windows → Bigger effects for MP shocks about forward guidance

# MP Shocks: Break-even Inflation

[Back to Reg Results](#)

	30-minute Window			Optimal Window			Difference		
	$\Delta BEI_2$	$\Delta BEI_5$	$\Delta BEI_{10}$	$\Delta BEI_2$	$\Delta BEI_5$	$\Delta BEI_{10}$	$\Delta BEI_2$	$\Delta BEI_5$	$\Delta BEI_{10}$
$GSS_T$	1.63*** (1.46)	0.13 (0.29)	-0.18 (0.17)	1.67*** (1.58)	-0.01 (0.29)	-0.26** (0.17)	<b>+0.05</b>	<b>-0.14</b>	<b>-0.08</b>
$GSS_P$	-0.75 (0.46)	-0.08 (0.24)	-0.10 (0.12)	-0.69* (0.36)	-0.10 (0.23)	-0.09 (0.12)	<b>+0.06</b>	<b>-0.02</b>	<b>+0.01</b>
$NS_{MP}$	0.07 (0.70)	-0.01 (0.23)	-0.13* (0.12)	-0.01 (0.65)	-0.07 (0.23)	-0.14** (0.12)	<b>-0.08</b>	<b>-0.07</b>	<b>-0.01</b>
$JK_{MP}$	-0.09 (0.81)	-0.01 (0.29)	-0.17** (0.13)	-0.31 (0.61)	-0.12 (0.25)	-0.22*** (0.11)	<b>-0.22</b>	<b>-0.11</b>	<b>-0.05</b>
$JK_{CBI}$	0.54 (0.76)	0.01 (0.29)	-0.02 (0.20)	0.60 (0.86)	0.01 (0.30)	0.02 (0.23)	<b>+0.07</b>	<b>+0.00</b>	<b>+0.04</b>

Table 12: Diff in Responses of Break-even Inflation to Shocks from Event Window Choice

→ Using optimal windows → Bigger effects for MP shocks about forward guidance

# MP Shocks: Stock Prices

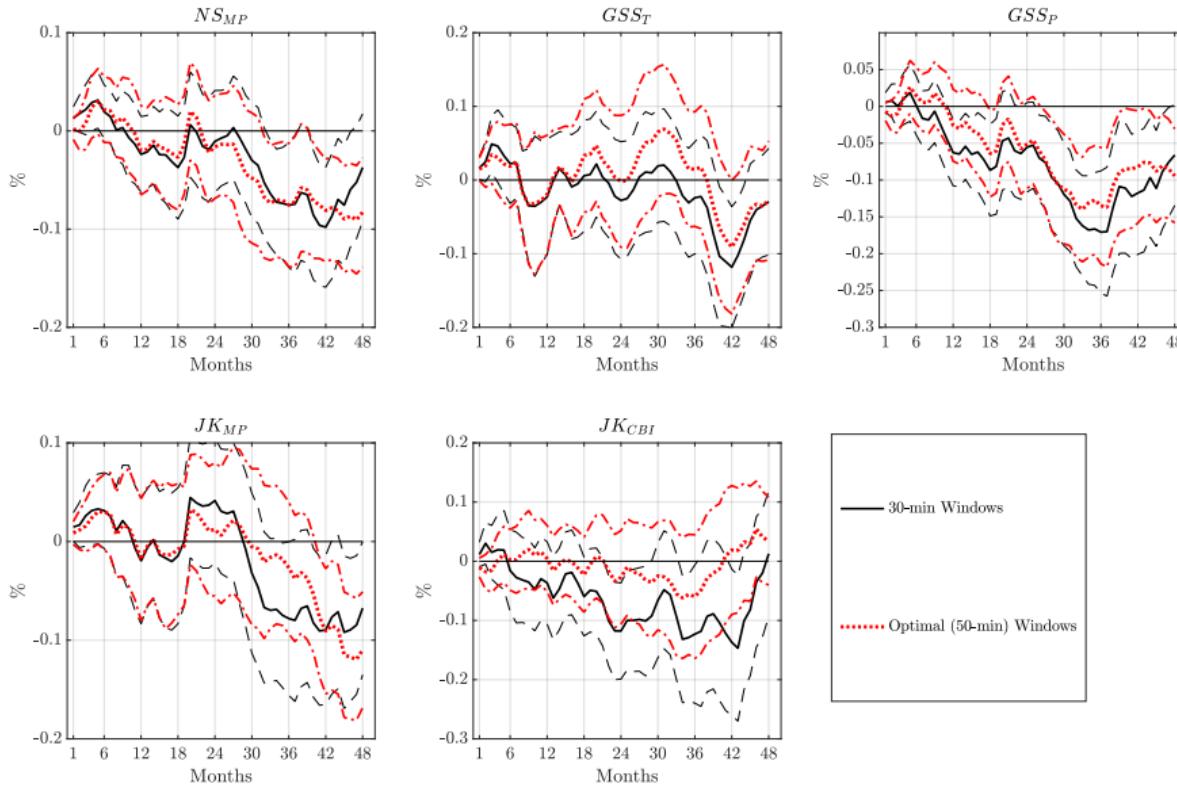
[Back to Reg Results](#)

	30-minute Window			Optimal Window			Percentage Difference		
	$DP_{SPX}$	$DP_{ESc1}$	$DP_{ESc2}$	$DP_{SPX}$	$DP_{ESc1}$	$DP_{ESc2}$	$DP_{SPX}$	$DP_{ESc1}$	$DP_{ESc2}$
$GSS_T$	-8.40*** (2.71)	-8.83*** (2.68)	-7.25*** (2.78)	-7.39*** (3.10)	-7.43*** (3.15)	-7.34*** (3.12)	<b>-11.99%</b>	<b>-15.92%</b>	<b>+1.25%</b>
$GSS_P$	-6.14*** (1.81)	-6.27*** (1.83)	-6.12*** (1.76)	-6.85*** (2.88)	-6.96*** (2.91)	-7.63*** (2.81)	<b>+11.51%</b>	<b>+11.00%</b>	<b>+24.61%</b>
$NS_{MP}$	-6.92*** (1.32)	-7.15*** (1.37)	-6.51*** (1.31)	-7.00*** (1.85)	-7.10*** (1.89)	-7.55*** (1.84)	<b>+1.23%</b>	<b>-1.00%</b>	<b>+16.00%</b>
$JK_{MP}$	-14.76*** (0.81)	-15.08*** (0.91)	-13.73*** (0.94)	-17.46*** (1.04)	-17.77*** (1.08)	-17.30*** (1.06)	<b>+18.25%</b>	<b>+17.88%</b>	<b>+26.00%</b>
$JK_{CBI}$	15.19*** (2.29)	13.84*** (2.35)	15.18*** (2.39)	14.08*** (2.11)	14.44*** (2.14)	12.12*** (2.07)	<b>-7.36%</b>	<b>-4.90%</b>	<b>-12.43%</b>

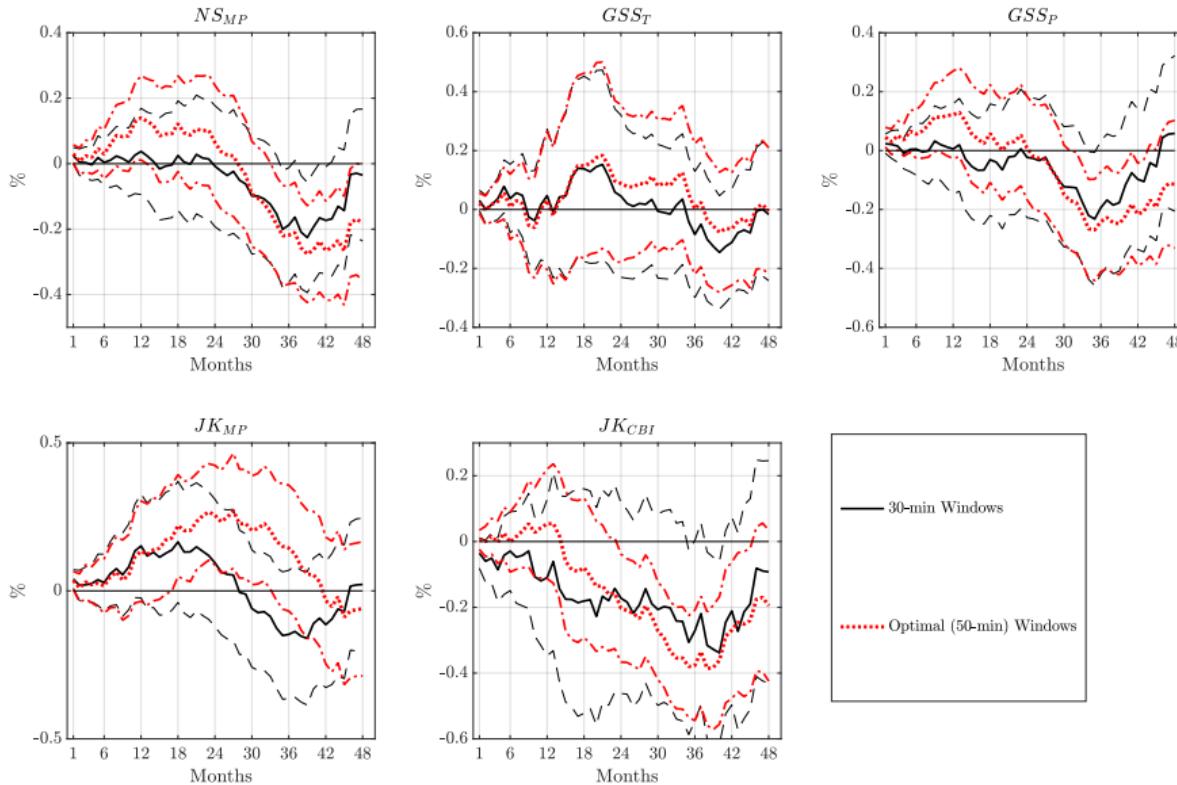
**Table 13:** Diff in Responses of Stock Prices to Shocks from Event Window Choice  
 Notes: Positive (negative) values → stronger (weaker) effect in same direction

→ Using optimal windows → Bigger effects for MP shocks about forward guidance

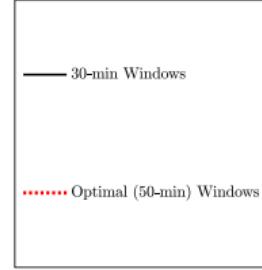
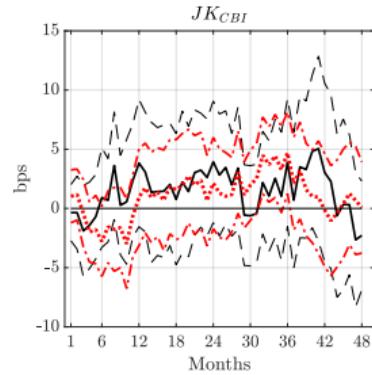
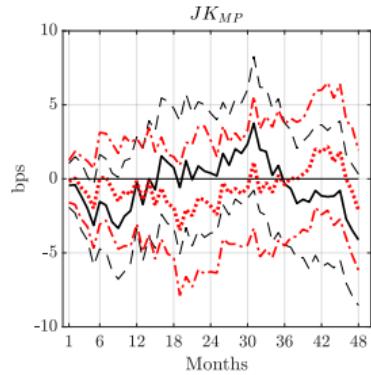
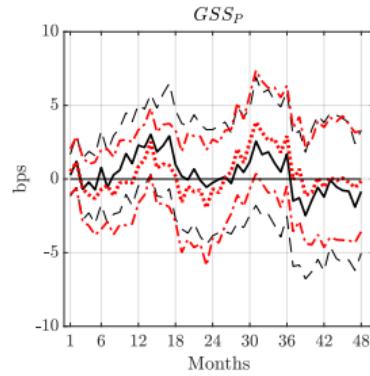
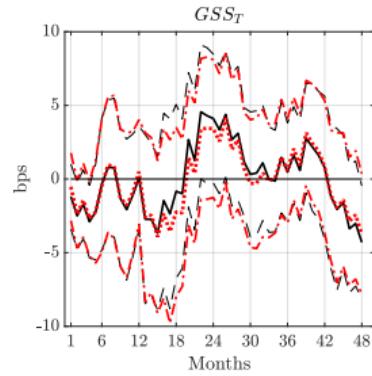
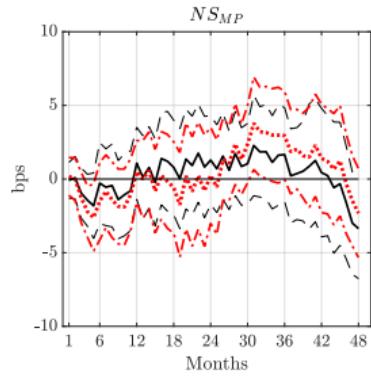
# MP Shocks: Impulse Responses for CPI

[Back to LP Results](#)


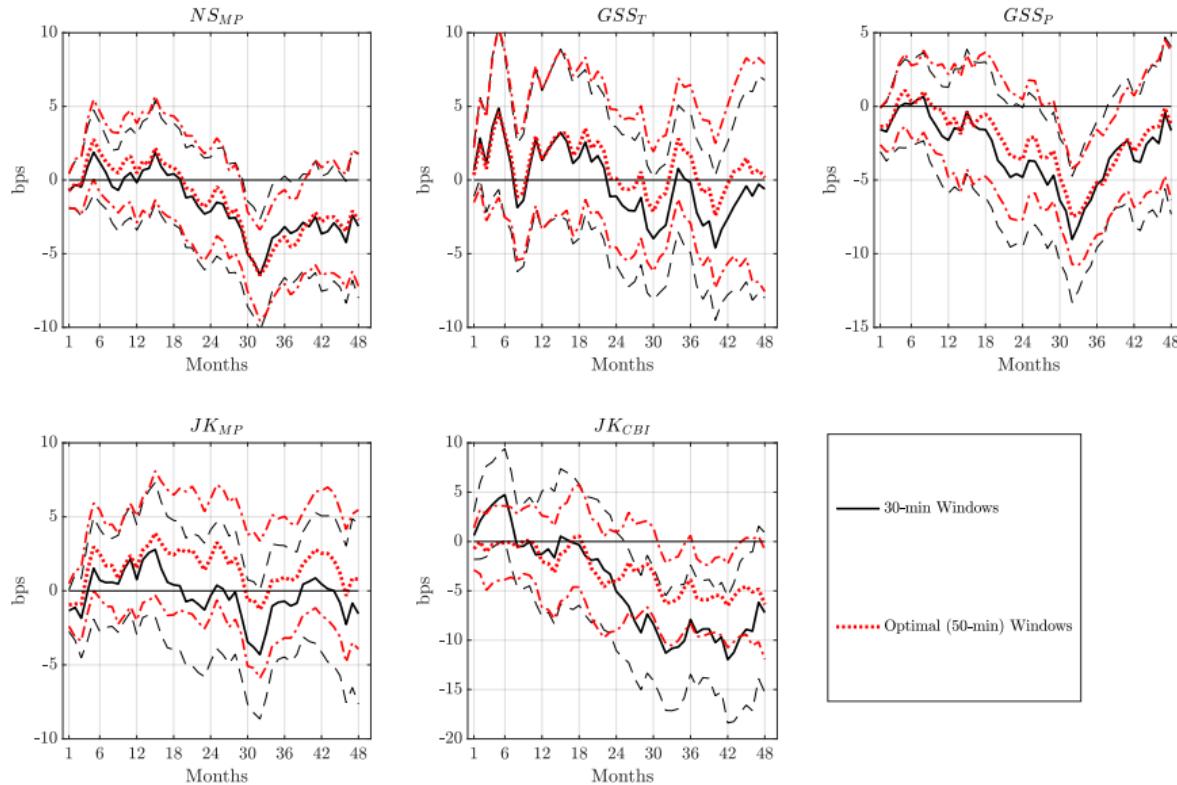
# MP Shocks: Impulse Responses for IP

[Back to LP Results](#)


# MP Shocks: Impulse Responses for EBP

[Back to LP Results](#)


# MP Shocks: Impulse Responses for 2Y Treasury Yield

[Back to LP Results](#)


# “Joint” and “One Signal” Approaches

[Back to Main](#)

- ▶ **Recap:** XLNet-Base approx  $f(\text{FOMC Statement Text}) = DP_{t+5}$ , **forall Folds of all  $DP_{t+n}$** 
  - “**Joint**” estimation of signal **and** optimal event window length

# “Joint” and “One Signal” Approaches

[Back to Main](#)

- ▶ **Recap:** XLNet-Base approx  $f(\text{FOMC Statement Text}) = DP_{t+5}$ , **forall Folds of all  $DP_{t+n}$** 
  - “**Joint**” estimation of signal **and** optimal event window length

# “Joint” and “One Signal” Approaches

[Back to Main](#)

- ▶ **Recap:** XLNet-Base approx  $f(\text{FOMC Statement Text}) = DP_{t+5}$ , **forall Folds of all  $DP_{t+n}$** 
  - “Joint” estimation of signal **and** optimal event window length
- ▶ Fine-tuning XLNet-Base for “joint” estimation = Computationally intensive
  - GPU + Financial constraints = Estimate optimal window lengths only up to **t + 60**
  - Current computation time: **249+ days**

# “Joint” and “One Signal” Approaches

[Back to Main](#)

- ▶ **Recap:** XLNet-Base approx  $f(\text{FOMC Statement Text}) = DP_{t+5}, \forall \text{Folds of } \forall DP_{t+n}$ 
  - “Joint” estimation of signal **and** optimal event window length
- ▶ Fine-tuning XLNet-Base for “joint” estimation = Computationally intensive
  - GPU + Financial constraints = Estimate optimal window lengths only up to **t + 60**
  - Current computation time: **249+ days**
- ▶ **Assumption:** NN Predictions in “joint-estimated” event window = **Constant  $\forall t^{\$}$** 
  1. Much less computationally intensive
  2. Can check if FOMC statement **characteristics** affect optimal window length
  3. Can check if  $\exists$  **greater** out-of-sample  $R^2_{OOS}$  for  $t + n > t + 60$

[Robustness Check](#)

---

<sup>\$</sup>Signal from XLNet-Base is likely to change ∵ Changing LHS  $DP_{t+n} \rightarrow$  retraining NN + “Joint” estimation was performed on “general” sample of FOMC statements, not specific types of statements.

[Back to Main](#)

# Effects of FOMC Statement Characteristics on Event Windows

- ▶ Use “one signal” approach to compare MSEs computed based on:

1. Complexity of FOMC statements

Complexity

2. Similarity of FOMC statements

Similarity

3. Presence of Dissents

Dissents

# FOMC Statement Characteristics: Text Complexity (1/3)

[Back to Characteristics](#)

- ▶ Condition FOMC statements based on **semantic** complexity
  - Hernandez-Murillo and Shell (2014); Hansen and McMahon (2016); Smales and Apergis (2017); Haldane and McMahon (2018); De Pooter (2021); McMahon (2023); and others...

# FOMC Statement Characteristics: Text Complexity (1/3)

[Back to Characteristics](#)

- ▶ Condition FOMC statements based on **semantic** complexity
  - Hernandez-Murillo and Shell (2014); Hansen and McMahon (2016); Smales and Apergis (2017); Haldane and McMahon (2018); De Pooter (2021); McMahon (2023); and others...
- ▶ Measured based on **Flesch Kincaid Grade Level** [Summary Stats](#)
  - Based on sentence structure, word structure, and word phonology

# FOMC Statement Characteristics: Text Complexity (1/3)

[Back to Characteristics](#)

- ▶ Condition FOMC statements based on **semantic** complexity
  - Hernandez-Murillo and Shell (2014); Hansen and McMahon (2016); Smales and Apergis (2017); Haldane and McMahon (2018); De Pooter (2021); McMahon (2023); and others...
- ▶ Measured based on **Flesch Kincaid Grade Level** [Summary Stats](#)
  - Based on sentence structure, word structure, and word phonology
  - Range of reading Levels: 12.2–21.3
  - Median Reading Level: 16.5

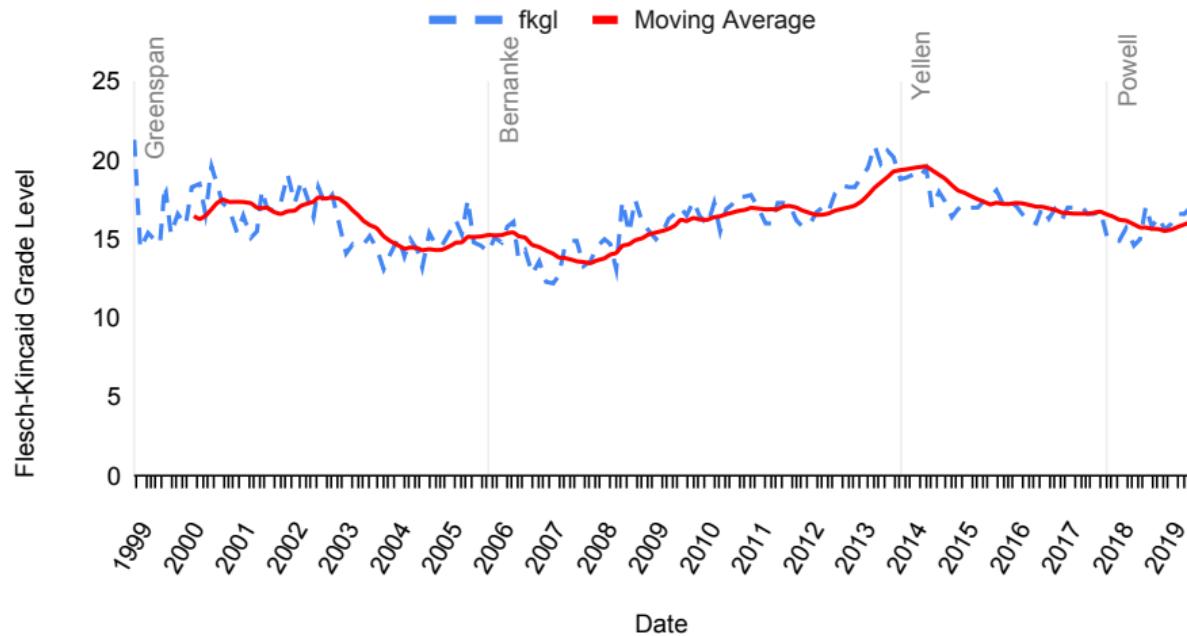
# FOMC Statement Characteristics: Text Complexity (1/3)

[Back to Characteristics](#)

- ▶ Condition FOMC statements based on **semantic** complexity
  - Hernandez-Murillo and Shell (2014); Hansen and McMahon (2016); Smales and Apergis (2017); Haldane and McMahon (2018); De Pooter (2021); McMahon (2023); and others...
- ▶ Measured based on **Flesch Kincaid Grade Level** [Summary Stats](#)
  - Based on sentence structure, word structure, and word phonology
  - Range of reading Levels: 12.2–21.3
  - Median Reading Level: 16.5
- ▶ Split sample conditioned on being  $\leq$  or  $>$  16.5
- ▶ Calculate sub-set MSEs and event window lengths

# FOMC Statement Characteristics: Text Complexity (2/3)

Flesch-Kincaid Grade Level Readability of FOMC Statements



# FOMC Statement Characteristics: Text Complexity (3/3)

Metric	Simple	Complicated
<i>Minimised MSE</i>		
Average	1.25e-5	<b>1.06e-5</b>
<i>Event Window Length (Minutes)</i>		
Average	60	<b>71</b>

Table 14: Average MSEs and Event Window Lengths Using the “One Signal” Approach, Conditioned by FOMC Statement Complexity

→ FOMC statements with ↑ complexity → Longer event window on average

# FOMC Statement Characteristics: Text Similarity (1/4)

[Back to Characteristics](#)

- ▶ Condition FOMC statements based on text similarity
  - Acosta and Meade (2015); Handlan (2022a); and others...

# FOMC Statement Characteristics: Text Similarity (1/4)

[Back to Characteristics](#)

- ▶ Condition FOMC statements based on text similarity
  - Acosta and Meade (2015); Handlan (2022a); and others...
- ▶ Measured based on Term Frequency-Inverse Document Frequency (TFIDF)
  - Weighted frequency assigned to terms based on:
    1. Number of times term appears in a document
    2. Number of documents terms appears in

[TFIDF Equation](#)

# FOMC Statement Characteristics: Text Similarity (1/4)

[Back to Characteristics](#)

- ▶ Condition FOMC statements based on text similarity
  - Acosta and Meade (2015); Handlan (2022a); and others...
- ▶ Measured based on Term Frequency-Inverse Document Frequency (TFIDF)
  - Weighted frequency assigned to terms based on:
    1. Number of times term appears in a document
    2. Number of documents terms appears in
- ▶ Terms with  $\uparrow TFIDF_{d,t}$  = Informative terms at **distinguishing** documents  $d$ 
  - [TFIDF Terms](#)

[TFIDF Equation](#)

# FOMC Statement Characteristics: Text Similarity (2/4)

- ▶ TFIDF matrix dimensions:  $D$  documents  $\times T$  terms

# FOMC Statement Characteristics: Text Similarity (2/4)

- ▶ TFIDF matrix dimensions:  $D$  documents  $\times T$  terms
- ▶ Row vector: All terms  $t$  of document  $d$  represented by  $TFIDF_{d,t}$  values

# FOMC Statement Characteristics: Text Similarity (2/4)

- ▶ TFIDF matrix dimensions:  $D$  documents  $\times T$  terms
- ▶ Row vector: All terms  $t$  of document  $d$  represented by  $TFIDF_{d,t}$  values
- ▶ All row vectors normalised by number of  $d$  and  $t$  in matrix

# FOMC Statement Characteristics: Text Similarity (2/4)

- ▶ TFIDF matrix dimensions:  $D$  documents  $\times T$  terms
- ▶ Row vector: All terms  $t$  of document  $d$  represented by  $TFIDF_{d,t}$  values
- ▶ All row vectors normalised by number of  $d$  and  $t$  in matrix
- ▶  $\Rightarrow TFIDF \cdot TFIDF^T =$  Dot product between every **pair** of FOMC statements

## FOMC Statement Characteristics: Text Similarity (2/4)

- ▶ TFIDF matrix dimensions:  $D$  documents  $\times T$  terms
- ▶ Row vector: All terms  $t$  of document  $d$  represented by  $TFIDF_{d,t}$  values
- ▶ All row vectors normalised by number of  $d$  and  $t$  in matrix
- ▶  $\Rightarrow TFIDF \cdot TFIDF^T =$  Dot product between every pair of FOMC statements
- ▶  $\Rightarrow$  Degree of similarity between 2 FOMC statements = Cosine similarity:

Similarity Matrix

$$S^{A,B} := \cos \theta = \frac{\mathbf{A} \cdot \mathbf{B}}{\|\mathbf{A}\| \|\mathbf{B}\|},$$

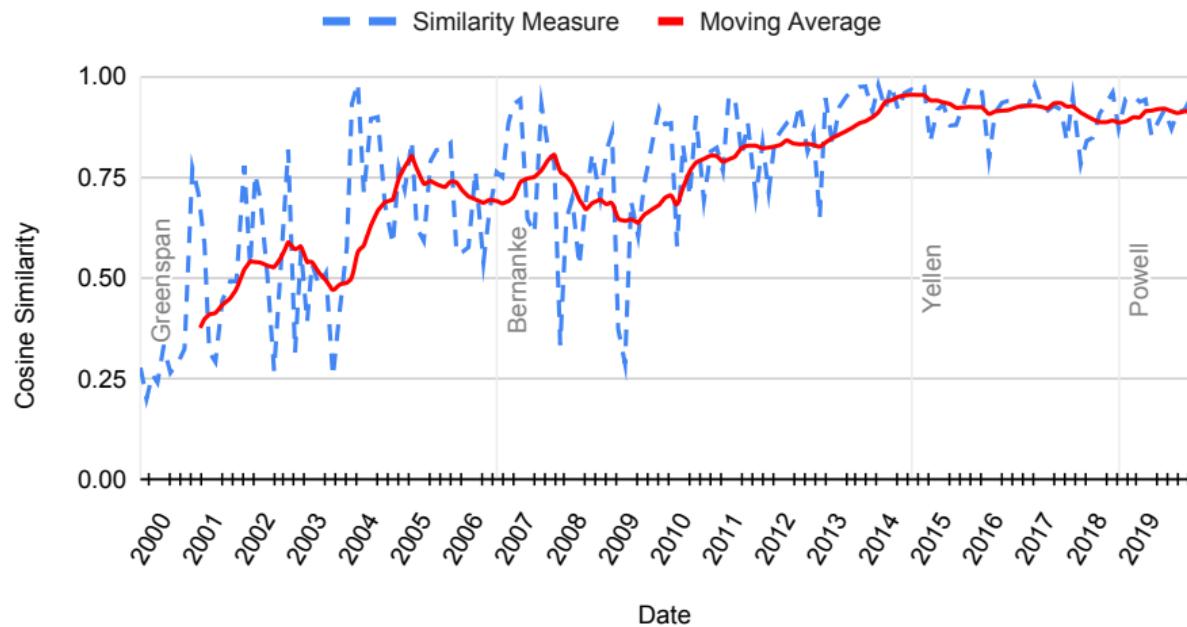
- ▶ **Scale:** Entirely different  $= 0 \leq$  Cosine Similarity  $\leq 1 =$  Exact same

# FOMC Statement Characteristic: Text Similarity (3/4)

- ▶  $S^1 := (d, d - 1)$ : Degree of similarity between sequential FOMC statements  
[Summary Stats](#)
  - Range of  $S^1$ : 0.02–0.984
  - Median of  $S^1$ : 0.826
- ▶ Split sample conditioned on being  $\leq$  or  $>$  0.826
- ▶ Calculate sub-set MSEs and event window lengths

# FOMC Statement Characteristic: Text Similarity (3/4)

Cosine Similarity of Sequential FOMC Statements



# FOMC Statement Characteristics: Text Similarity (4/4)

Metric	Different	Similar
<i>Minimised MSE</i>		
Average	<b>1.18e-5</b>	1.13e-5
<i>Event Window Length (Minutes)</i>		
Average	<b>62</b>	51

Table 15: Average MSEs and Event Window Lengths Using the “One Signal” Approach, Conditioned by FOMC Statement Similarity

→ Less similar FOMC statements → Longer event windows on average

# FOMC Statement Characteristics: Presence of Dissents (1/2)

[Back to Characteristics](#)

- ▶ Condition FOMC statements based presence of dissent votes or not¶
  - Riboni and Ruge-Murcia (2014); Tsang and Yang (2024); Bobrov et al. (2025); and others...

---

¶I do not record and distinguish between dissent votes for tighter policy, easier, policy, or other reasons.

# FOMC Statement Characteristics: Presence of Dissents (1/2)

[Back to Characteristics](#)

- ▶ Condition FOMC statements based presence of dissent votes or not¶
  - Riboni and Ruge-Murcia (2014); Tsang and Yang (2024); Bobrov et al. (2025); and others...
- ▶ Roughly 40% of FOMC statement sample has recorded dissents
- ▶ By Fed tradition, dissents usually recorded if majority opinion = unacceptable
- ▶ Presence of dissents provides additional info. for markets to process

---

¶I do not record and distinguish between dissent votes for tighter policy, easier, policy, or other reasons.

# FOMC Statement Characteristics: Presence of Dissents (1/2)

[Back to Characteristics](#)

- ▶ Condition FOMC statements based presence of dissent votes or not¶
  - Riboni and Ruge-Murcia (2014); Tsang and Yang (2024); Bobrov et al. (2025); and others...
- ▶ Roughly 40% of FOMC statement sample has recorded dissents
- ▶ By Fed tradition, dissents usually recorded if majority opinion = unacceptable
- ▶ Presence of dissents provides additional info. for markets to process
- ▶ Calculate sub-set MSEs and event window lengths

---

¶I do not record and distinguish between dissent votes for tighter policy, easier, policy, or other reasons.

# FOMC Statement Characteristics: Presence of Dissents (2/2)

Metric	Unity	Dissents
<i>Minimised MSE</i>		
Average	9.57e-6	<b>1.43e-5</b>
<i>Event Window Length (Minutes)</i>		
Average	53	<b>83</b>

Table 16: Average MSEs and Event Window Lengths Using the “One Signal” Approach, Conditioned by Presence of Dissents in FOMC Statements

→ FOMC statements with dissents → longer event windows on average

# FOMC Statement Characteristics: Summary Table

Complexity S1 Similarity

Metric	FKGL	$S^1$
Count	165	164
Mean	16.361	0.751
SD	1.715	0.212
Max	21.3	0.984
$75^{th}$	17.3	0.920
Median	16.5	0.826
$25^{th}$	15.1	0.622
Min	12.2	0.200

Table 17: Descriptive Statistics for Heterogeneity Analyses

# Robustness Check of Optimal Event Windows

[Back to One Signal](#)

1. Pick an interest-rate or equity futures contract

---

||Performed for *FF2, FF4, TUc1, TYc2, USc1*.

# Robustness Check of Optimal Event Windows

[Back to One Signal](#)

1. Pick an interest-rate or equity futures contract
2. Take predictions  $\widehat{DP_{t+n}}$  for each  $k = 5$  fold from optimal event window

---

||Performed for *FF2, FF4, TUc1, TYc2, USc1*.

# Robustness Check of Optimal Event Windows

[Back to One Signal](#)

1. Pick an interest-rate or equity futures contract
2. Take predictions  $\widehat{DP_{t+n}}$  for each  $k = 5$  fold from optimal event window
3. Check if  $\overline{R^2_{OOS}} \forall t + n \geq \overline{R^2_{OOS}}$  in optimal window length
  - Yes: Perform “joint” estimation in that window length<sup>||</sup>
  - No: Go back to step 1

---

<sup>||</sup>Performed for *FF2, FF4, TUc1, TYc2, USc1*.

# Robustness Check of Optimal Event Windows

[Back to One Signal](#)

1. Pick an interest-rate or equity futures contract
2. Take predictions  $\widehat{DP_{t+n}}$  for each  $k = 5$  fold from optimal event window
3. Check if  $\overline{R^2_{OOS}} \forall t + n \geq \overline{R^2_{OOS}}$  in optimal window length
  - Yes: Perform “joint” estimation in that window length<sup>||</sup>
  - No: Go back to step 1

## ► Results:

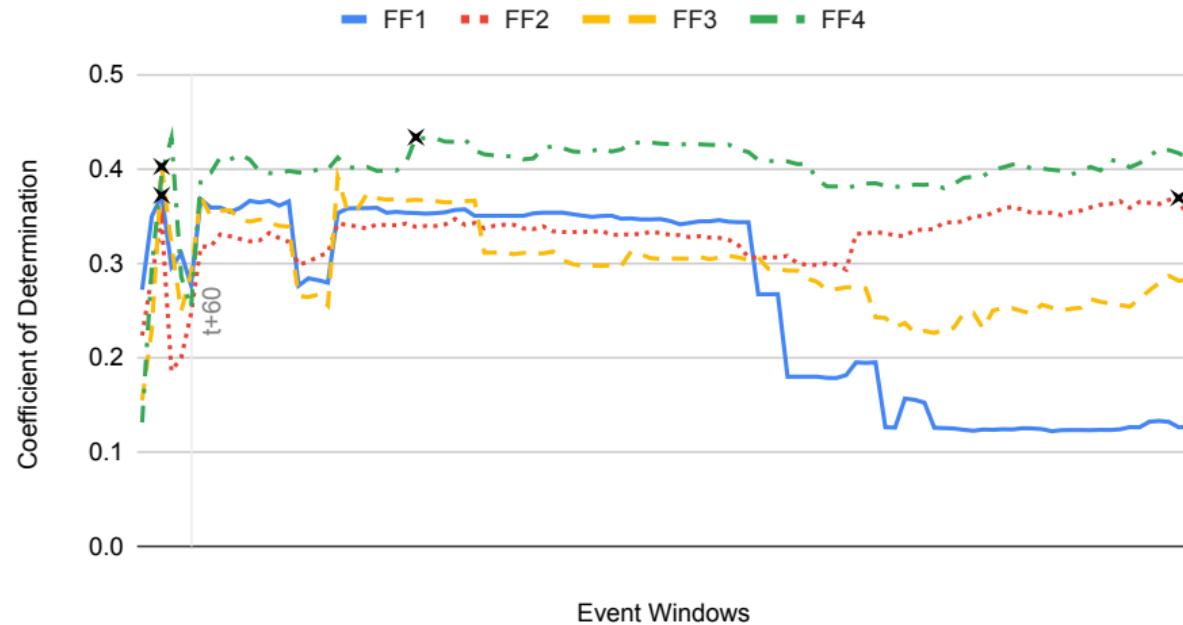
1. Optimal window length has highest  $\overline{R^2_{OOS}}$
2. “Jointly” estimated  $\overline{R^2_{OOS}}$  for window  $> t + 60$  greater than “” for window  $t + 20$ 
  - Event window with global maximum  $\overline{R^2_{OOS}}$  could be in window length  $> t + 60$

<sup>||</sup>Performed for *FF2, FF4, TUc1, TYc2, USc1*.

# Testing $R^2$ Using “One Signal” Approach for Federal Funds Futures

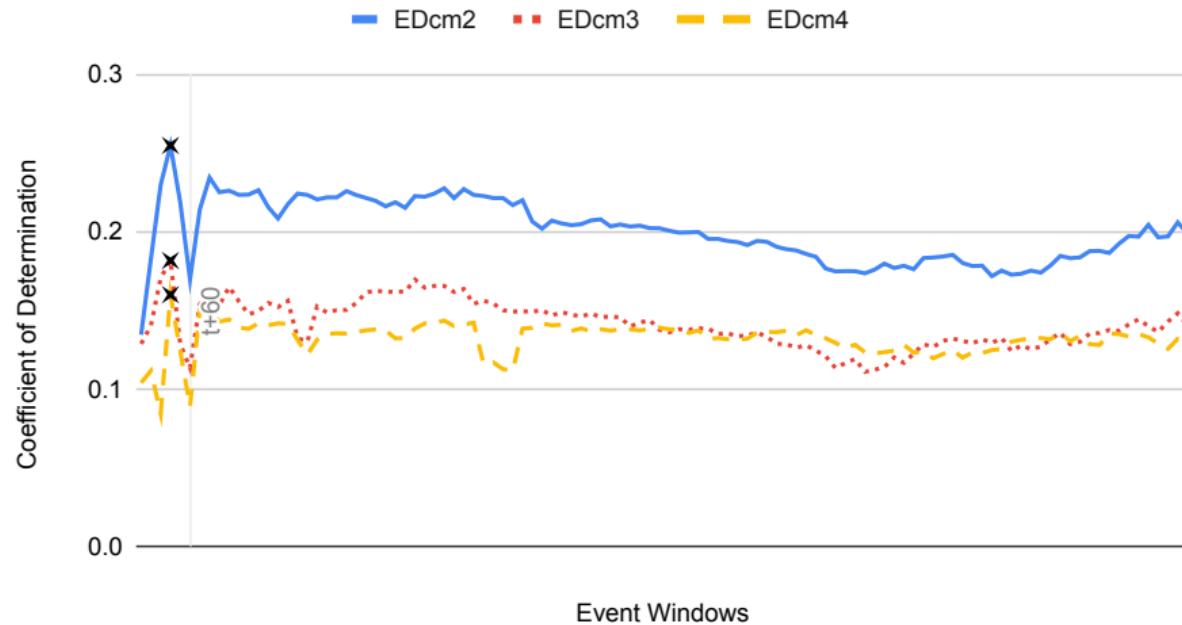
FF2 FF4

## Out-of-sample $R^2$ Using "One Signal" Approach (FFFs)



# Testing $R^2$ Using “One Signal” Approach for Eurodollar Futures

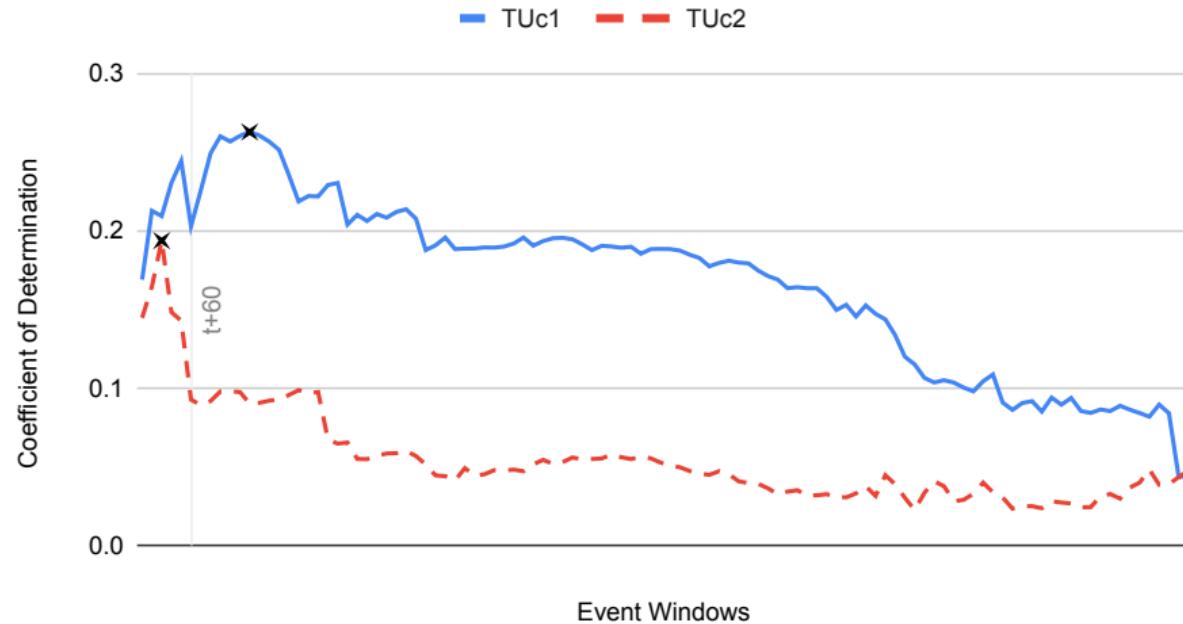
## Out-of-sample $R^2$ Using "One Signal" Approach (EDs)



# Testing $R^2$ Using “One Signal” Approach for 2-Year Treasury Futures

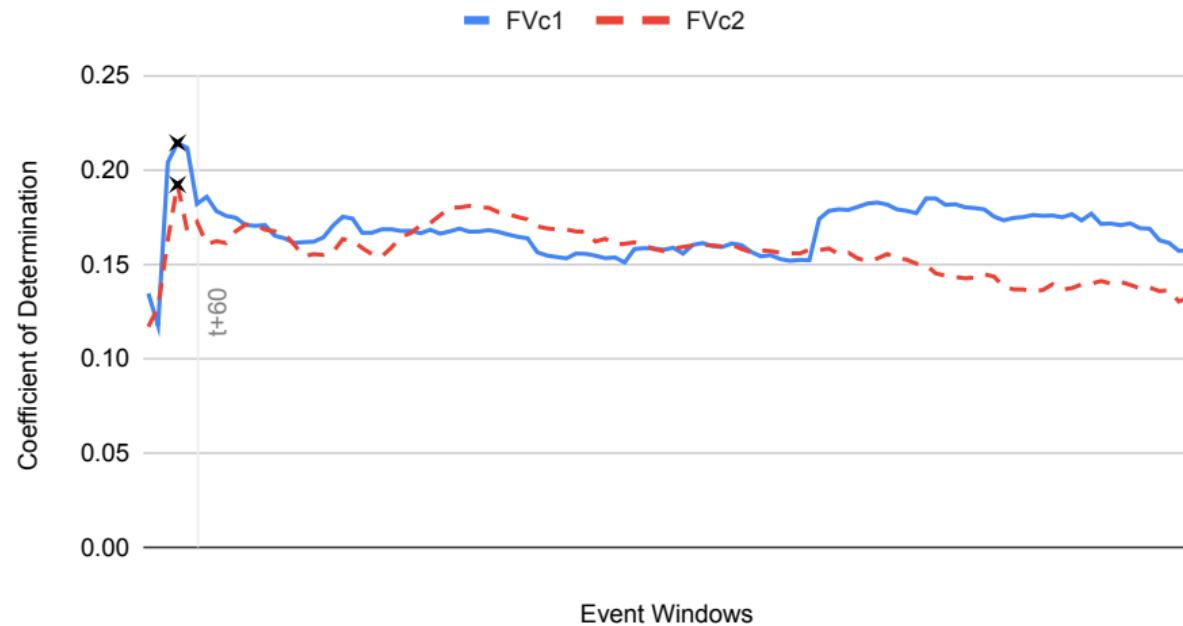
TUc1

## Out-of-sample $R^2$ Using "One Signal" Approach (TUs)



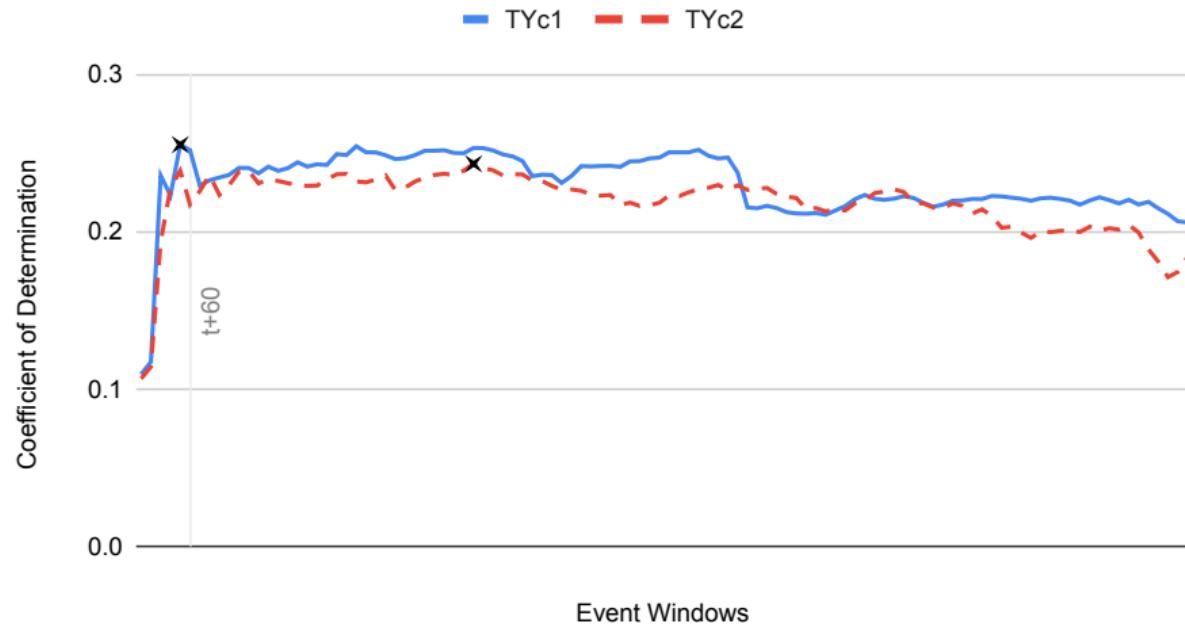
# Testing $R^2$ Using “One Signal” Approach for 5-Year Treasury Futures

## Out-of-sample $R^2$ Using "One Signal" Approach (FVs)



# Testing $R^2$ Using “One Signal” Approach for 10-Year Treasury Futures TYc2

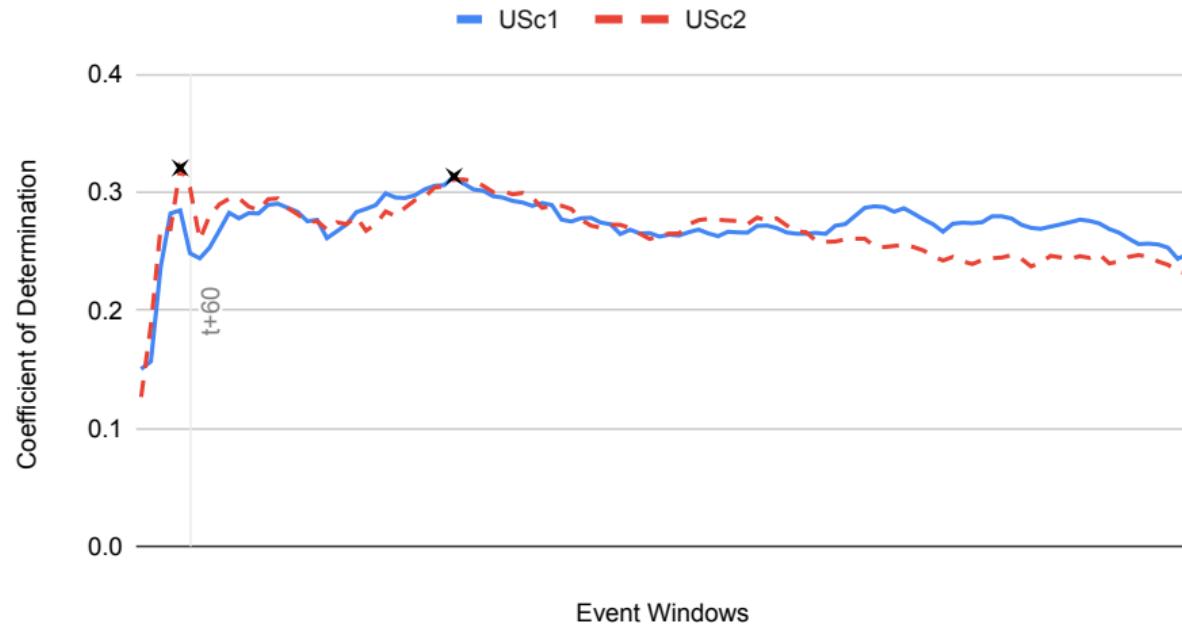
## Out-of-sample $R^2$ Using "One Signal" Approach (TYs)



# Testing $R^2$ Using “One Signal” Approach for 30-Year Treasury Futures

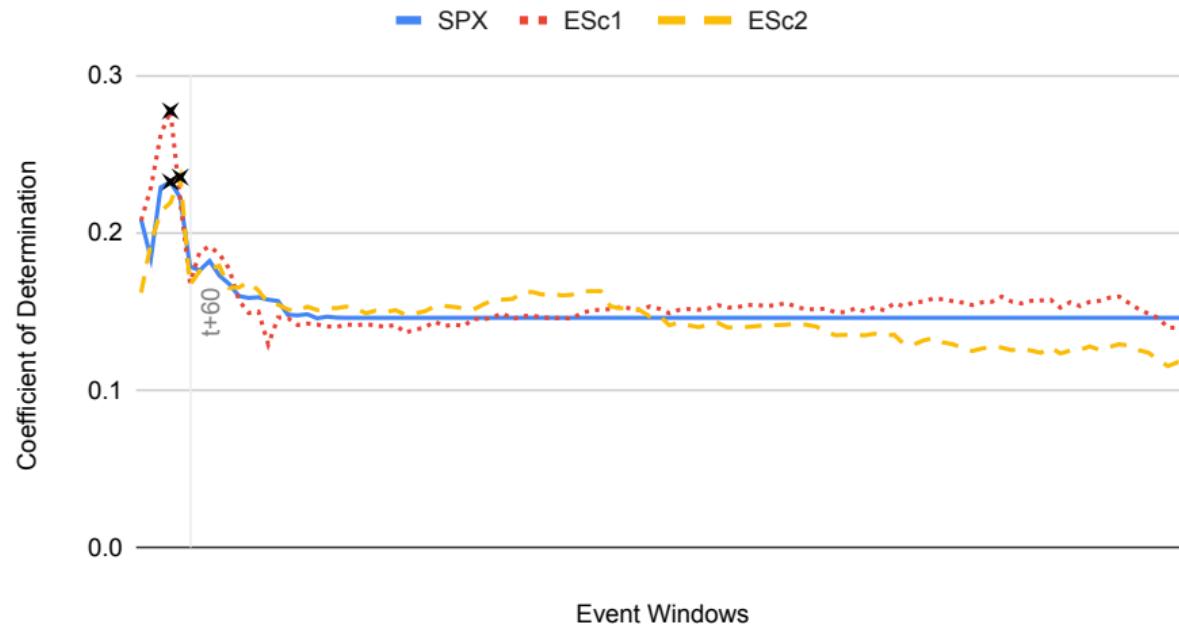
USc1

Out-of-sample  $R^2$  Using "One Signal" Approach (USs)



# Testing $R^2$ Using “One Signal” Approach for S&P Index

Out-of-sample  $R^2$  Using "One Signal" Approach (S&P 500)



# TFIDF Equation

[Back to Similarity](#)

$$\begin{aligned} TFIDF_{d,t} &= tf_{d,t} * idf_{d,t} \\ &= \left[ \ln \left( \frac{tc_{d,t}}{nt_d} \right) + 1 \right] * \left[ \ln \left( \frac{nd}{df_{d,t} + 1} \right) + 1 \right] \end{aligned}$$

- ▶  $tf_{d,t}$ : Number of times term  $t$  is in document  $d$
- ▶  $nt_d$ : Number of terms in document  $d$
- ▶  $nd$ : Number of documents
- ▶  $df_{d,t}$ : Number of documents term  $t$  appears in

# TFIDF Informative Terms

[Back to Similarity](#)

- ▶ Additional pre-processing steps on FOMC statements:
  1. Make all words lowercase
  2. Remove words with little semantic meaning (e.g., articles)
  3. Convert all words into base terms (e.g., “increas”)

# TFIDF Informative Terms

[Back to Similarity](#)

- ▶ Additional pre-processing steps on FOMC statements:

1. Make all words lowercase
2. Remove words with little semantic meaning (e.g., articles)
3. Convert all words into base terms (e.g., “increas”)

domestic	alreadytight	recov	tilt	buildup
alert	alter	foreign	imbal	undermin
direct	excess	quit	favor	perform
strength	fall	trend	eas	concern
background	firm	gener	demand	potenti
core	subdu	cost	longer	gain

Table 18: FOMC Statement Base Terms with Top 30 TFIDF Scores

# Cosine Similarity Matrix

[Back to Similarity](#)