The Impact of Central Bank Stock Purchases: Evidence from Discontinuities in Policy Rules

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Japan Economic Seminar

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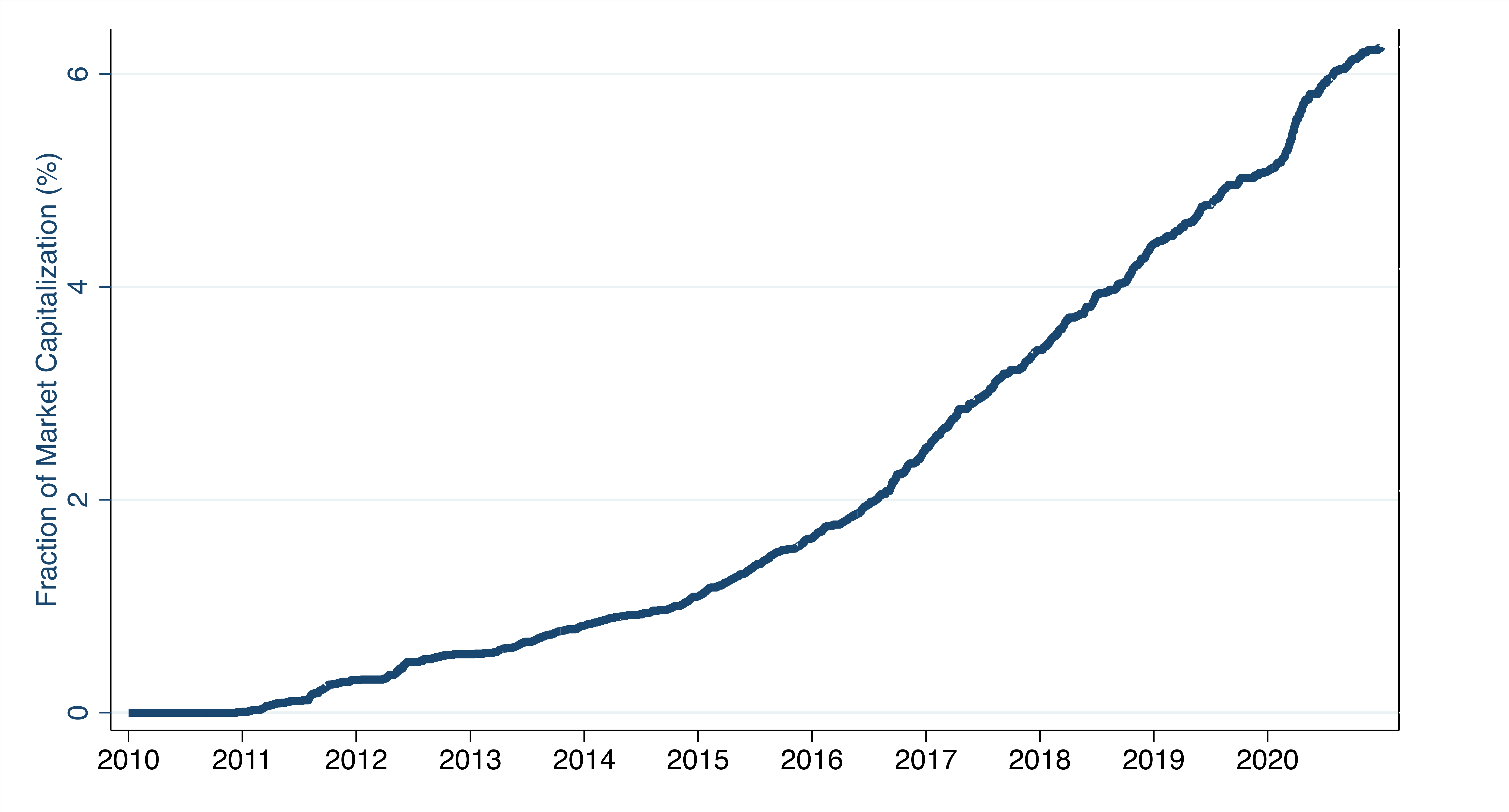
Motivation



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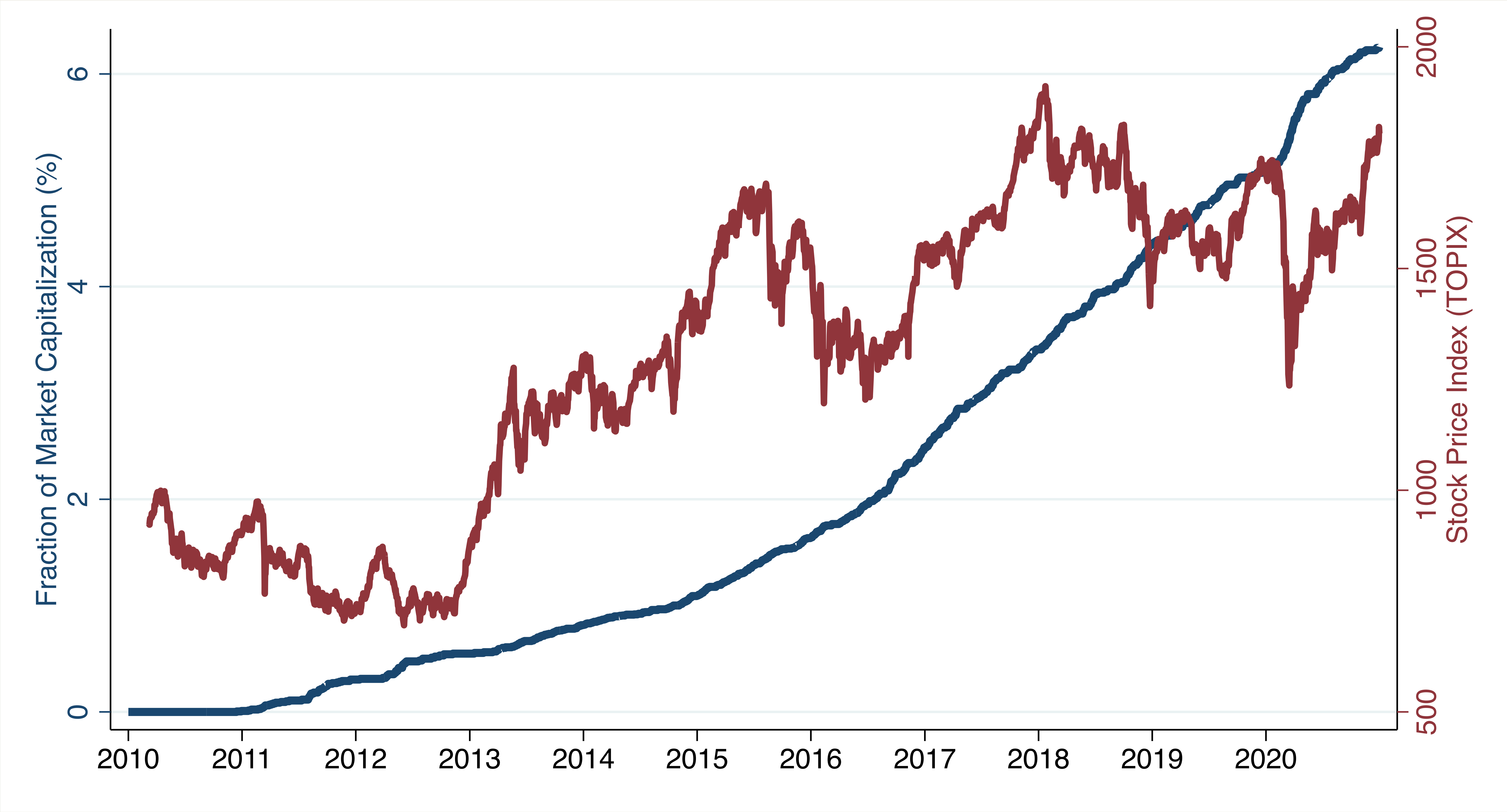

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Question

- What is the impact of central bank stock purchases?
- Why do we care?
  1. Frontier of "quantitative easing"
  2. Ideal laboratory to test new theories of stock market fluctuations

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  - ✓ BoJ appeared to intervene when stock index falls more than X% in the morning

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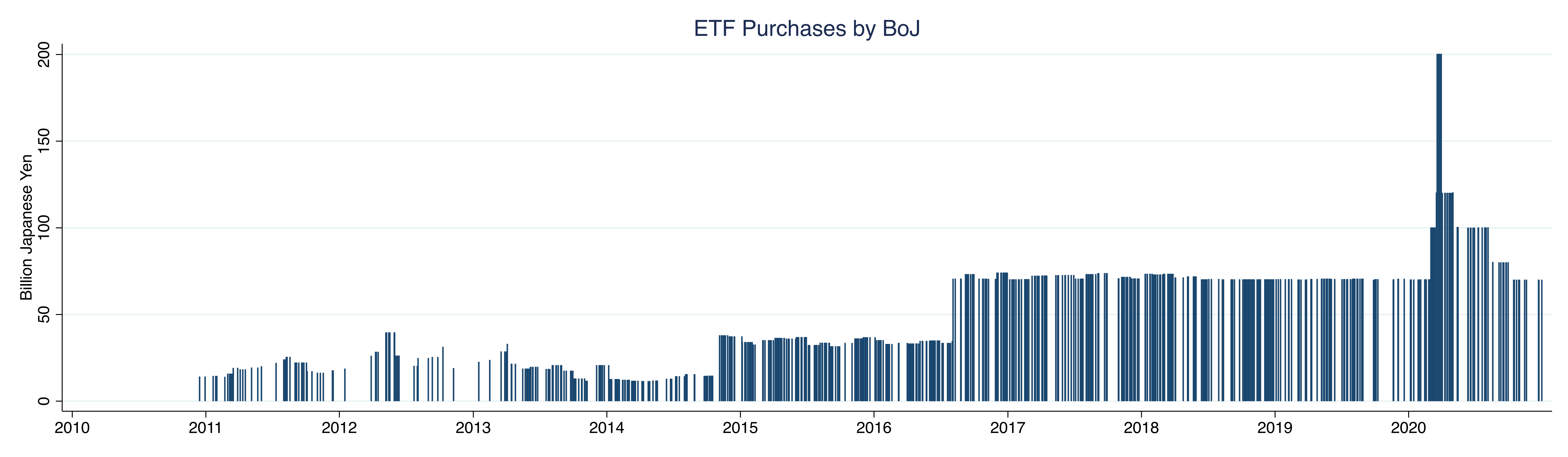
  - ✓ Inelastic stock & bond market model → Yes

Empirical Results

Goal



- Sample period: 2010 Dec - 2020 Dec

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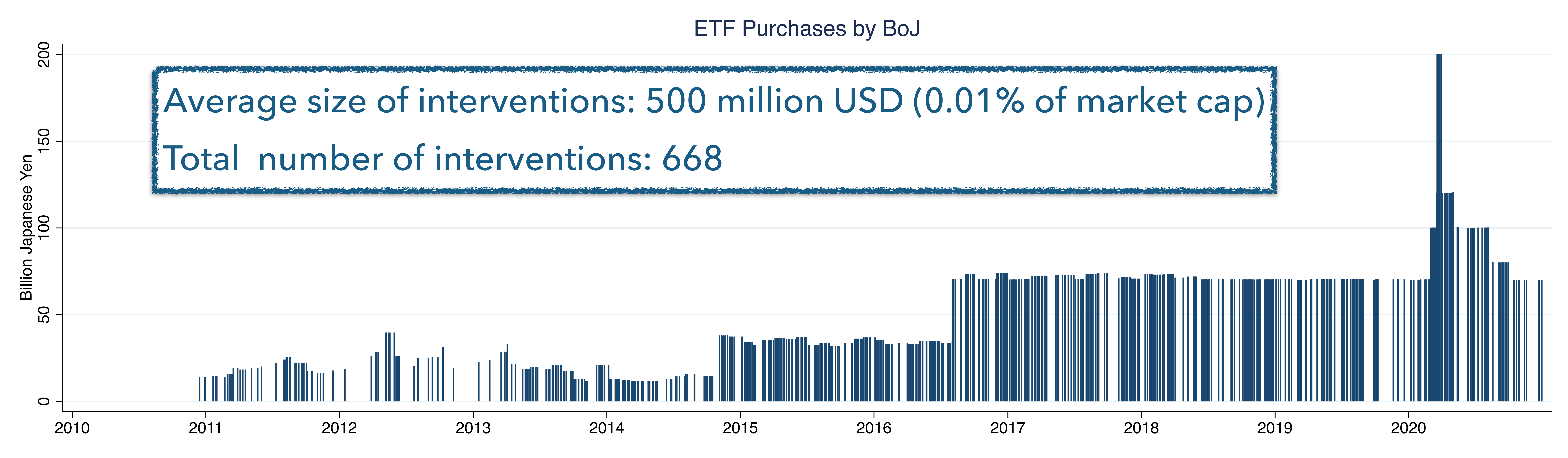

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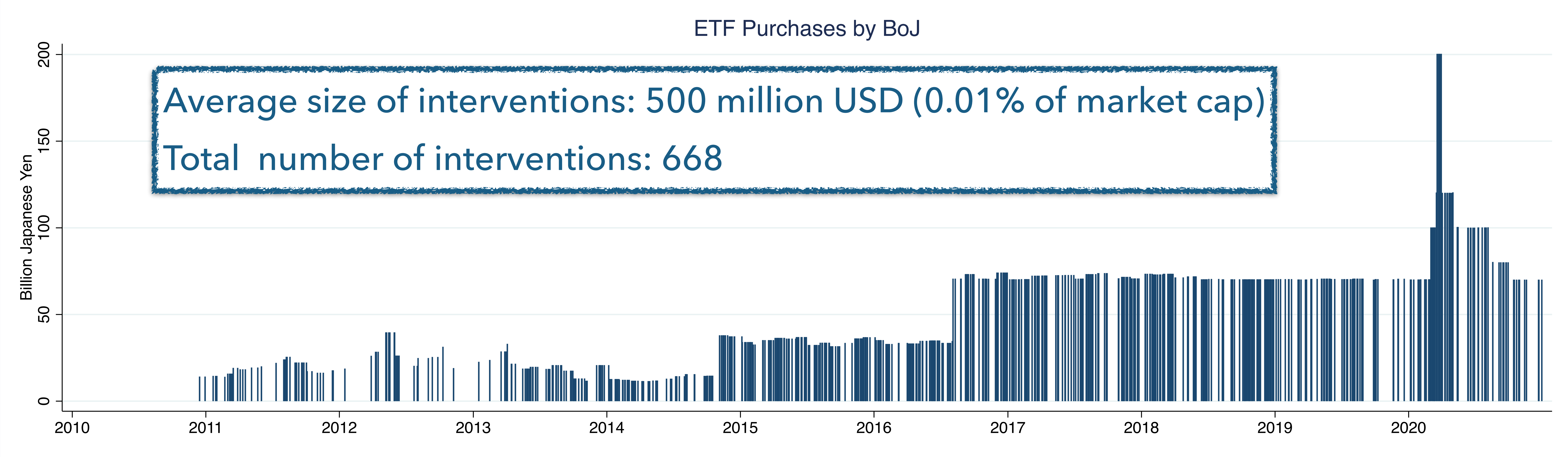

- Sample period: 2010 Dec - 2020 Dec
- The goal is to estimate

$$y_{t,h} - y_{t,0} = \beta_h E_t / S_t + \gamma_h' \mathbf{X}_t + \epsilon_{t,h}$$

$y_{t,h}$: outcome at horizon h, E_t: BoJ purchases, S_t: stock market capitalization

Identification Strategy

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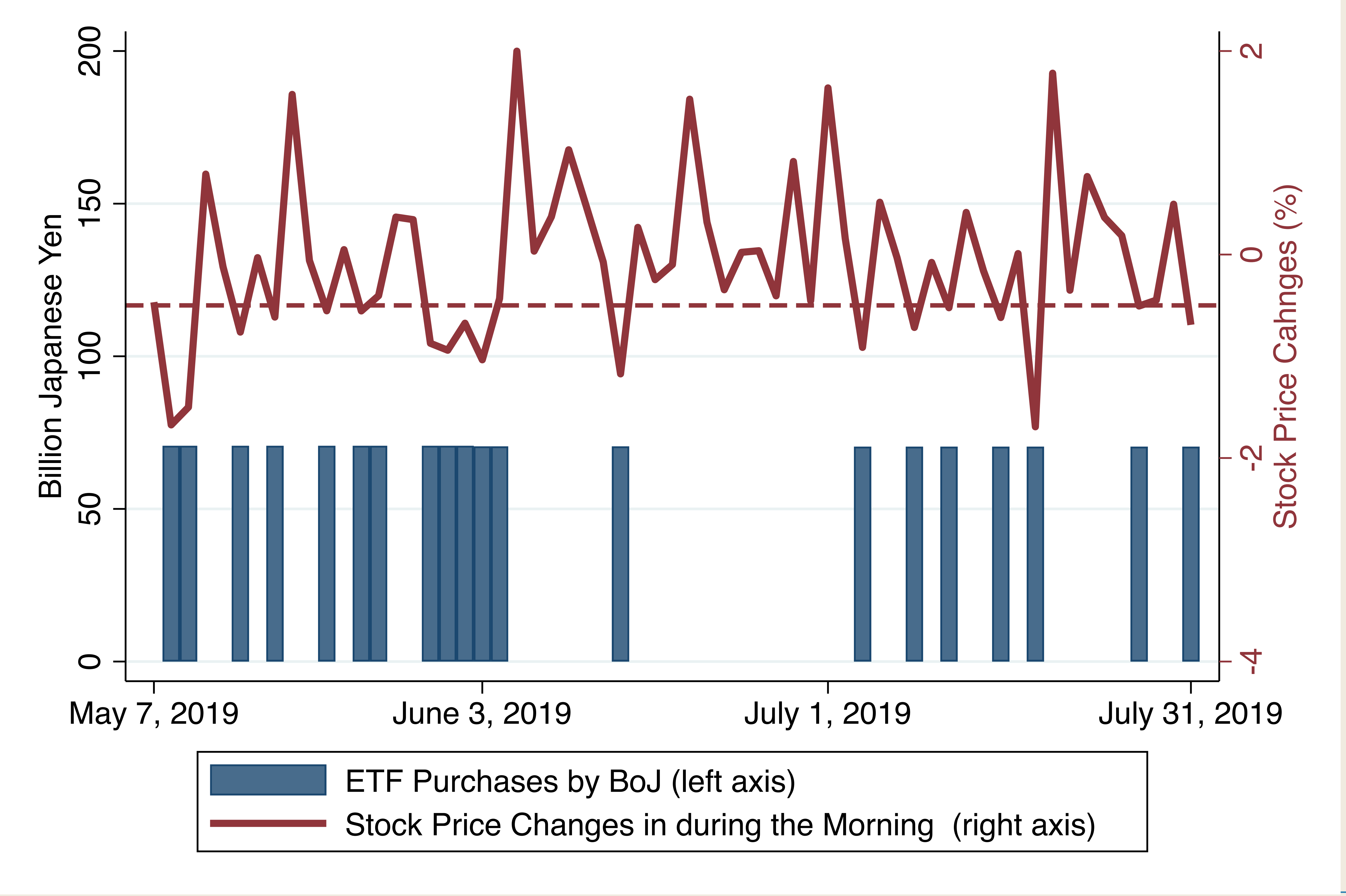

Selecting a Cutoff

- In general, the cut-off seems to be time-varying and therefore unknown
- We estimate the cut-off so as to maximize the discontinuity (Porter and Yu, 2015)
- In each sample split, for a given guess of the cut-off, we estimate

$$\Pr(E_t > 0 \,|\, \Delta p_t) = \Pr_{-,t}(E_t > 0 \,|\, \Delta p_t)\mathbb{I}(\Delta p_t < c_t) + \Pr_{+,t}(E_t > 0 \,|\, \Delta p_t)\mathbb{I}(\Delta p_t \geq c_t)$$

- Then we select the cut-off, c_t^*, so as to maximize the discontinuity

$$c_t^* \in \arg\max_{\bar{c} \in \mathbb{C}} \left[\lim_{\Delta p \uparrow \bar{c}} \widehat{\Pr}_{-,t}(E_t > 0 \,|\, \Delta p) - \lim_{\Delta p \downarrow \bar{c}} \widehat{\Pr}_{+,t}(E_t > 0 \,|\, \Delta p) \right]$$

- Sample split is based on (i) six major announcements by BoJ; and (ii) the stock market performance in the past two days

Identification

$$\beta_h = \frac{\lim_{c\uparrow c^*} \mathbb{E}[y_{t,h} - y_{t,0} \,|\, \Delta p_t = c, \mathbf{X}_t] - \lim_{c\downarrow c^*} \mathbb{E}[y_{t,h} - y_{t,0} \,|\, \Delta p_t = c, \mathbf{X}_t]}{\lim_{c\uparrow c^*} \mathbb{E}[E_t/S_t \,|\, \Delta p_t = c, \mathbf{X}_t] - \lim_{c\downarrow c^*} \mathbb{E}[E_t/S_t \,|\, \Delta p_t = c, \mathbf{X}_t]}$$

- Identification assumptions for fuzzy RDD:
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⇒ Substantially weaker assumptions than any of the existing works

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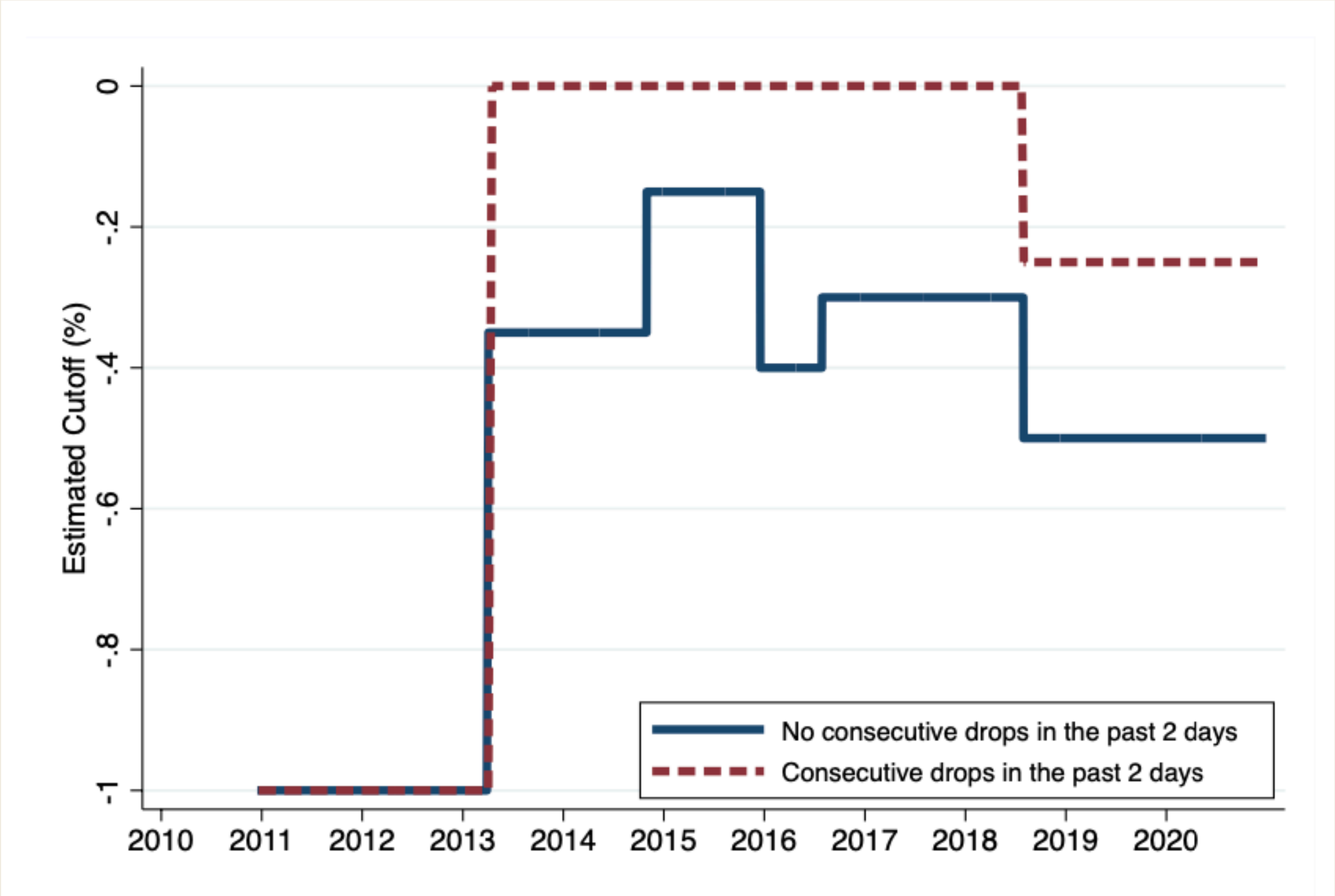
- What are we identifying?
  - ✓ The impact of a shock to flow from bonds to stocks (**liquidity channel**)
  - ✓ Unlikely to be **signaling channel**
    - BoJ announces the target amount of purchases in advance
  - ✓ We cannot identify the effect of policy rules

Cutoffs Estimation

Estimated Cutoffs over Time



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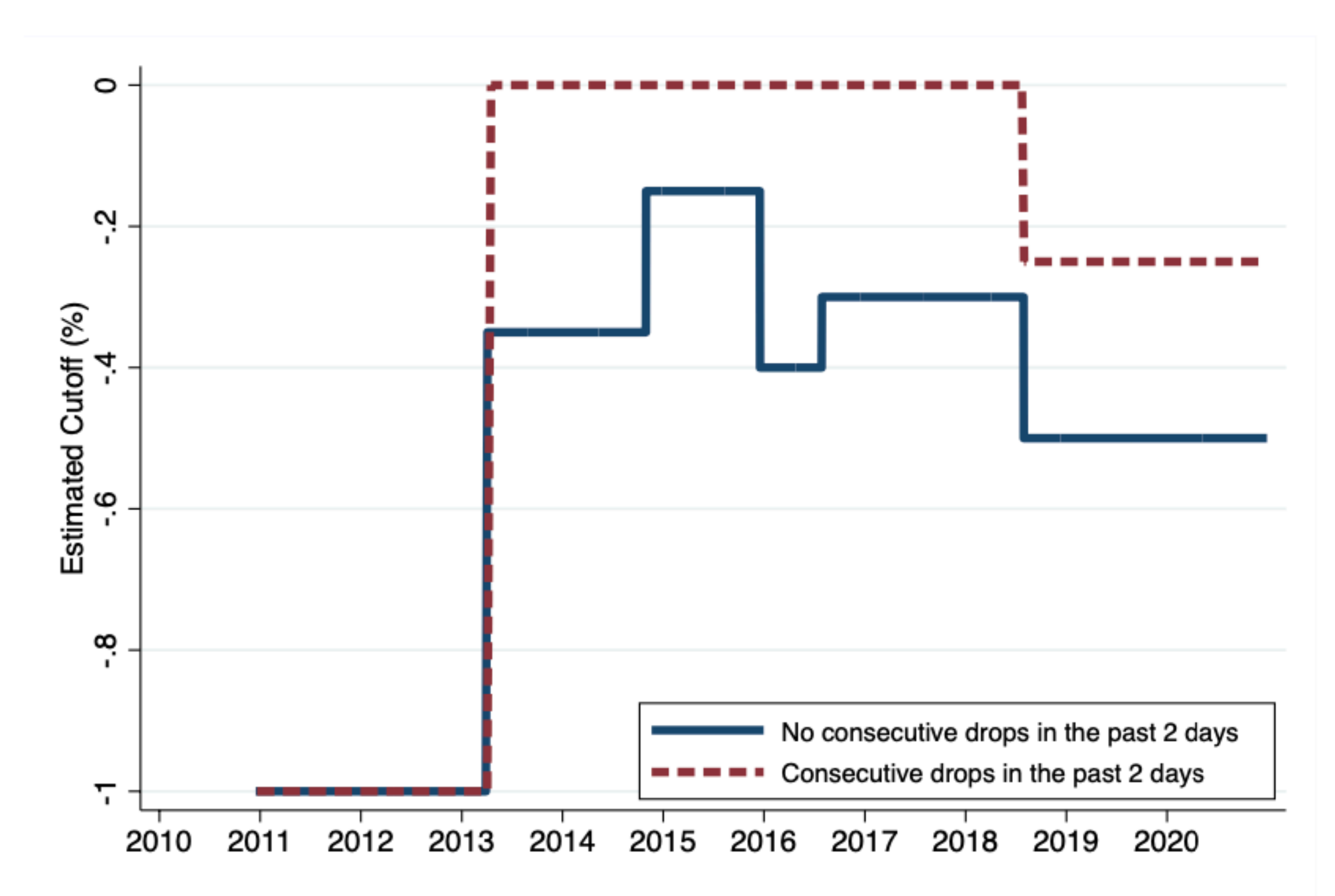
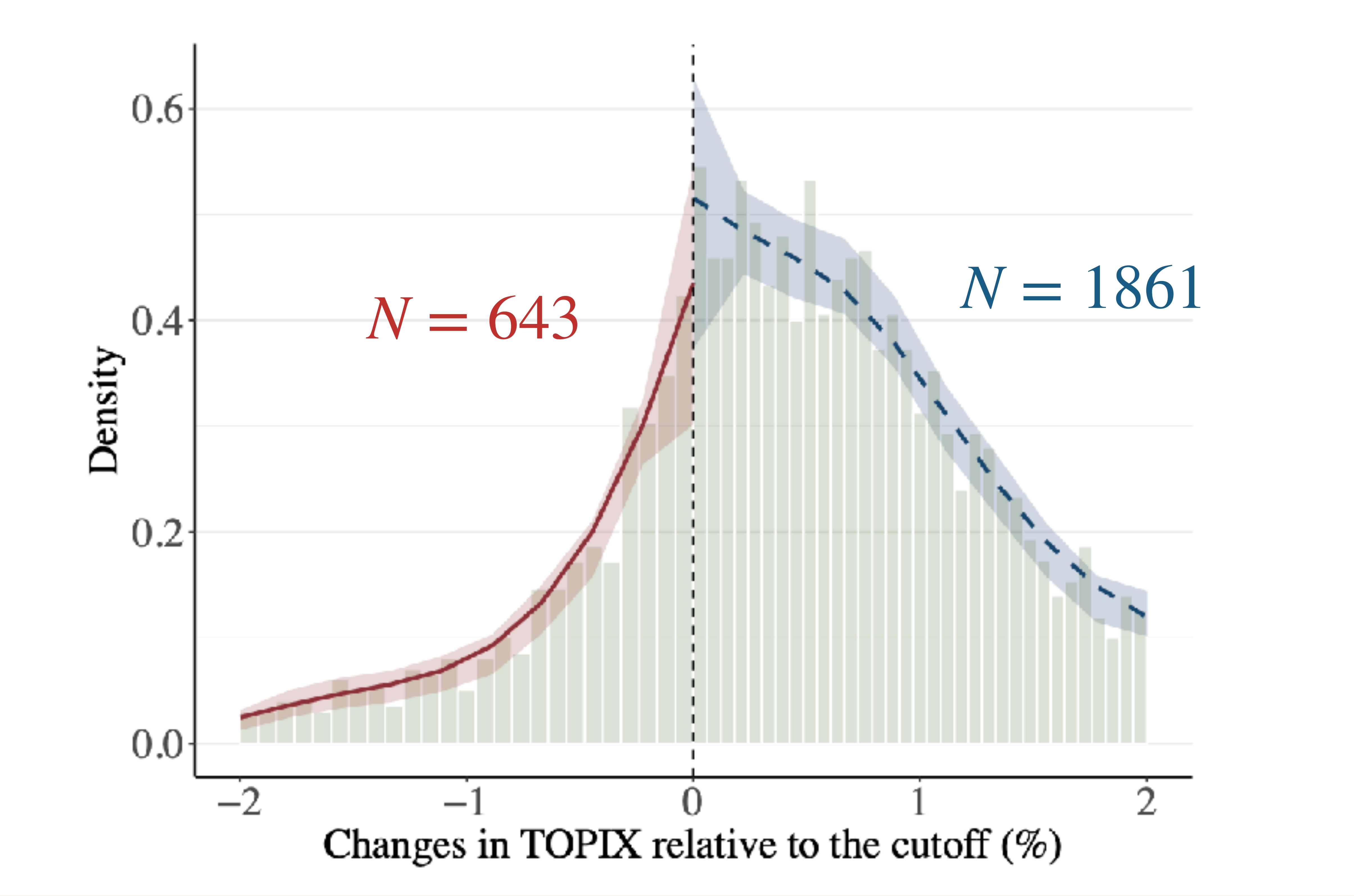
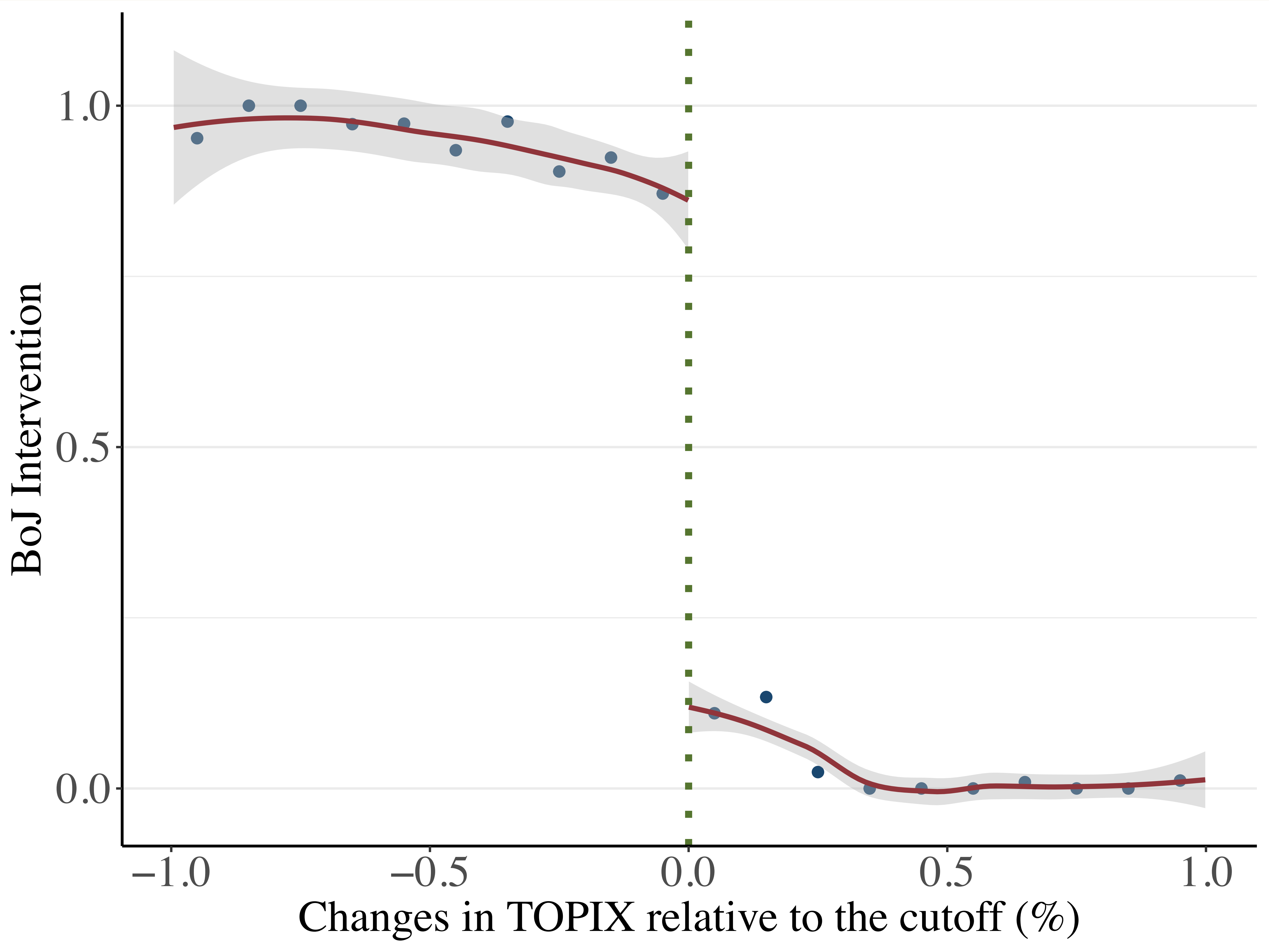


Density around the cutoff

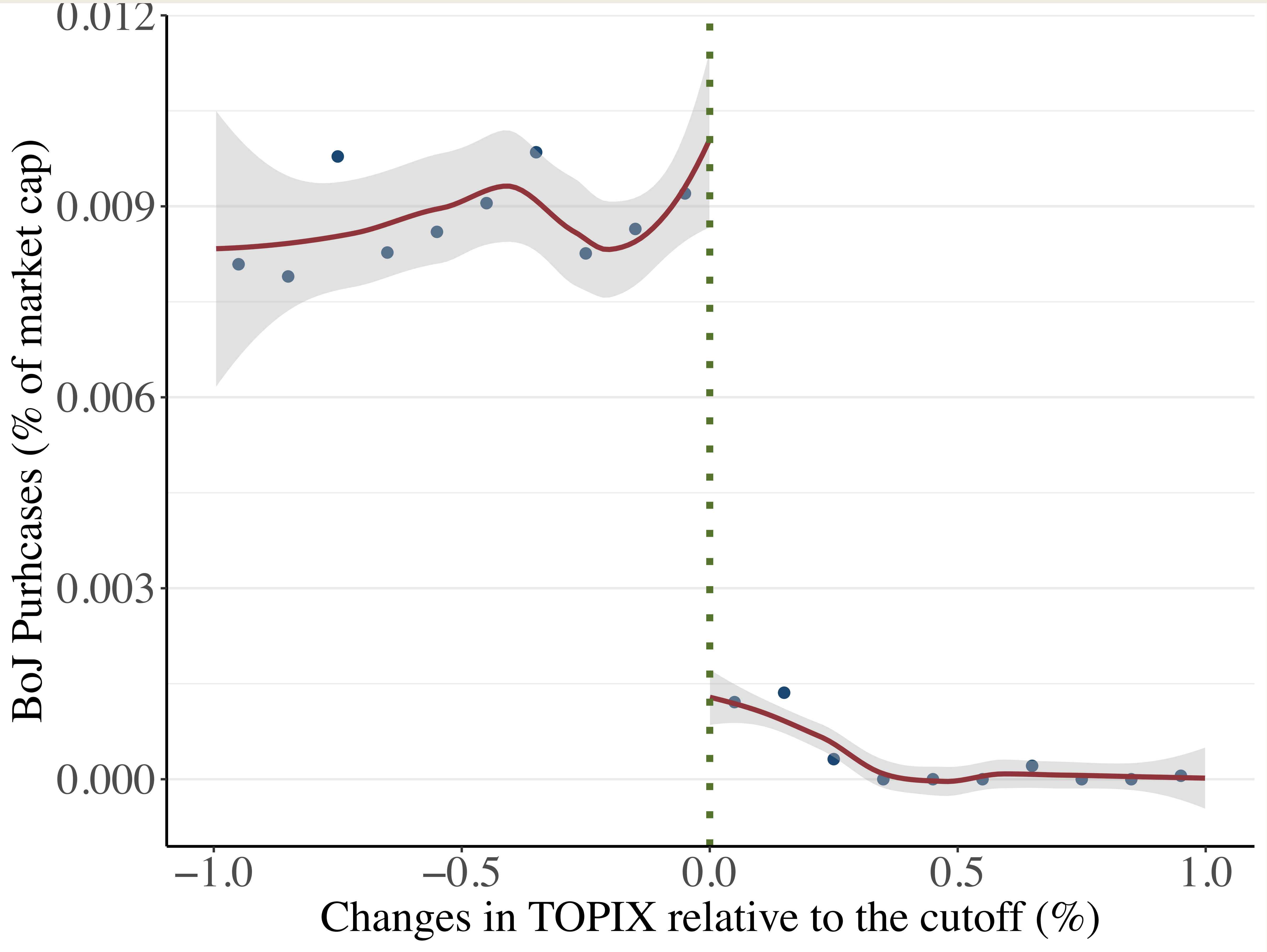


Discontinuity in Policy

Intervention Indicator

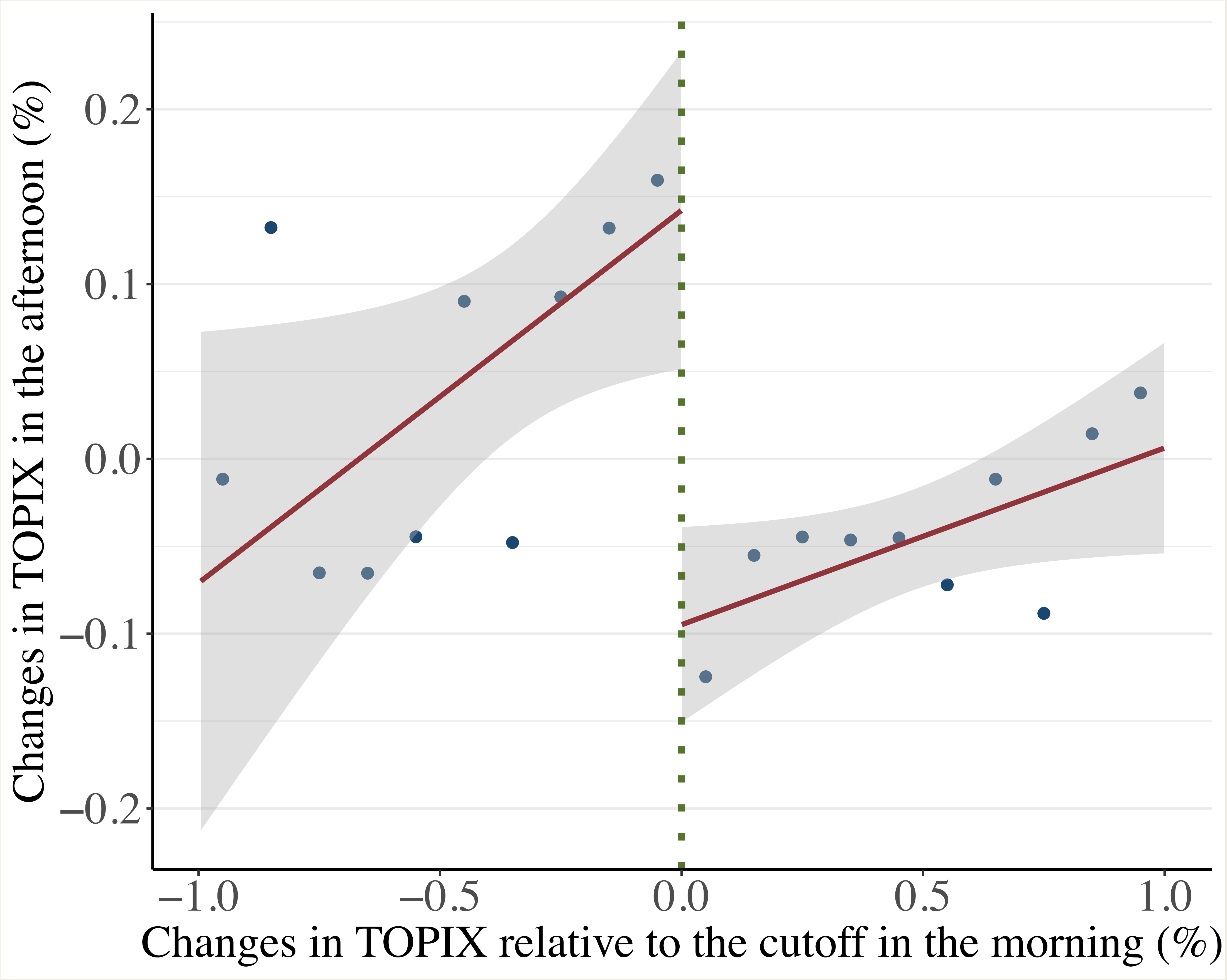


BoJ Purchases Amount



Discontinuity in Stock and Bond Prices

Stock (TOPIX) Price



Note: binned-scatter plot with bin size 0.1%.

- Discontinuity in policy leads to discontinuities in stock return **and** JGB yield

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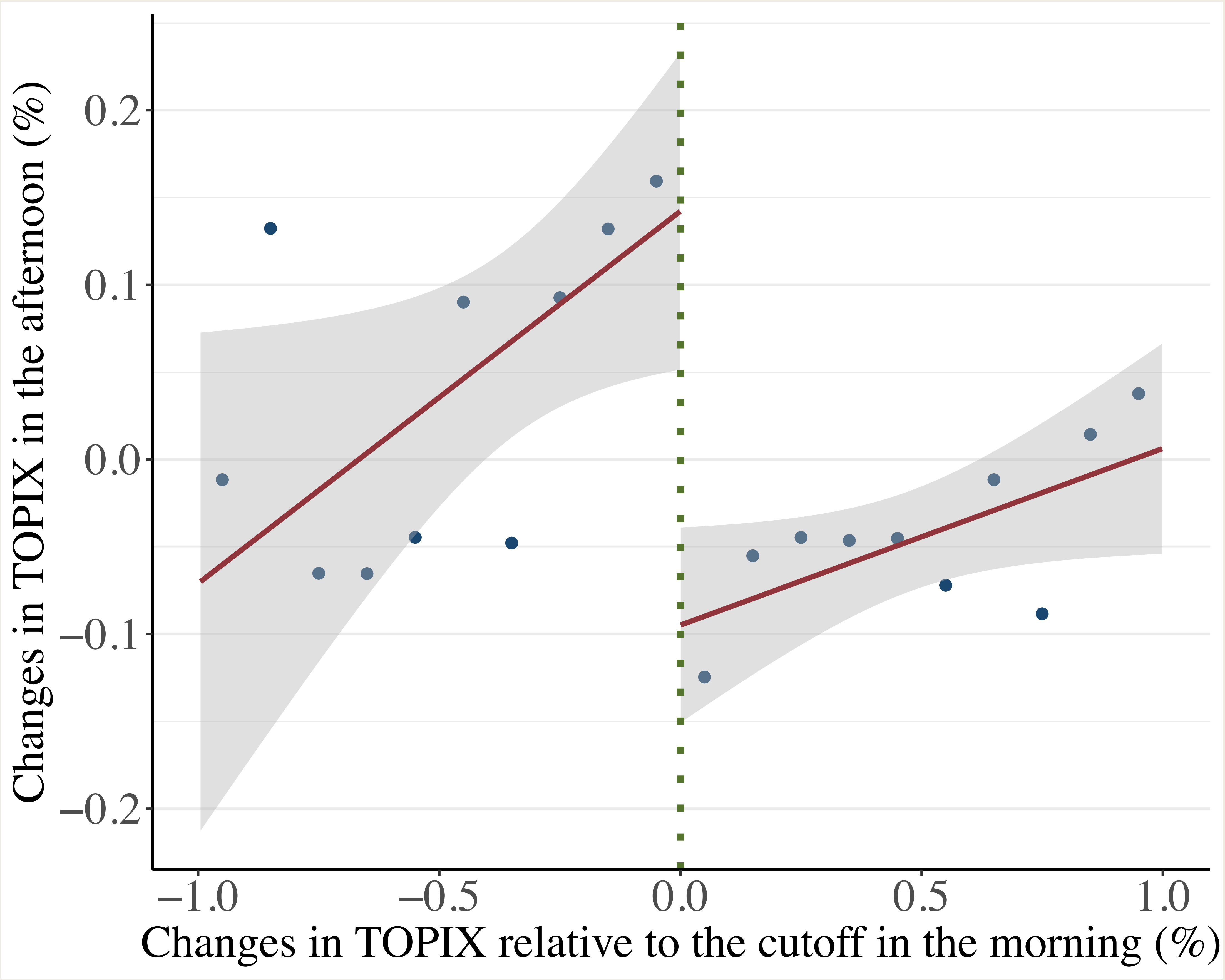
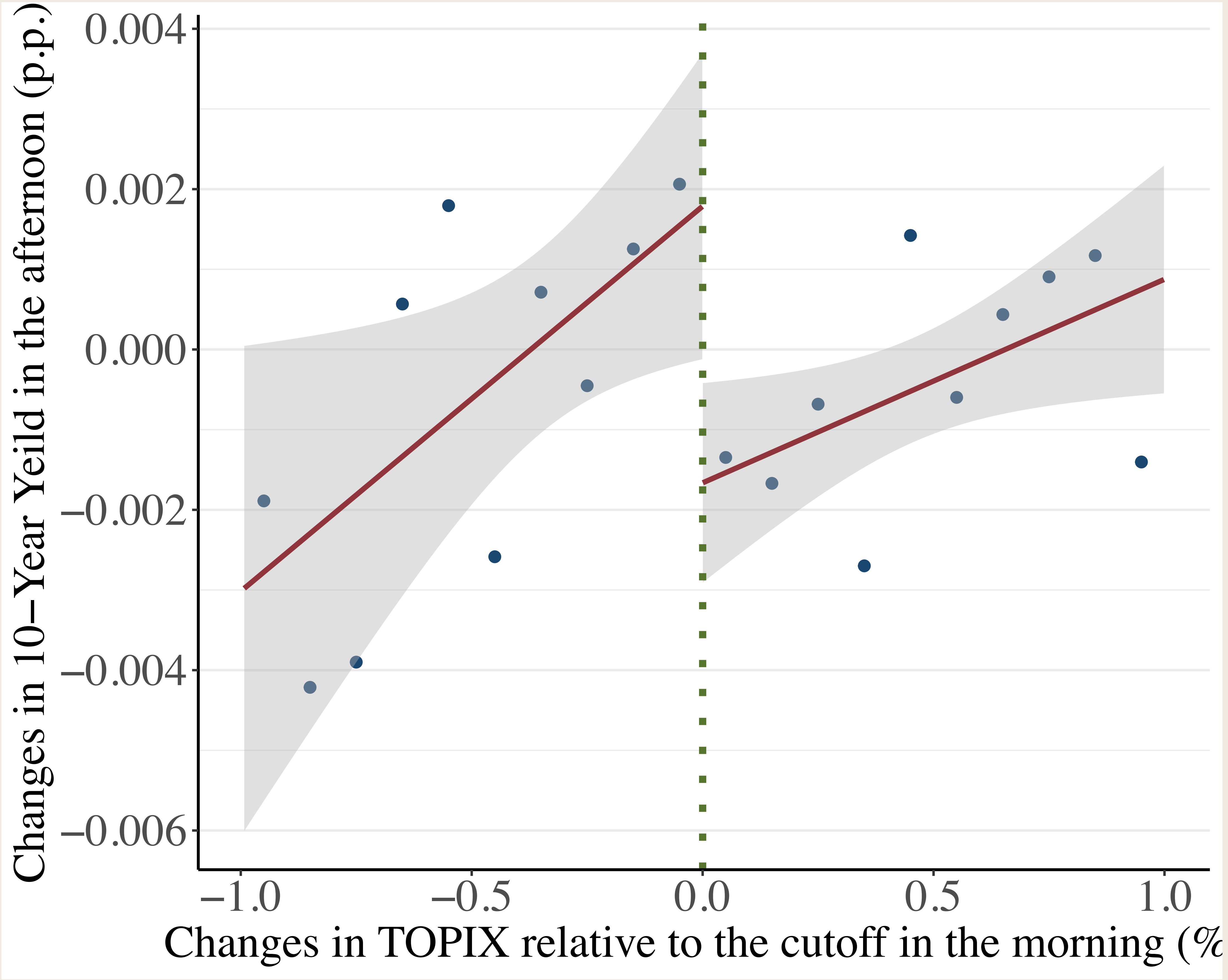


10-year JGB Yield



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Homogenous Responses

- Fuzzy RDD:

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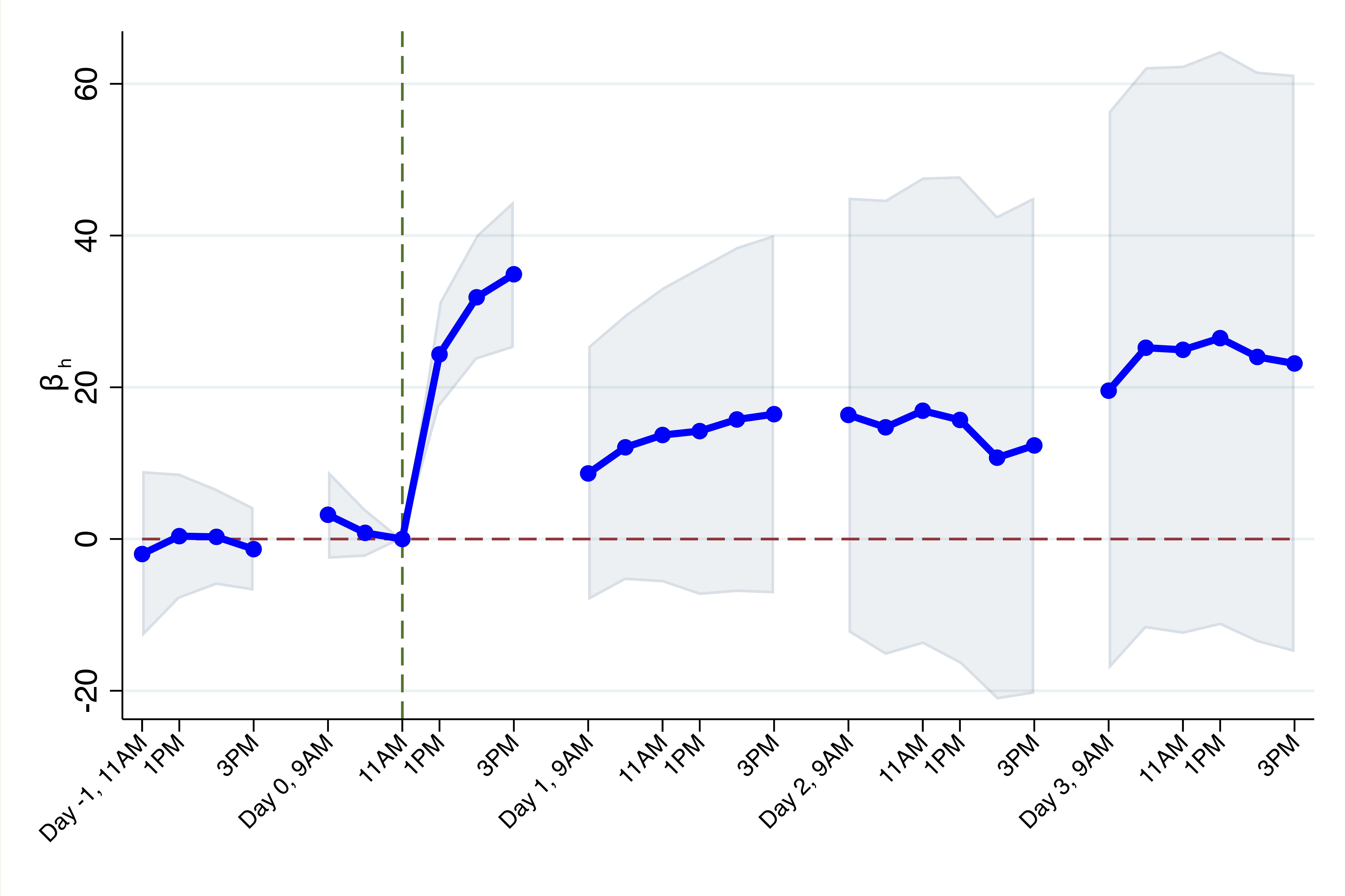

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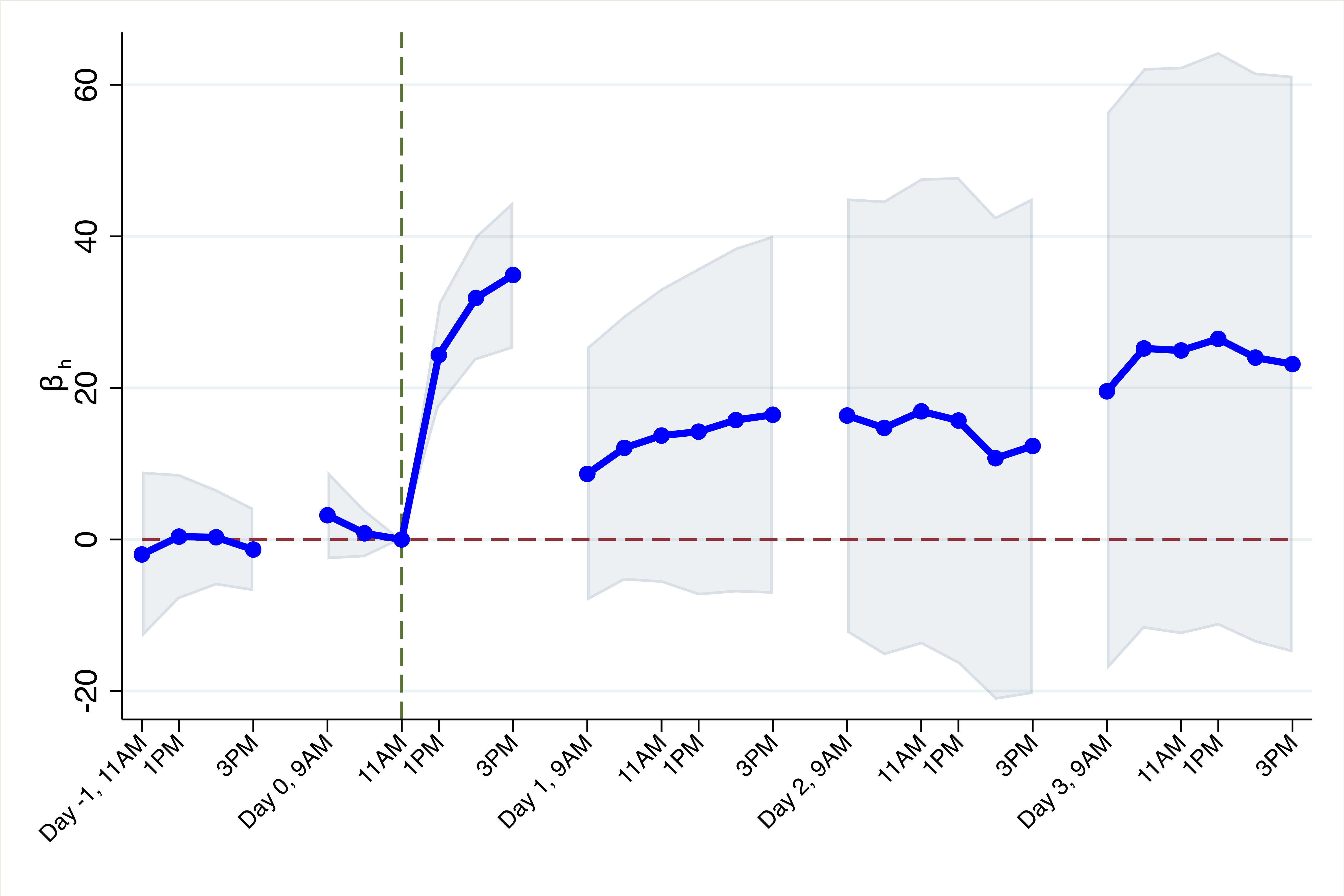

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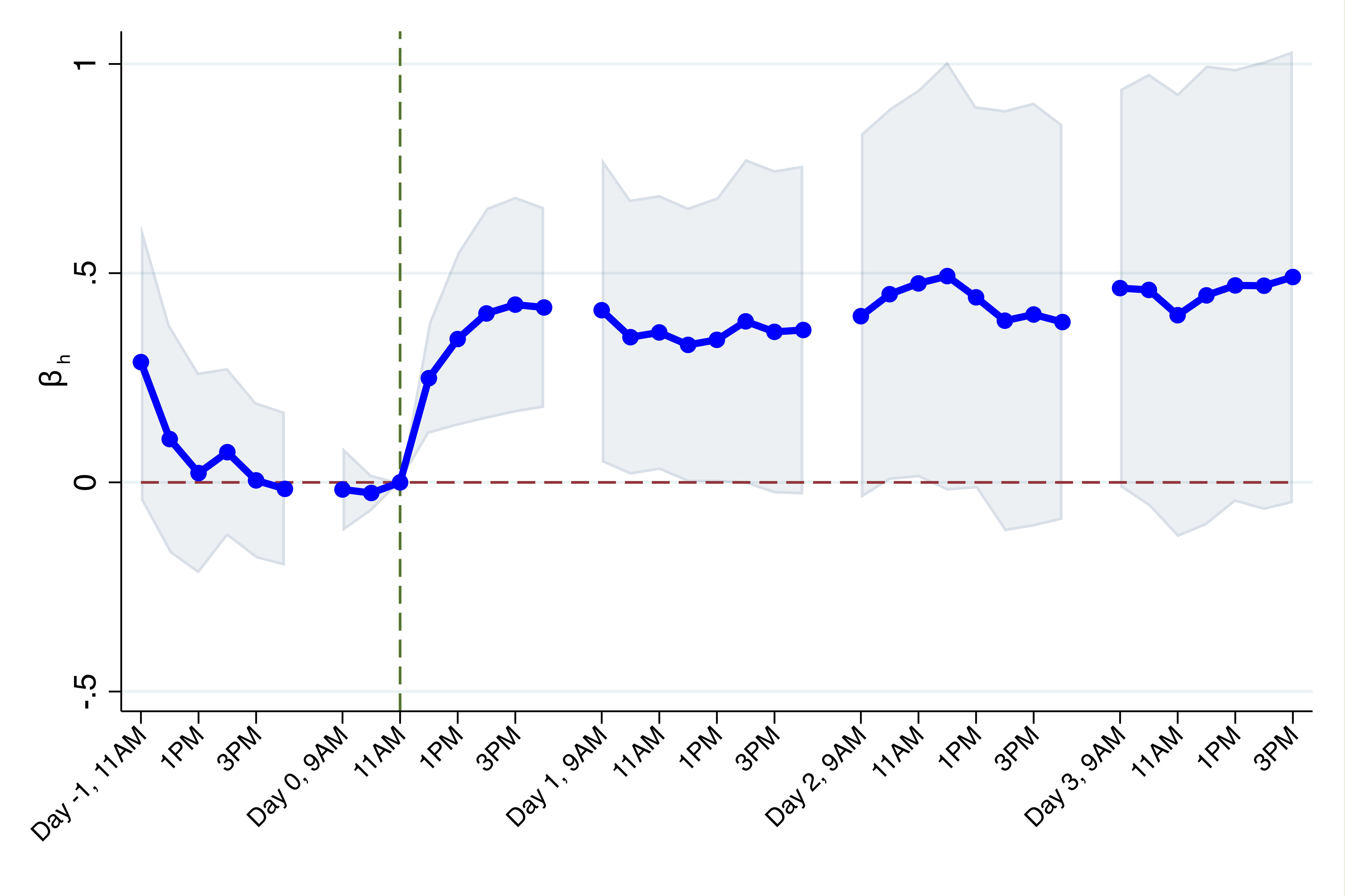

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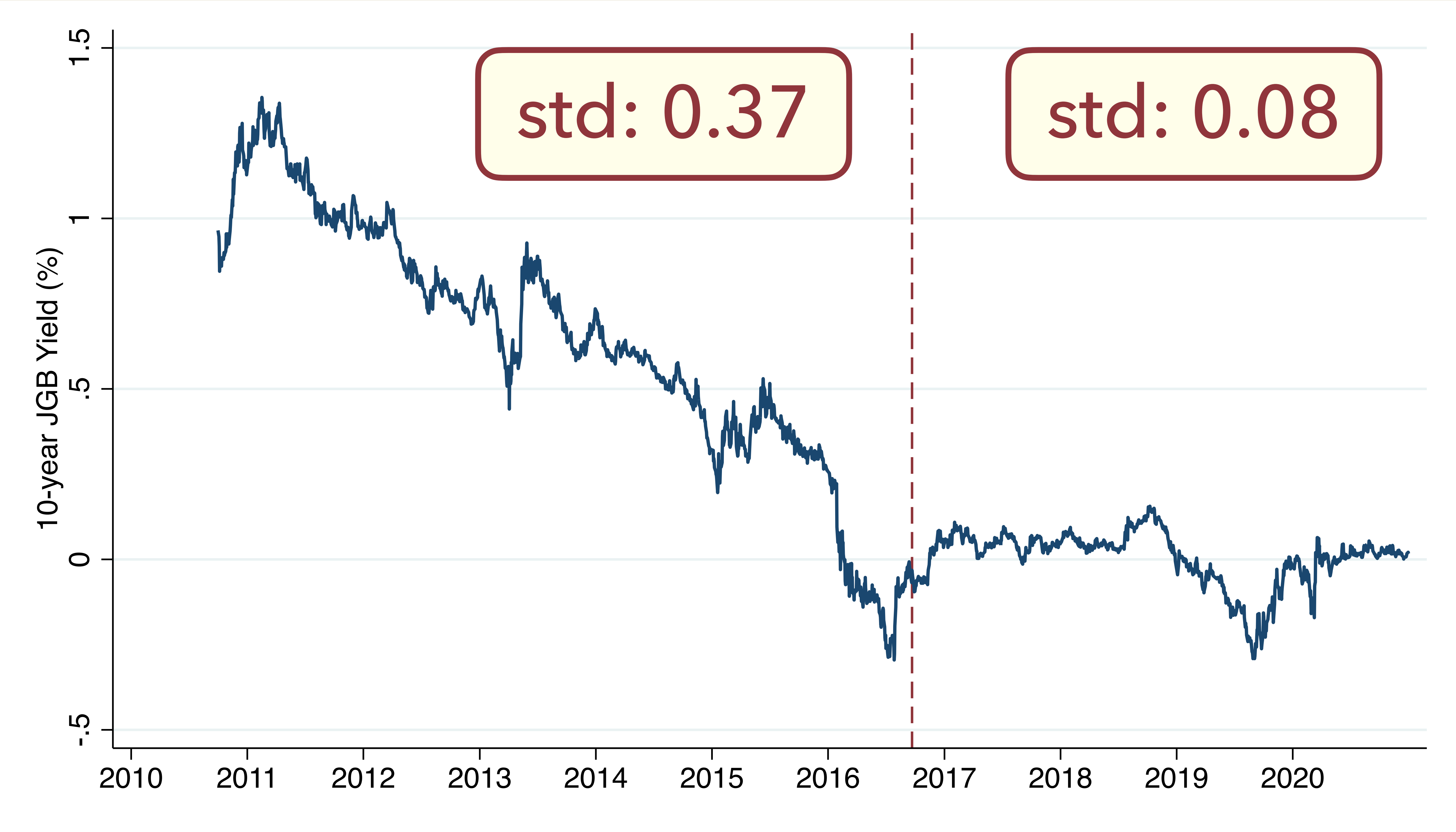

Heterogenous Interest Rate Responses

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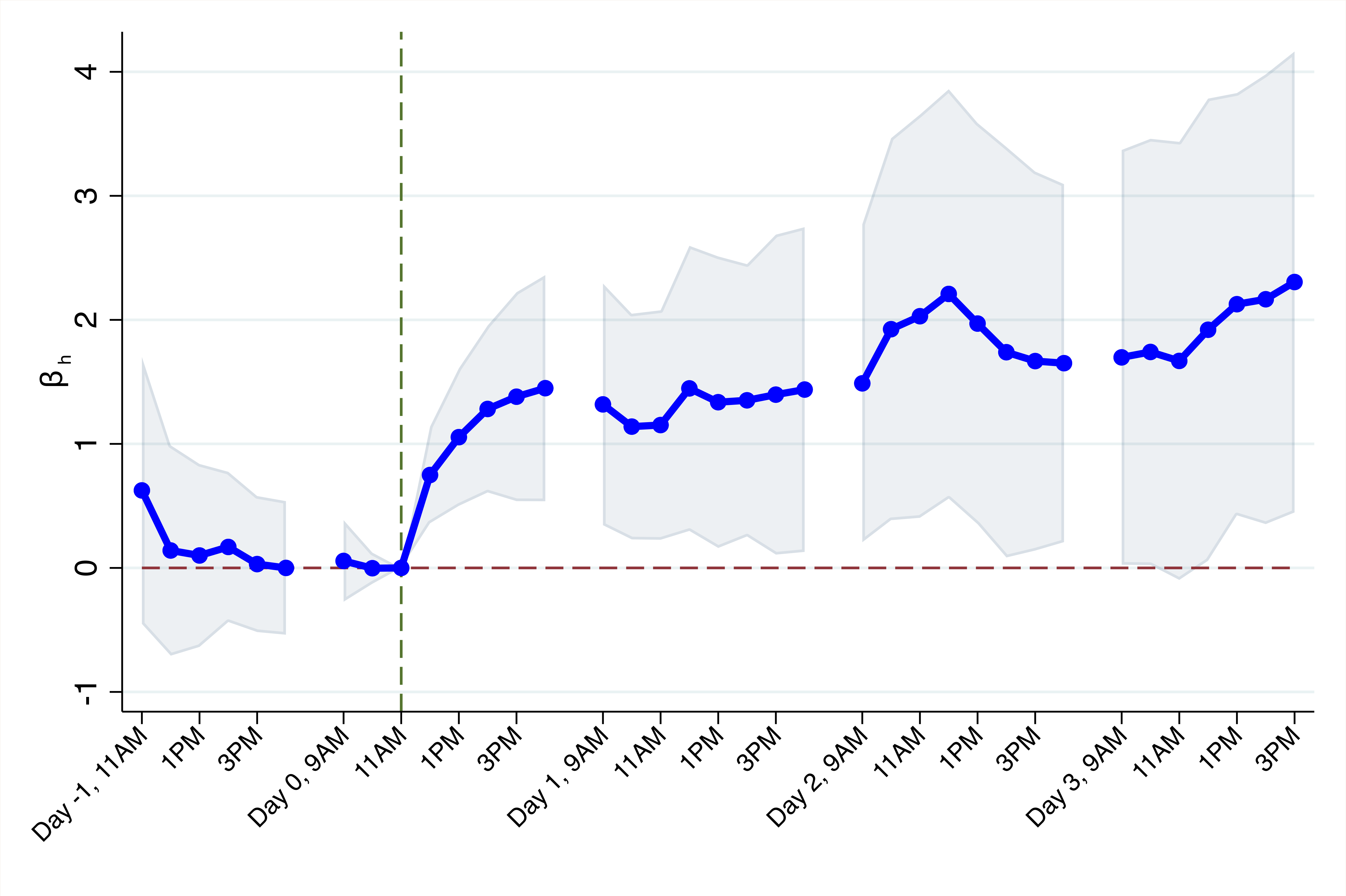
Before YCC



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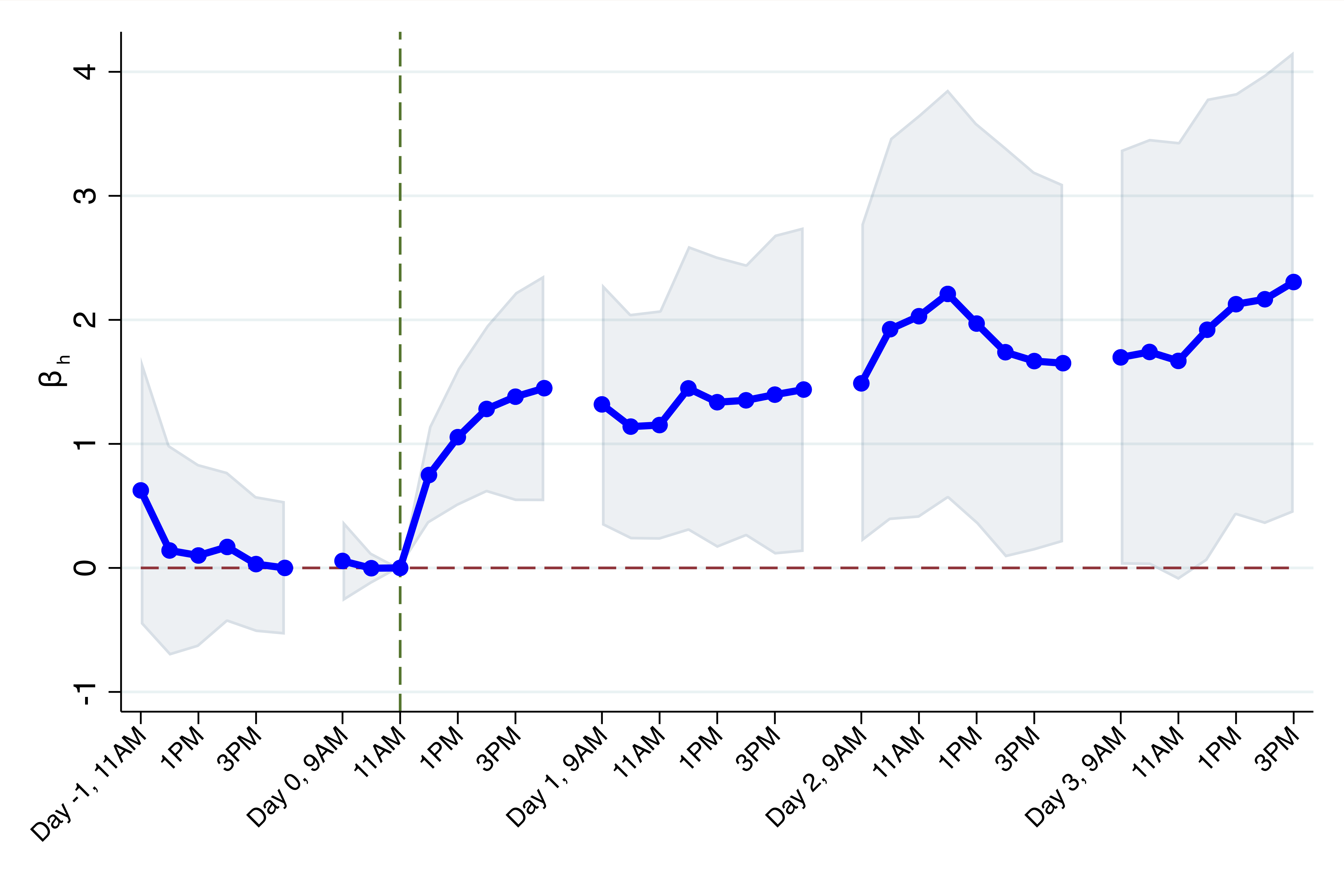

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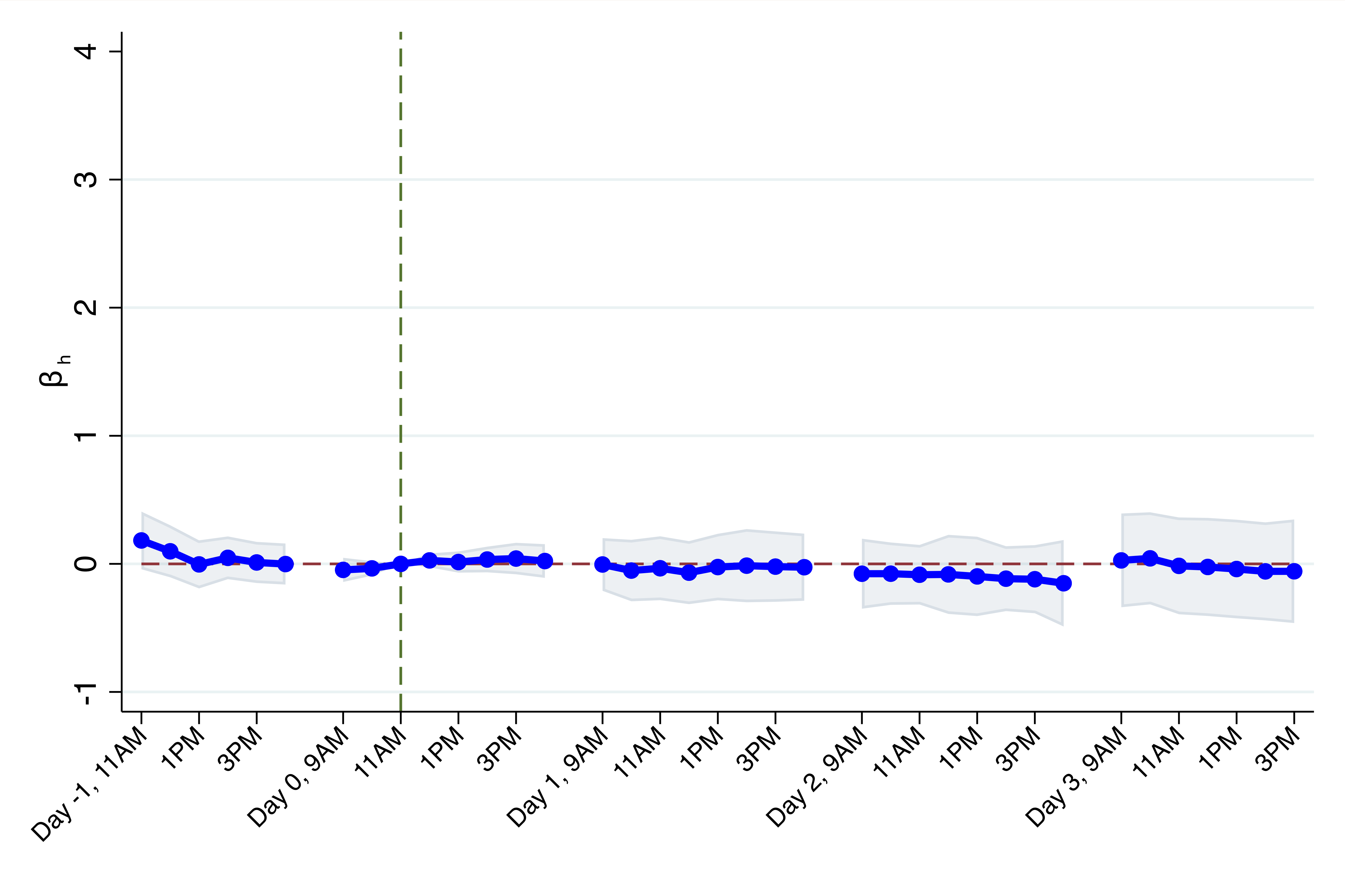

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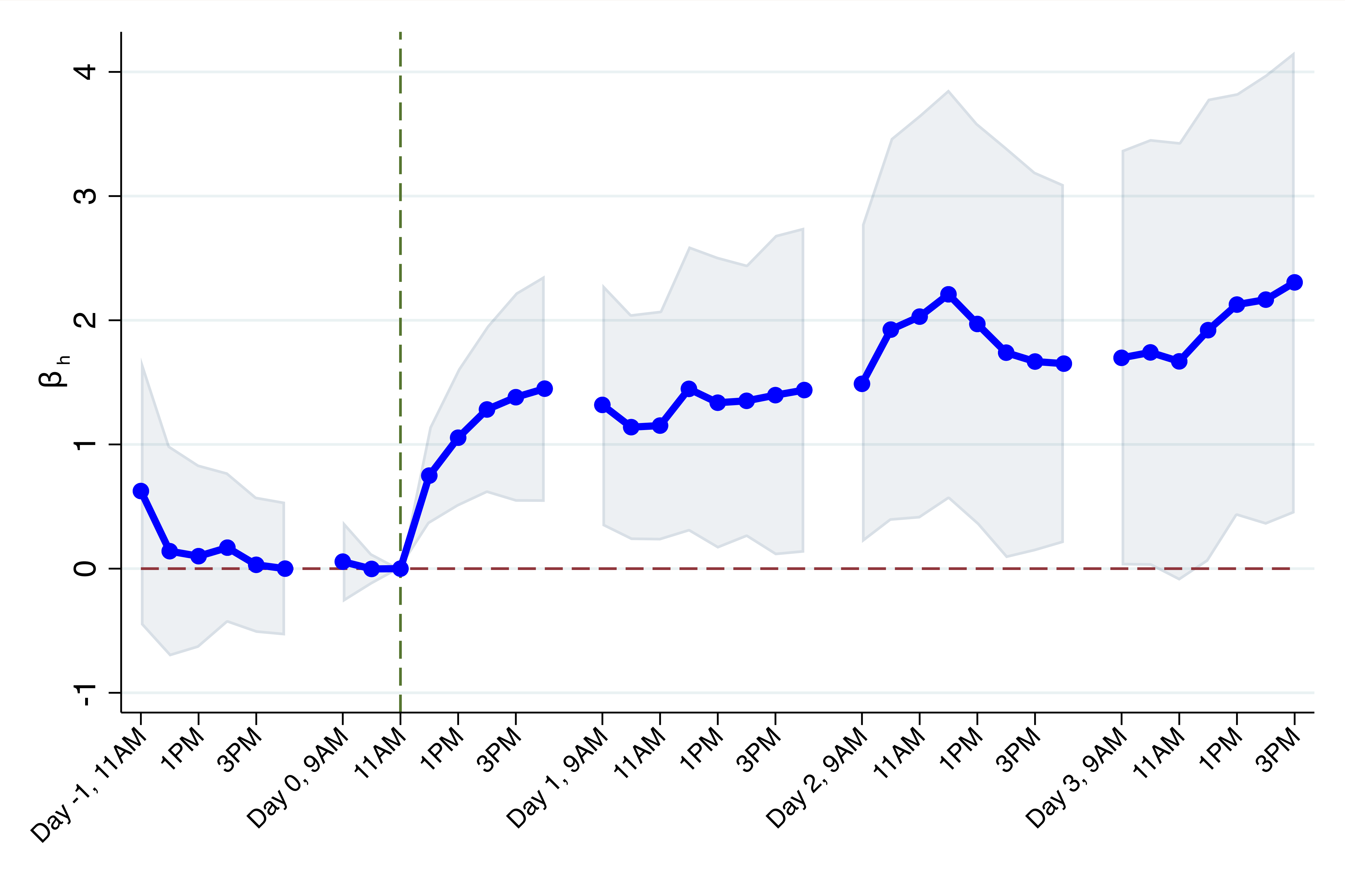

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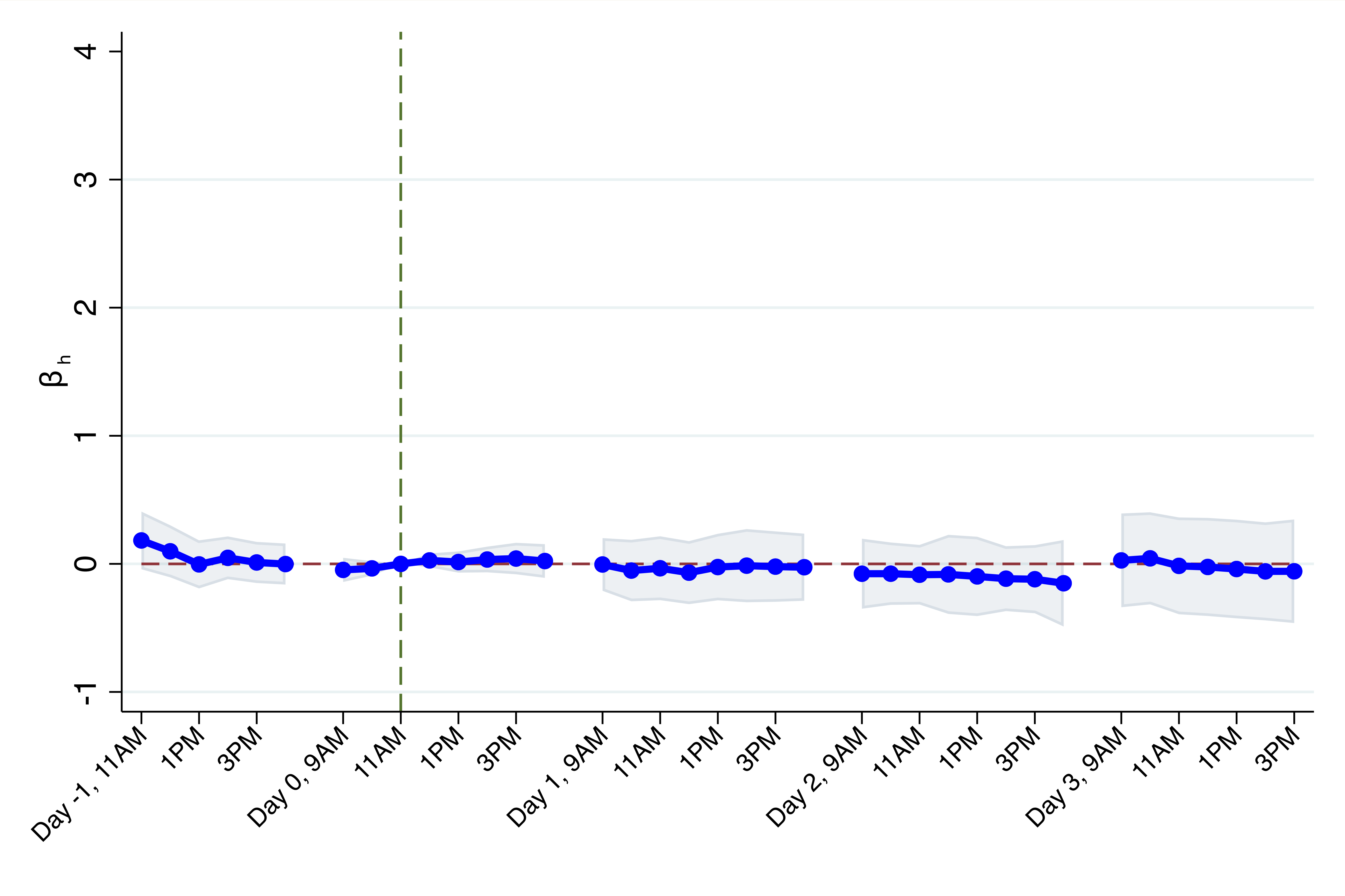
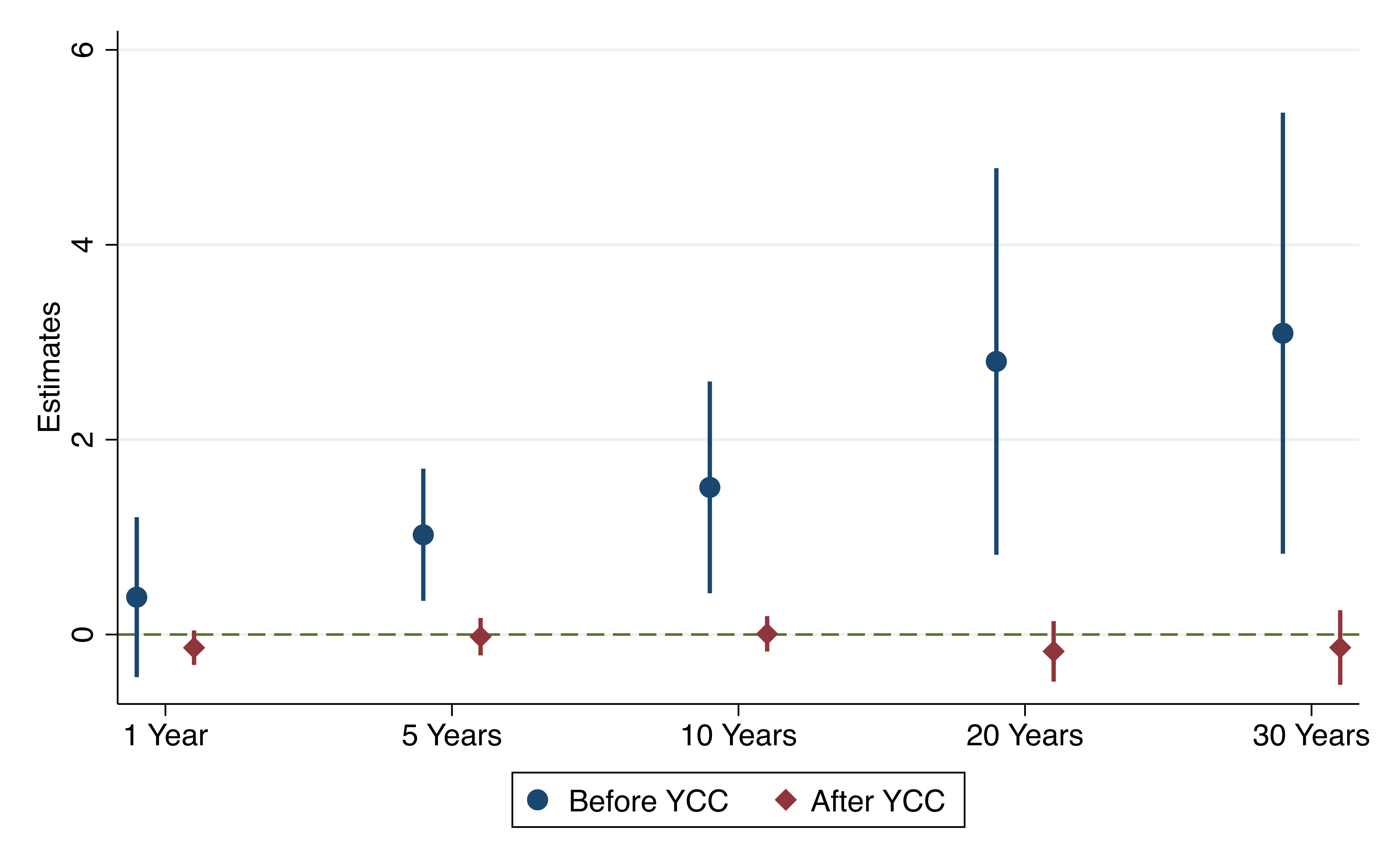


- In response to a 0.01% purchase of stocks by BoJ, long-term rate (i) rose by 1.4 b.p. before YCC; (ii) stopped responding after YCC

Response of Yield Curve

Next-day Response of Yields across Different Maturities

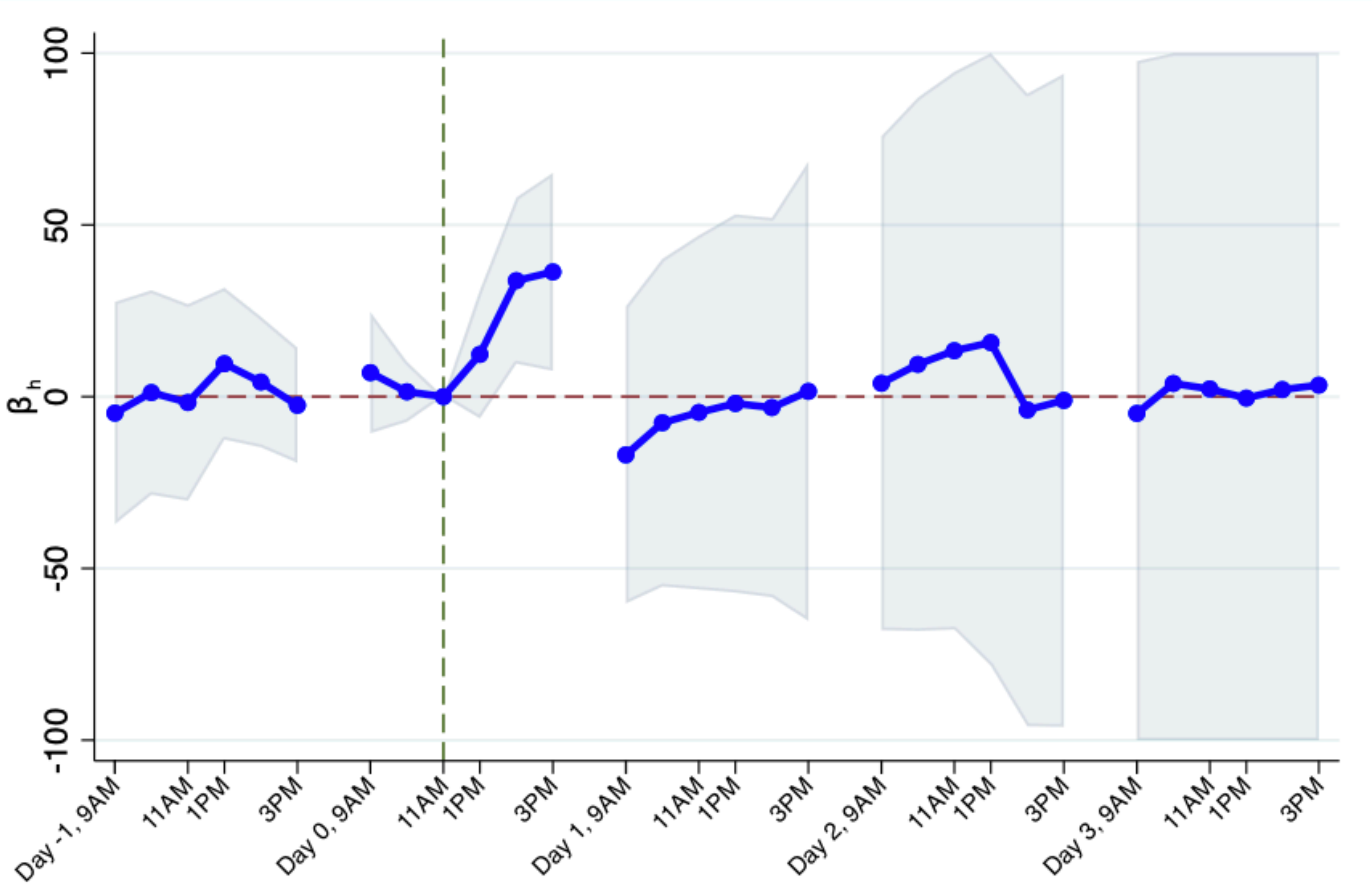


- Smaller responses for shorter maturity before YCC
  $\Rightarrow$ Our interpretation is that ZLB prevented the response of shorter maturity

Heterogenous Stock Price Responses

Stock (TOPIX) Price Changes

Before YCC



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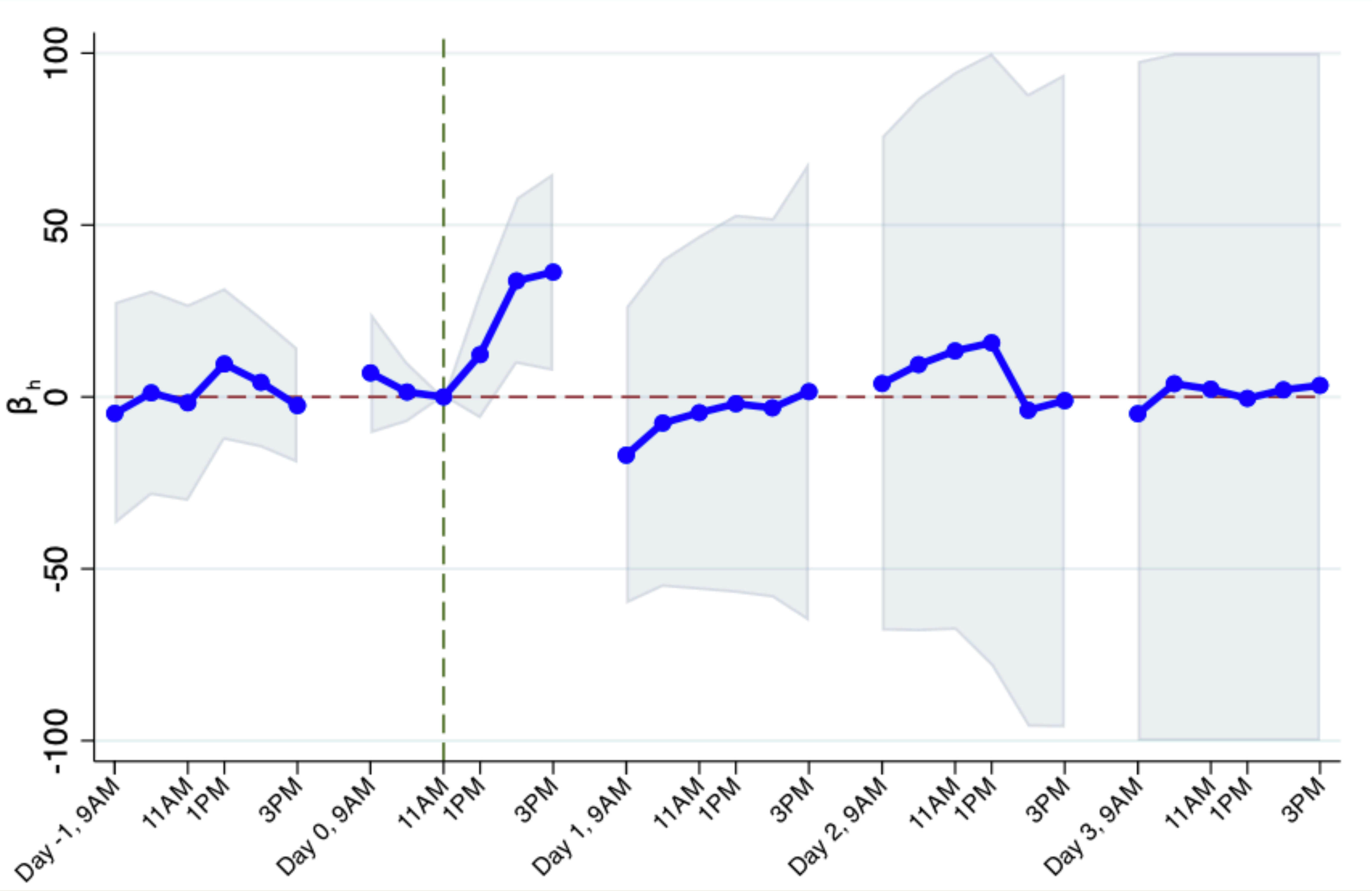

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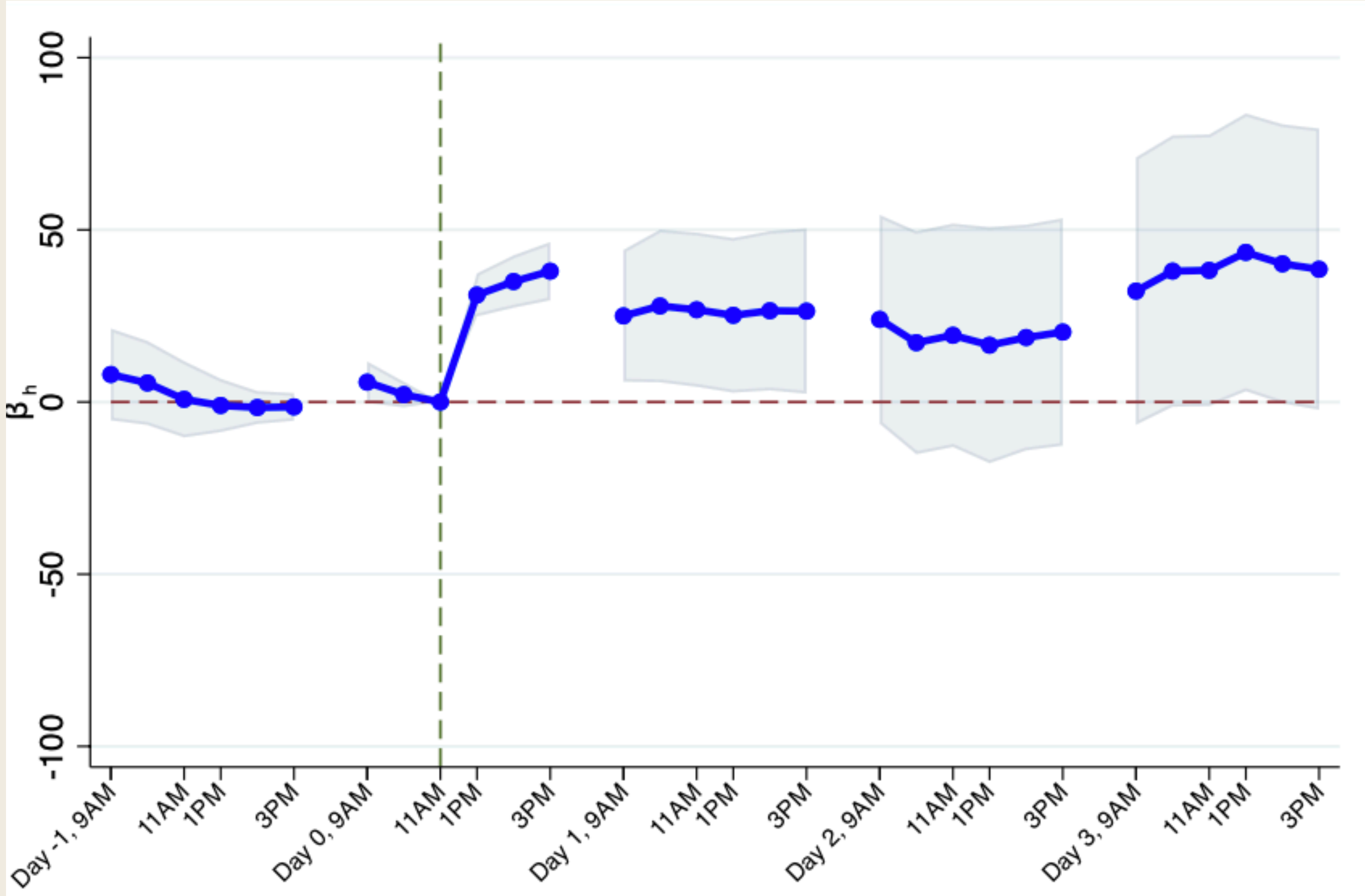

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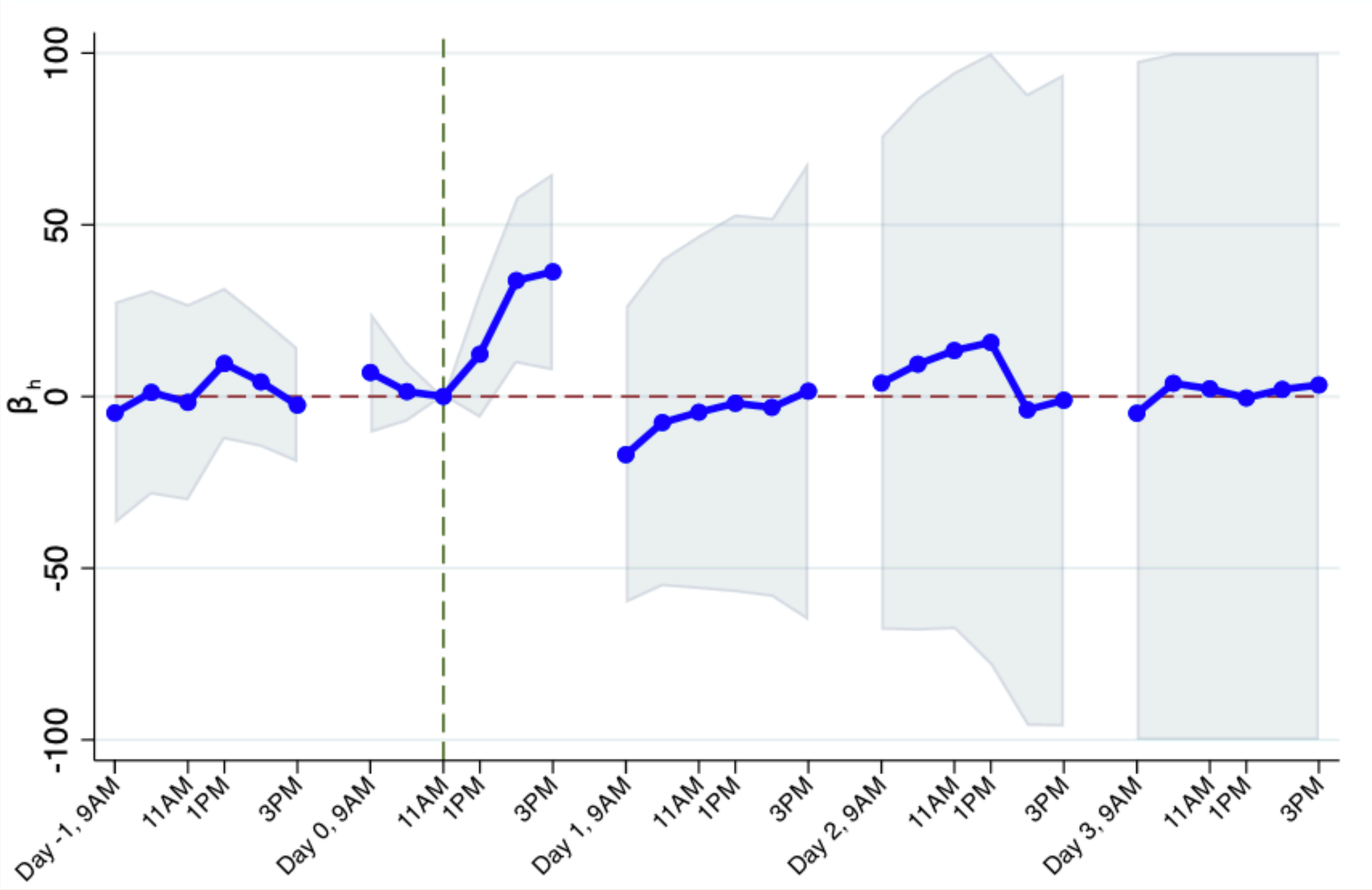

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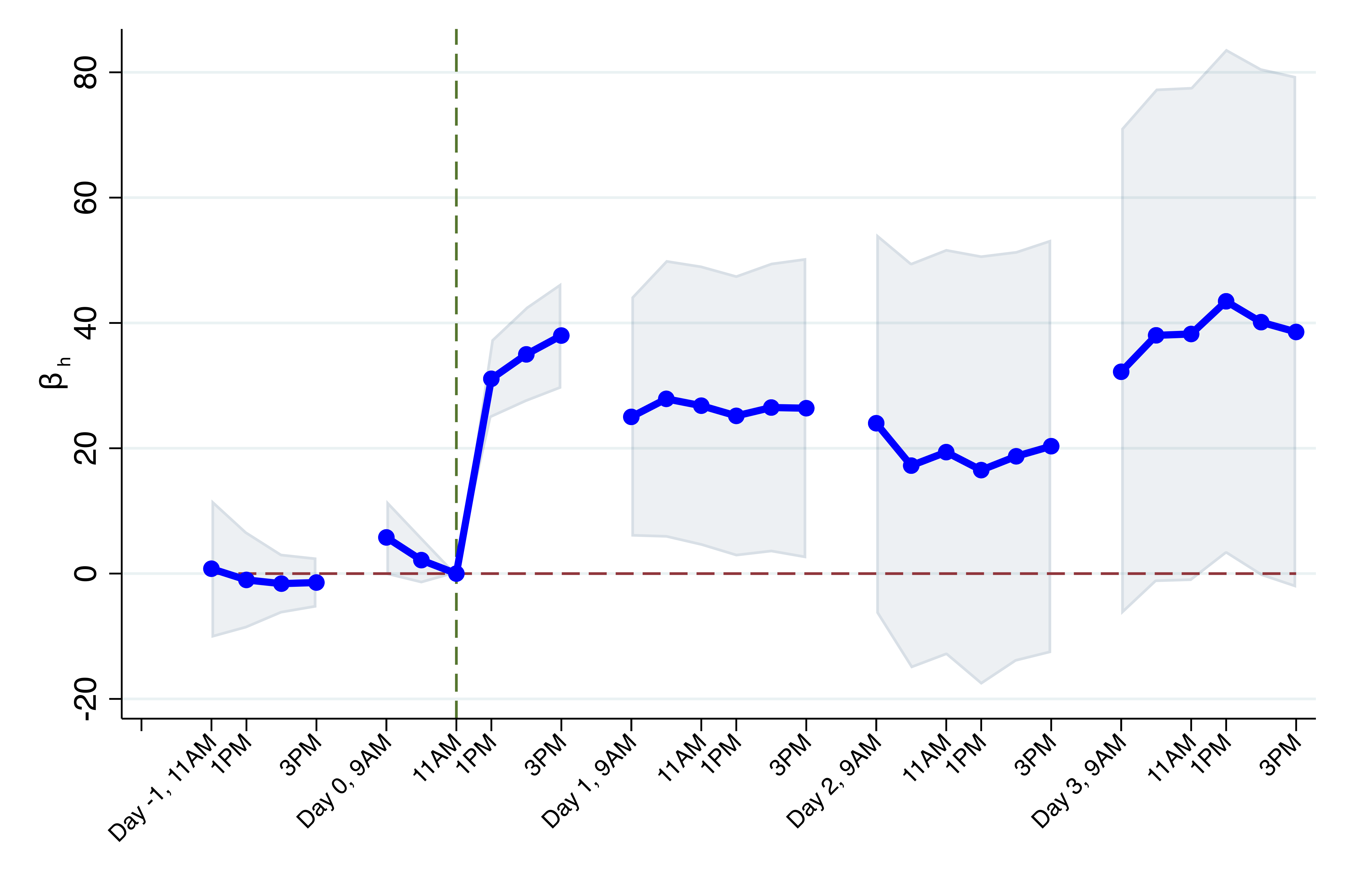

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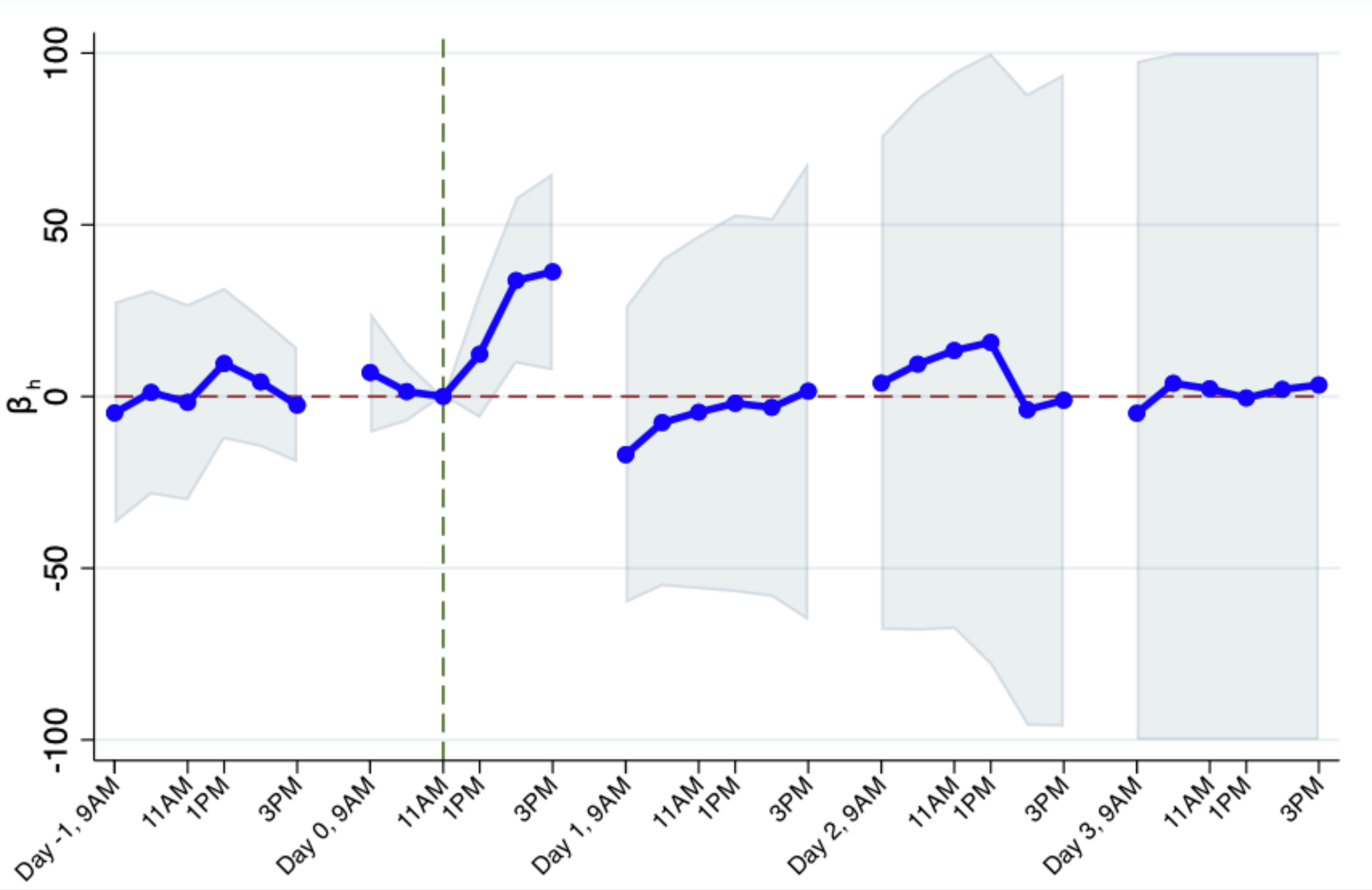

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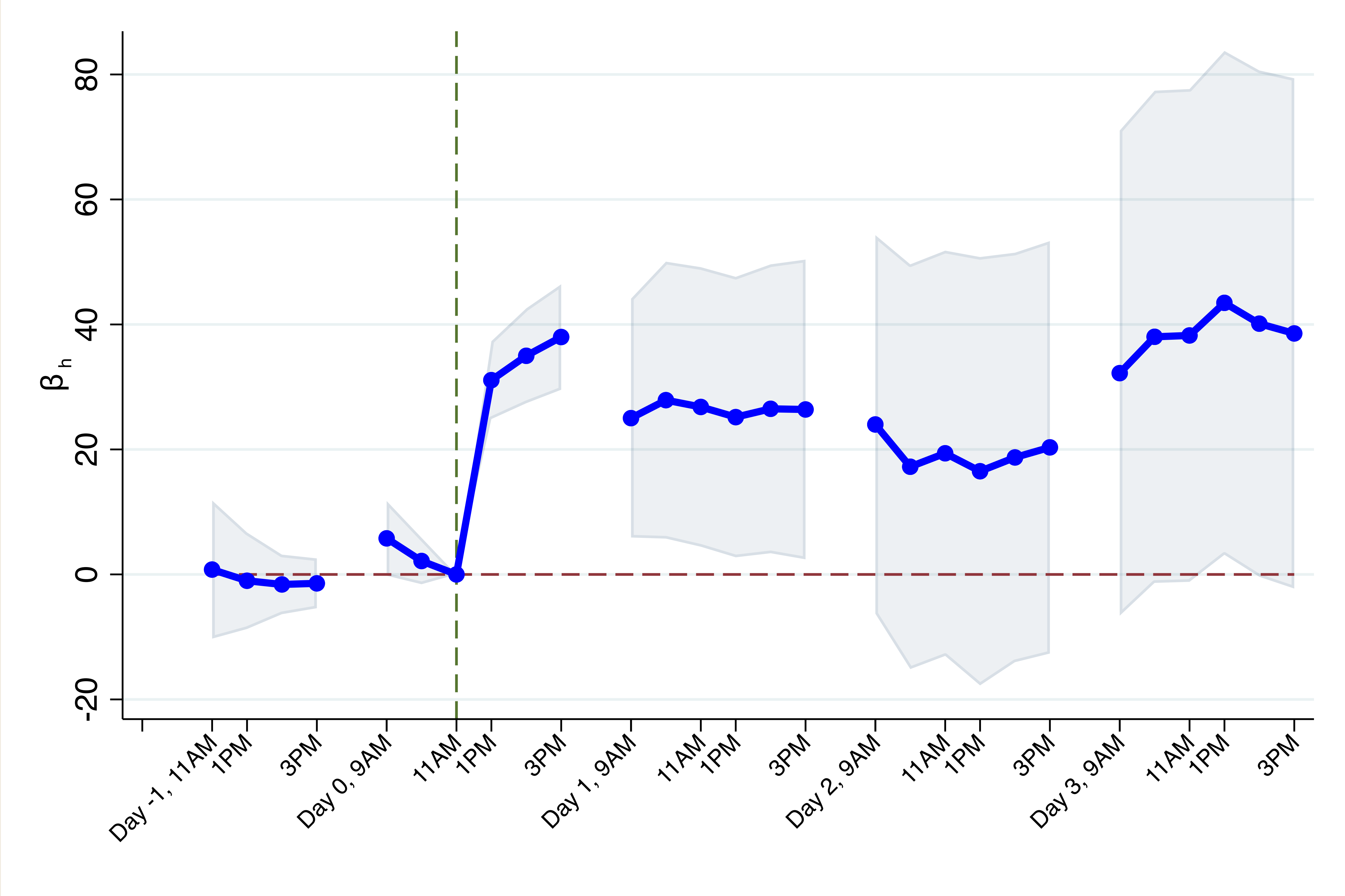
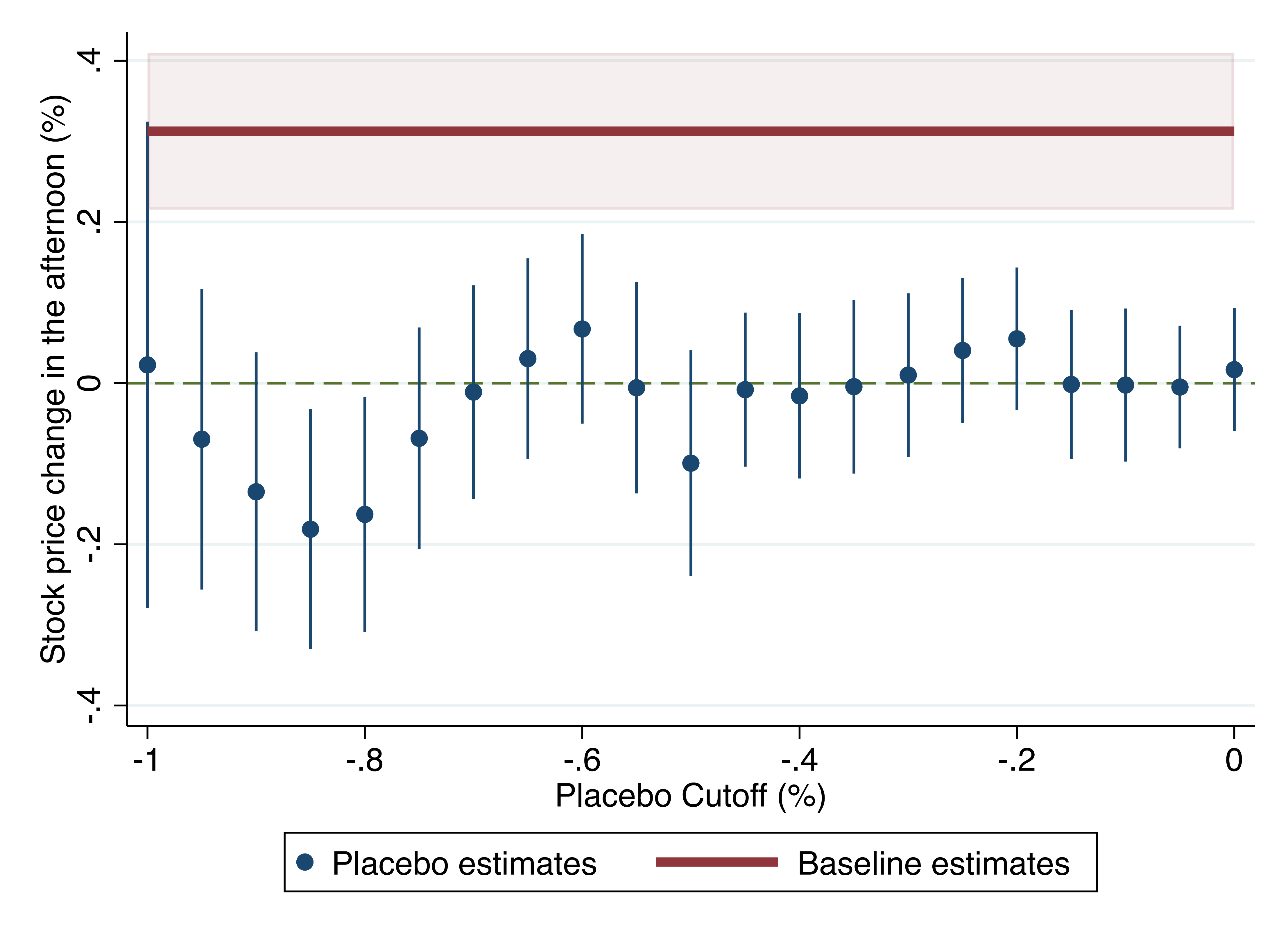


- In response to a 0.01% purchase of stocks by BoJ, (i) noisy zero effect before YCC; (ii) 0.22% increase in stock prices after YCC

Placebo Tests

- Run the same regression with arbitrary chosen cutoffs (excluding true ones)
  → no significant effect around the cutoff in which there is no policy discontinuity

Stock (TOPIX) Price



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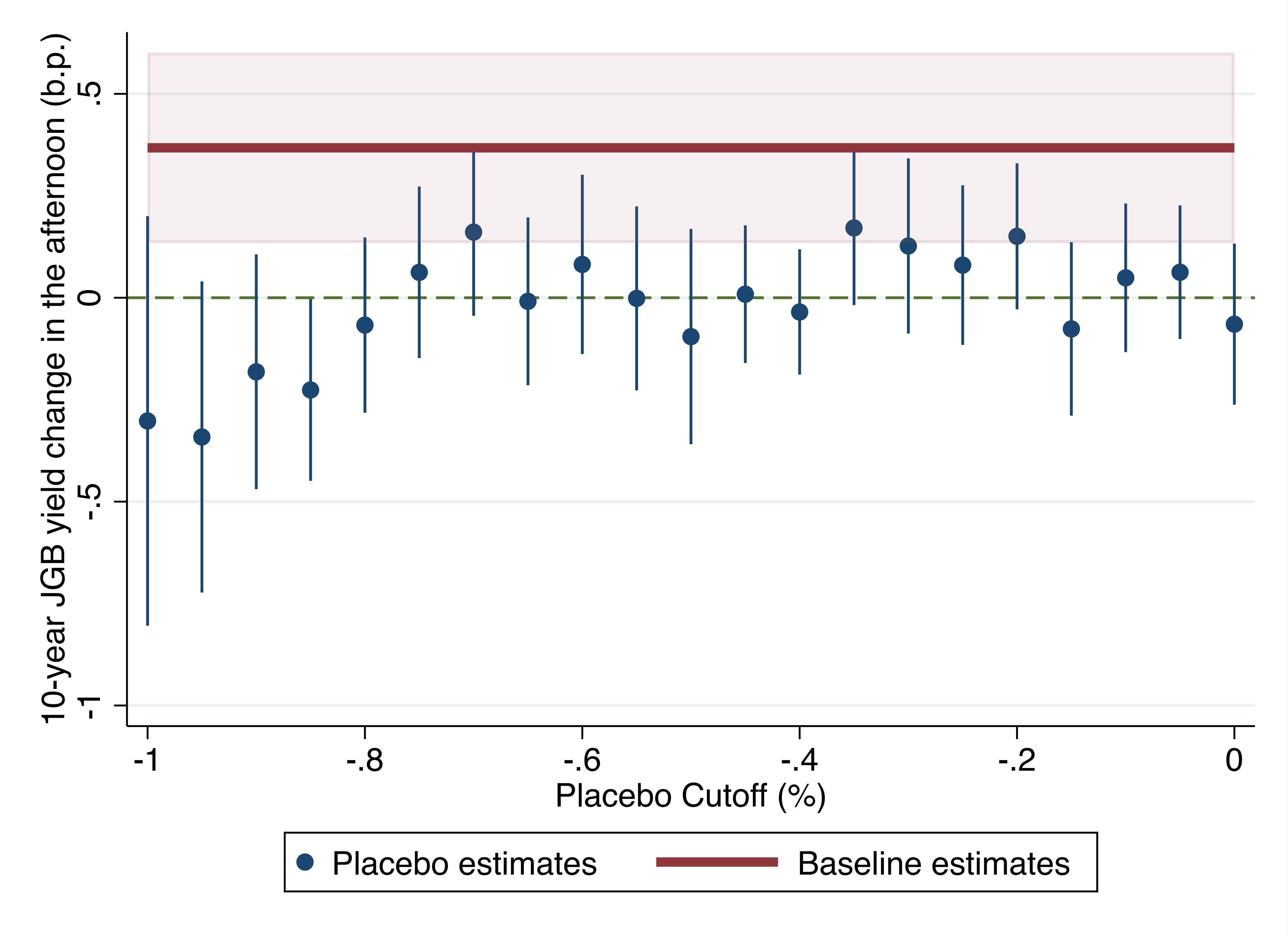

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- Results robust to (Table)
  - ✓ alternative bandwidths & polynomial orders
  - ✓ controls for past outcomes, policies
  - ✓ dropping the periods around cut-off changes

Theoretical Framework

Model Summary

- Single fixed factor (capital) with $Y_t = A_t K$ and $\log A_{t+1}/A_t \sim N(g - \sigma^2/2, \sigma^2)$
- Households decide saving with bonds in utility function, $\sum_t \beta^t [u(C_t) + v_b(B/Y)]$
- Mutual funds invest in stocks with portfolio adjustment cost, $v_s(s)$
- Central bank chooses the holdings of bonds and stocks as well as lump-sum taxes

Frictionless Economy ($v_b'' = v_s'' = 0$)

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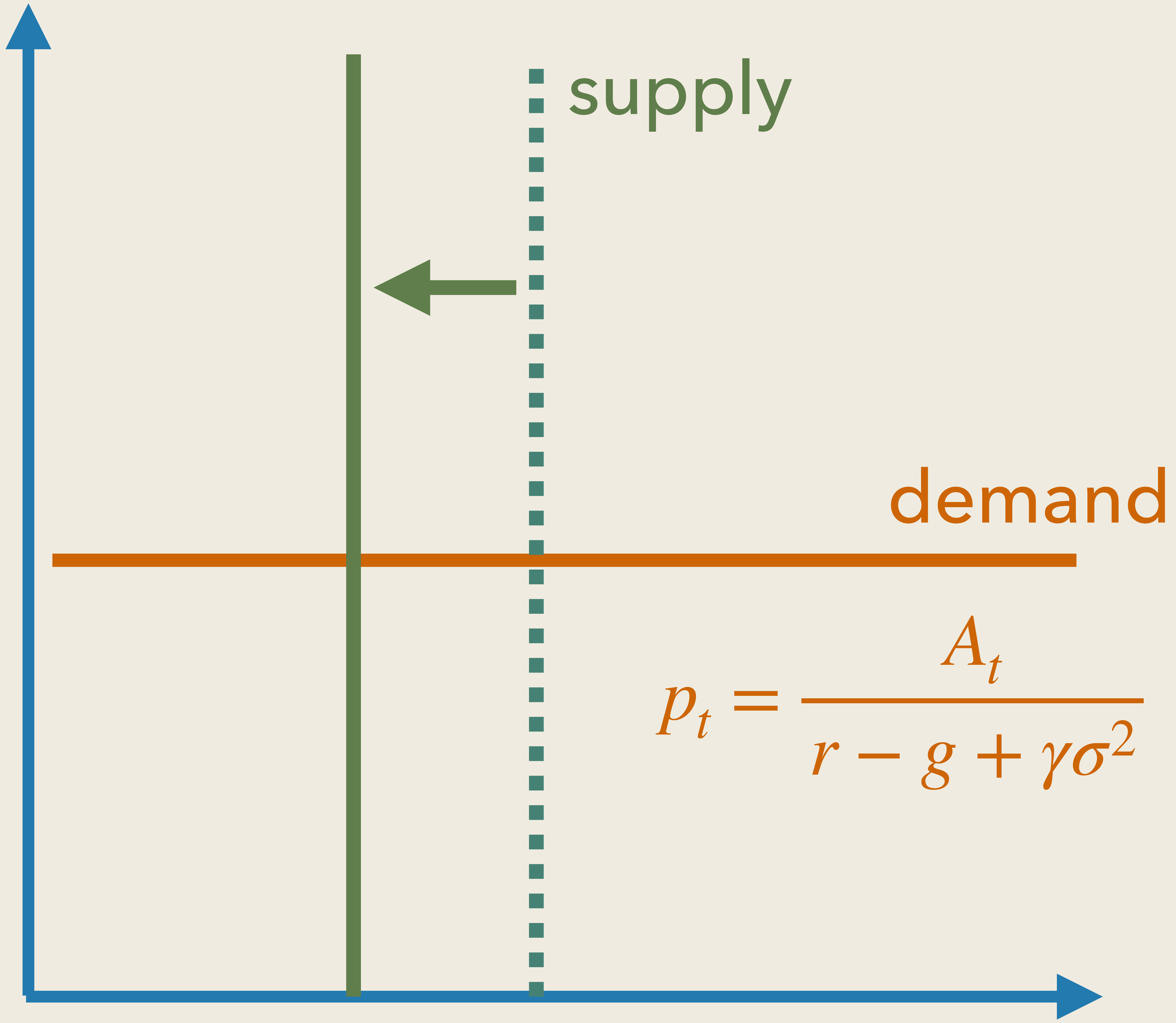
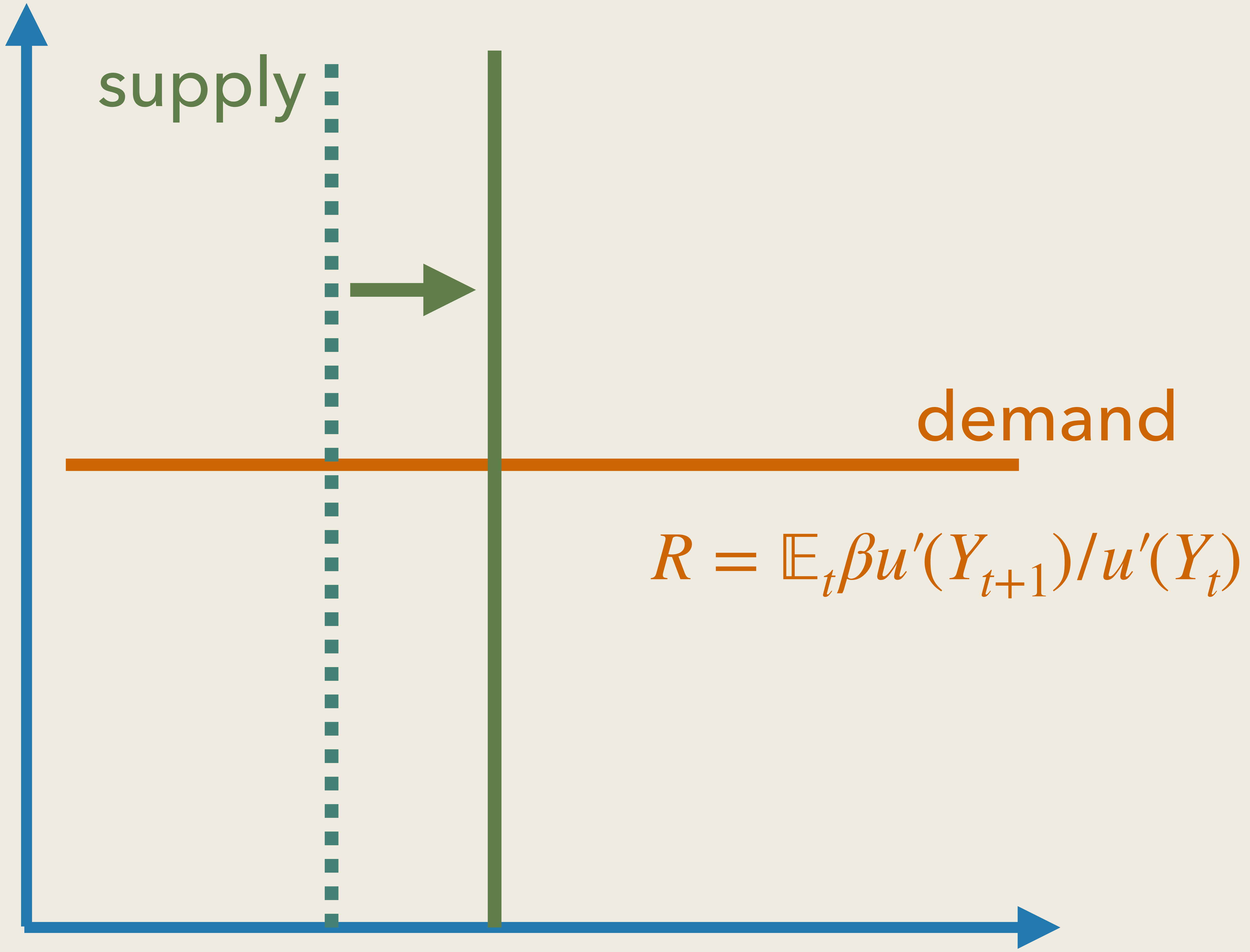
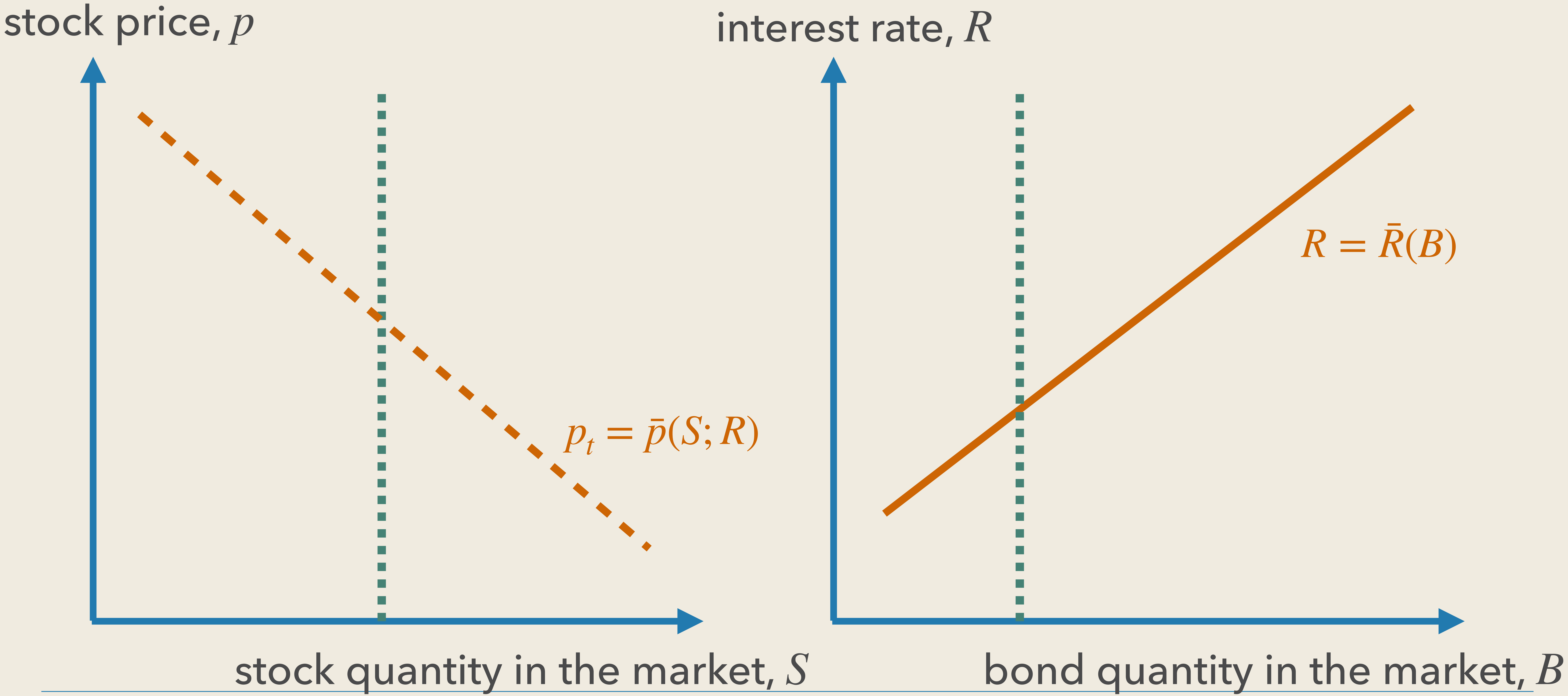




Inelastic Stock and Bond Market $(v_s'' > 0, v_b'' < 0)$



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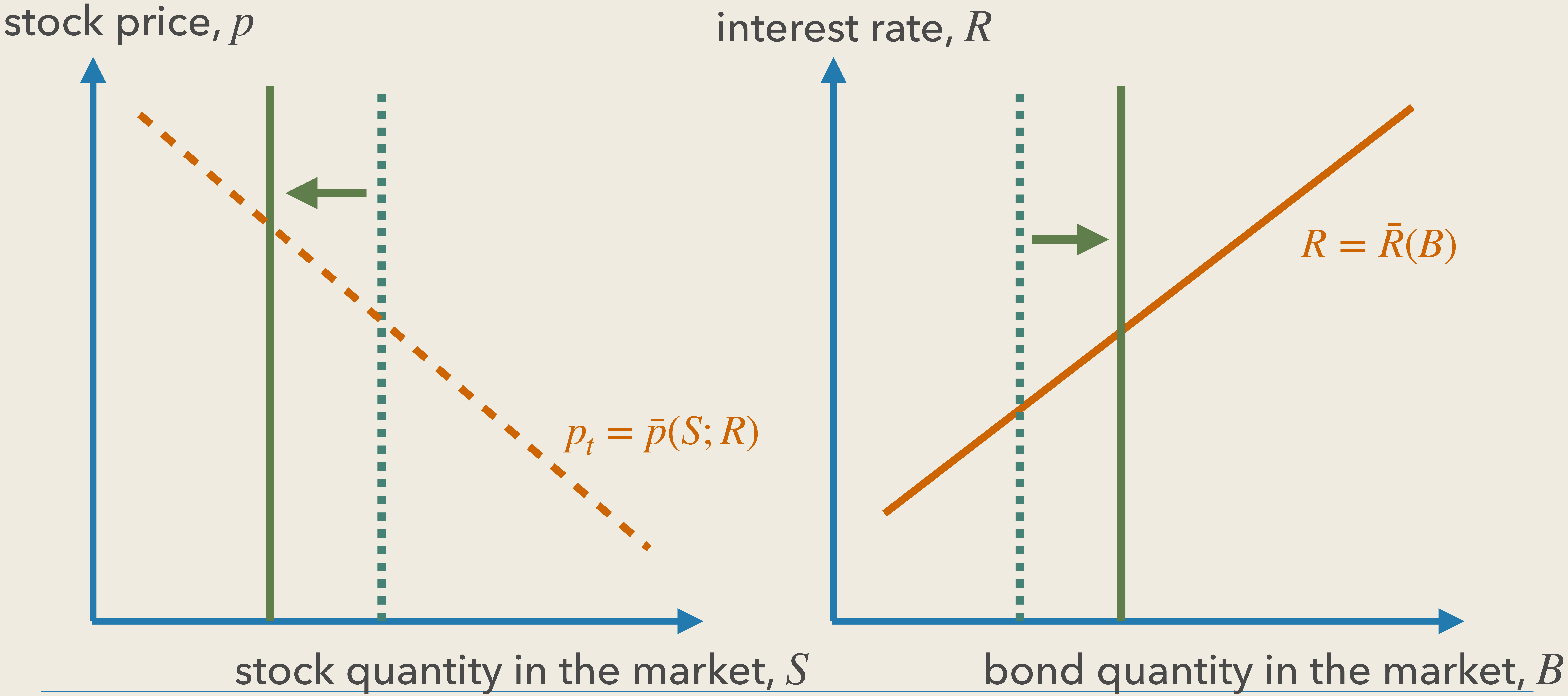

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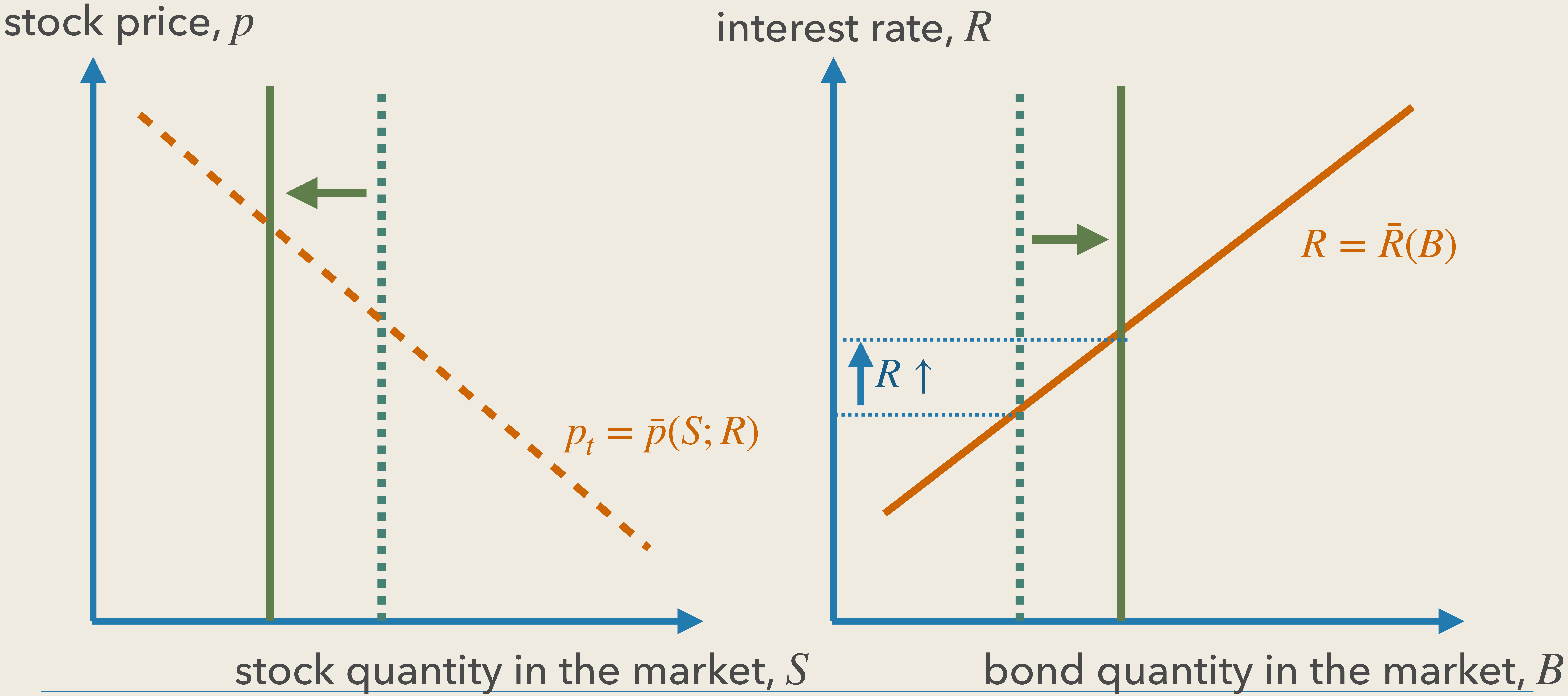

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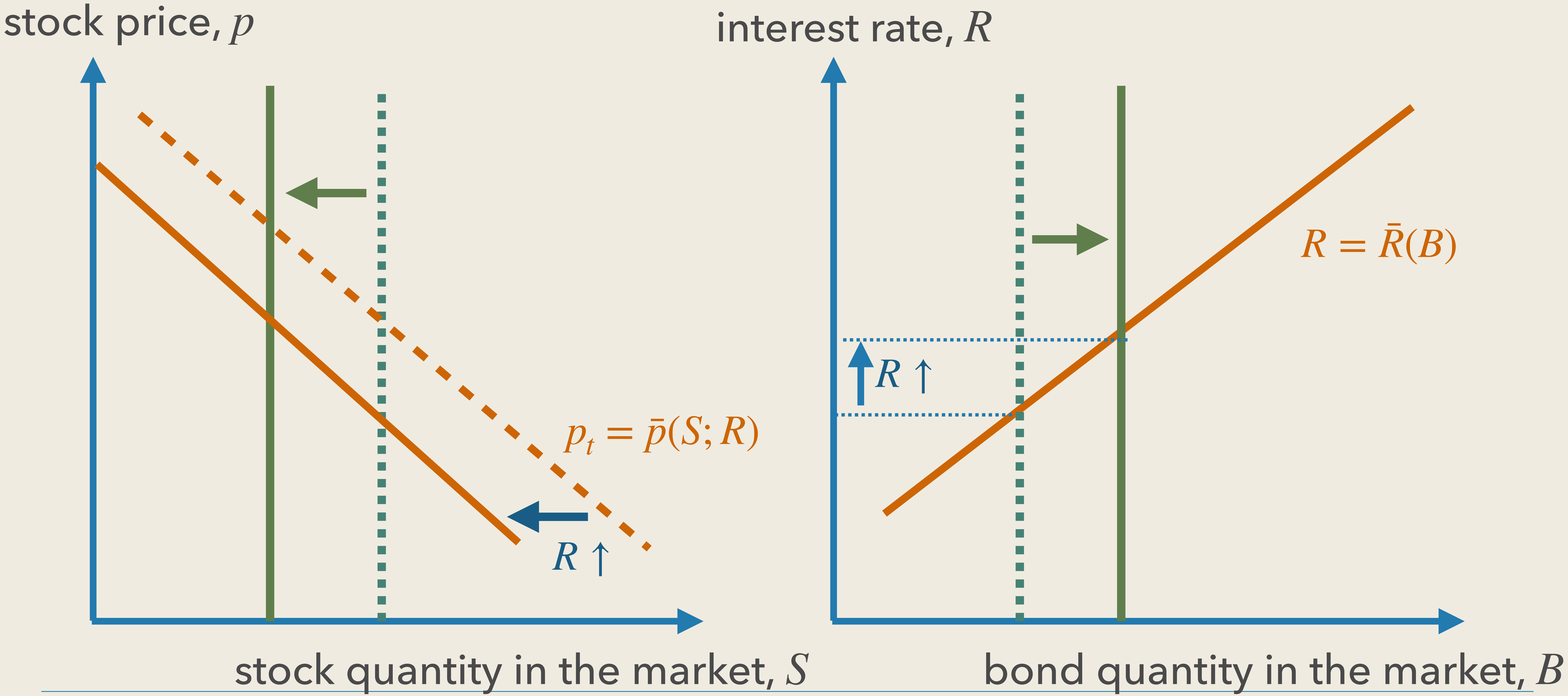

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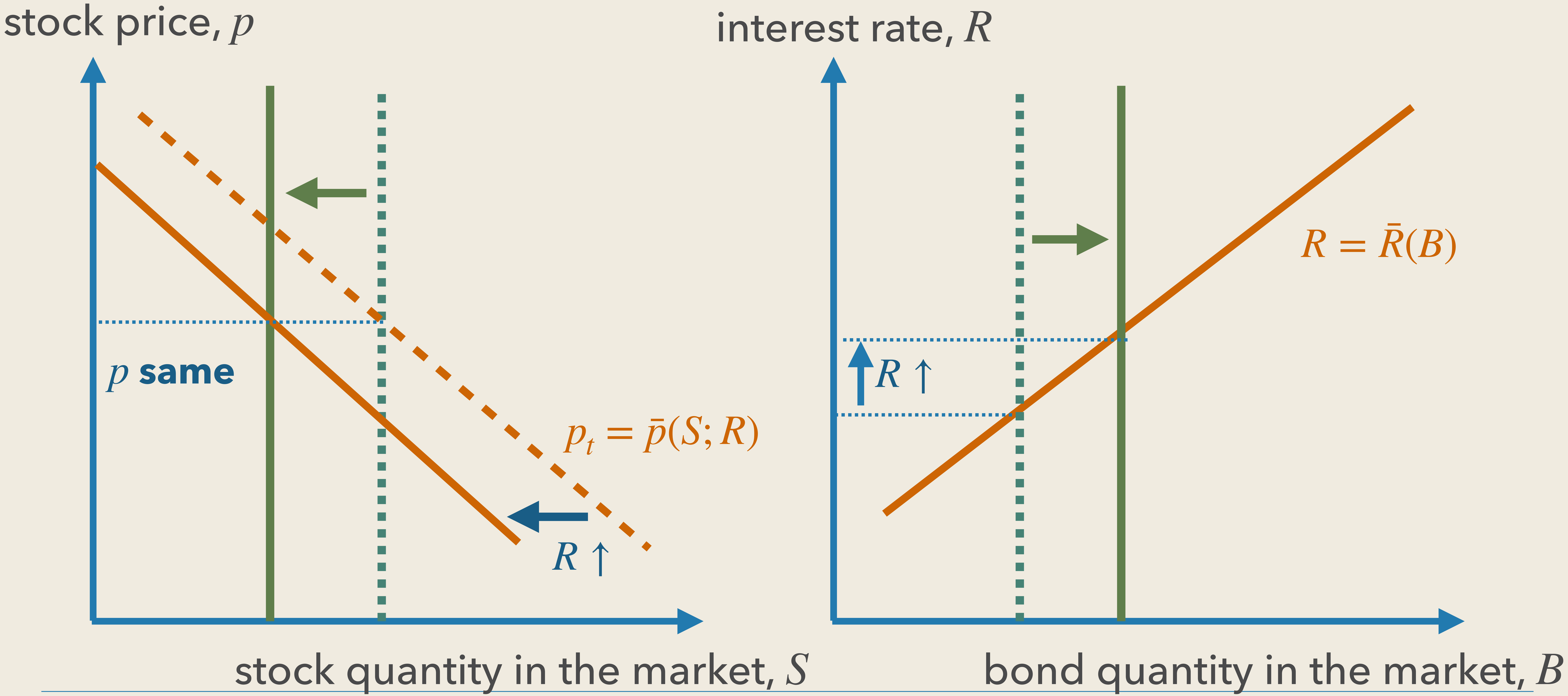
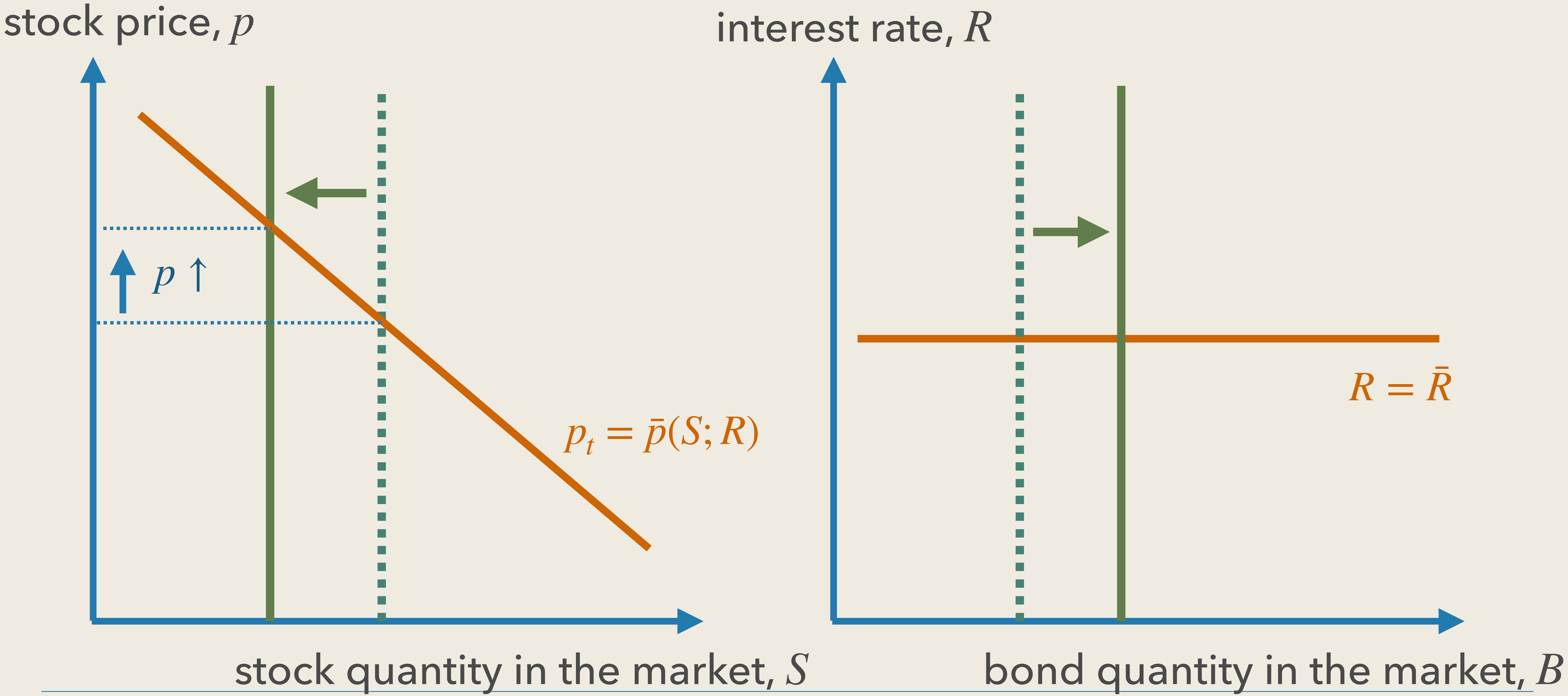


Yield Curve Control



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stock market inelasticity

holding R fixed

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$$\frac{\partial \ln \bar{R}(B)}{\partial \ln(B/S)}$$

bond market inelasticity

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$$\frac{\partial \ln \bar{R}(B)}{\partial \ln(B/S)}$$

bond market inelasticity

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Interest rate sensitivity

Identification

- Three sufficient stats:

$$-\frac{\partial \ln \bar{p}(S,R)}{\partial \ln S}$$

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$\approx$ 22

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Interest rate sensitivity

$\approx$ -15

- Gabaix and Koijen's (2020) estimates: $-\frac{d \ln \bar{p}(S,R(S))}{d \ln S} \approx 5$

Conclusion

- Two strands of literature:
  1. bond market is inelastic (Krishnamurthy & Vissing-Jorgensen, 2012, Vayanos & Vila, 2021)
  2. stock market is inelastic (Gabaix & Koijen, 2021)
- How a flow from bond to stock drives assets prices depends **jointly** on two elasticities
- Using a RDD design, we show
  - ✓ such a flow mostly ended up moving bond prices in a normal time
  - ✓ once bond market becomes elastic, stock prices start to respond substantially

  ⇒ evidence that *both* bond and stock market are substantially inelastic
- Central bank stock purchases "works" only when combined with YCC

Question

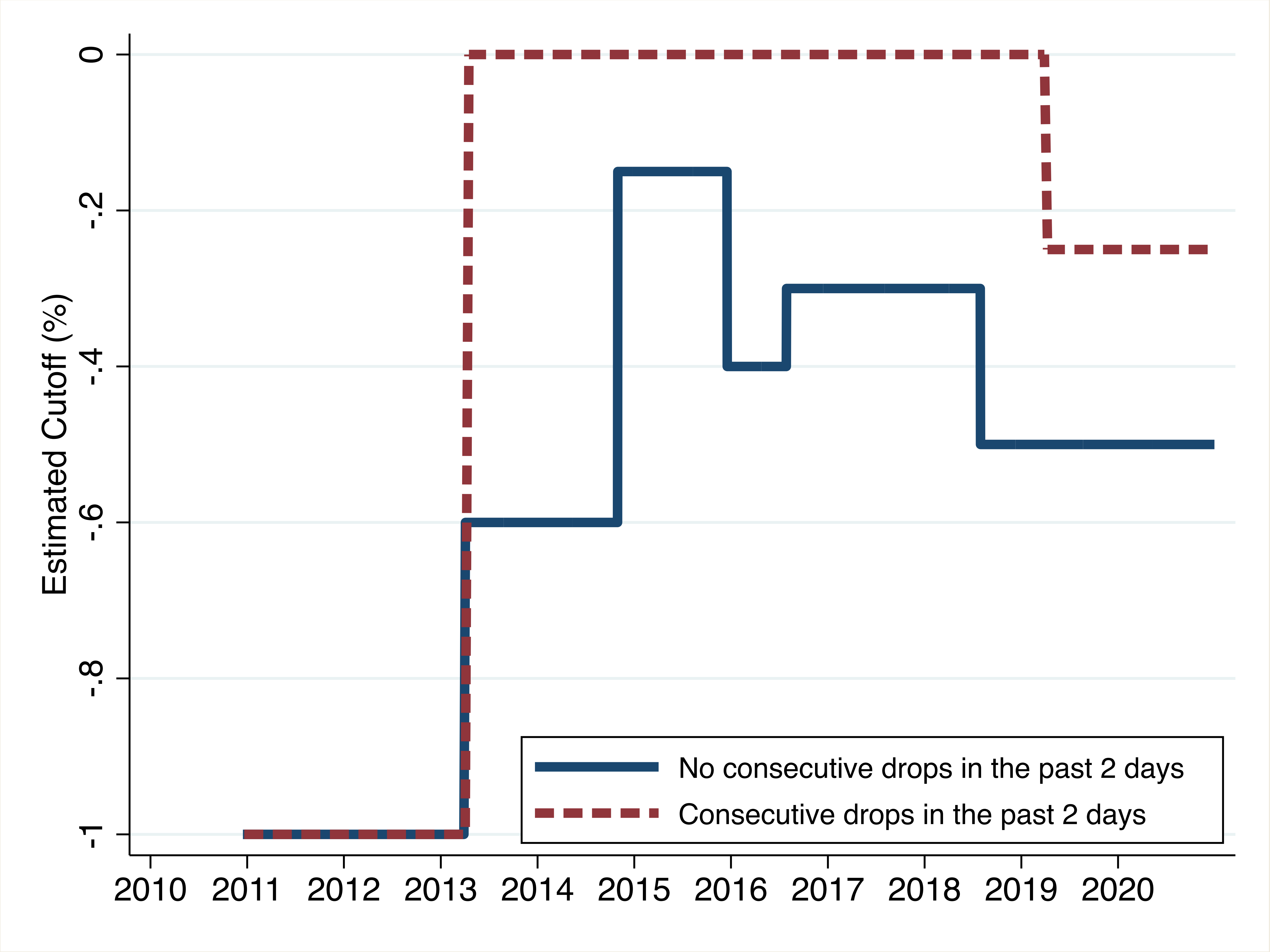
- What is the impact of central bank stock purchases?
- Why do we care?
  1. Frontier of "quantitative easing"
  2. Ideal laboratory to test new theories of stock market fluctuations

Literature

- Empirical studies on QE:
  - Krishnamurthy & Vissing-Jorgensen (2011,2013), Baba et al. (2006), Gagnon et al. (2010, 2011), Sarkar and Shrader (2010), Ashcraft et al. (2011), Hancock and Passmore (2011), Joyce et al. (2011), Swanson (2011, 2015), Stroebel and Taylor (2012), D'Amico and King (2013), Kandrac and Schlusche (2013), Koijen et al. (2018), Di Maggio et al (2020), Beraja et al (2020), Droste, Gordnichenko, and Ray (2021)
- Studies on BoJ stock purchases:
  - Charoenwong et al. (2019), Fukuda and Tanaka (2019), Shirota (2019), etc
- Market inelasticity:
  - Bonds market: Vayanos-Vila (2009), Krishnamurthy-Vissing-Jorgensen (2012)
  - Stock market: Koijen and Yogo (2019), Gabaix and Koijen (2020)

Cutoffs Estimation

Estimated Cutoffs over Time



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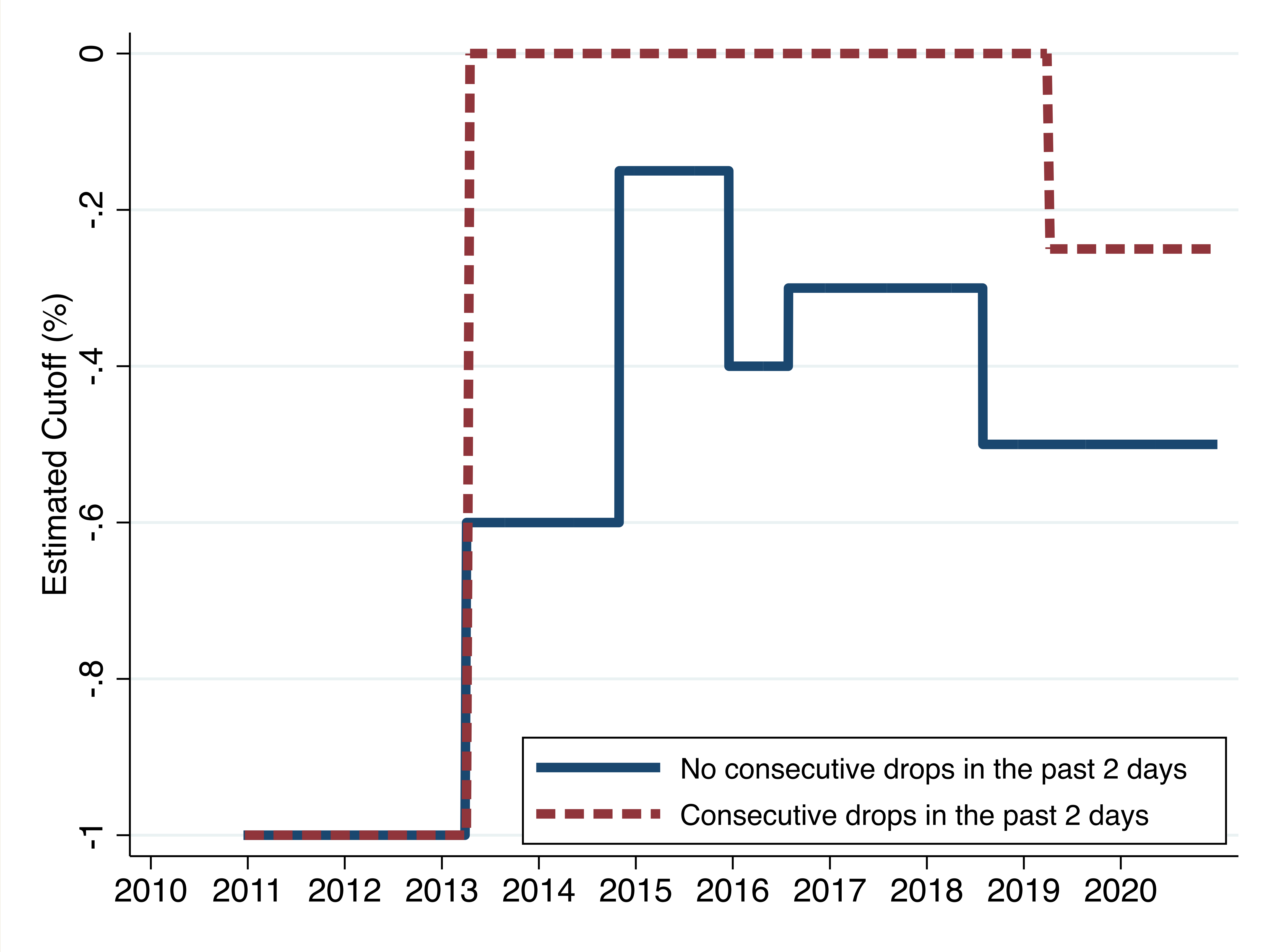
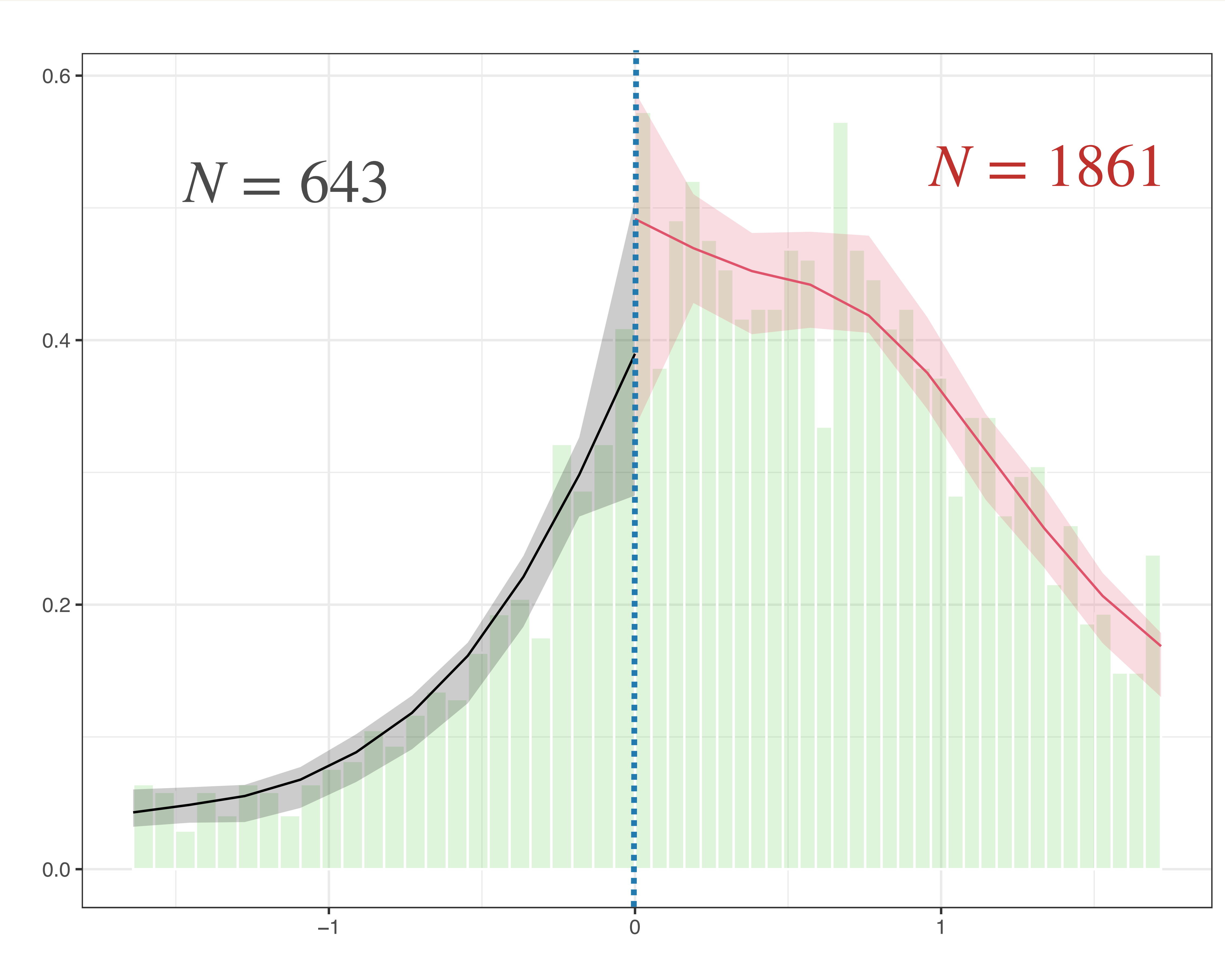


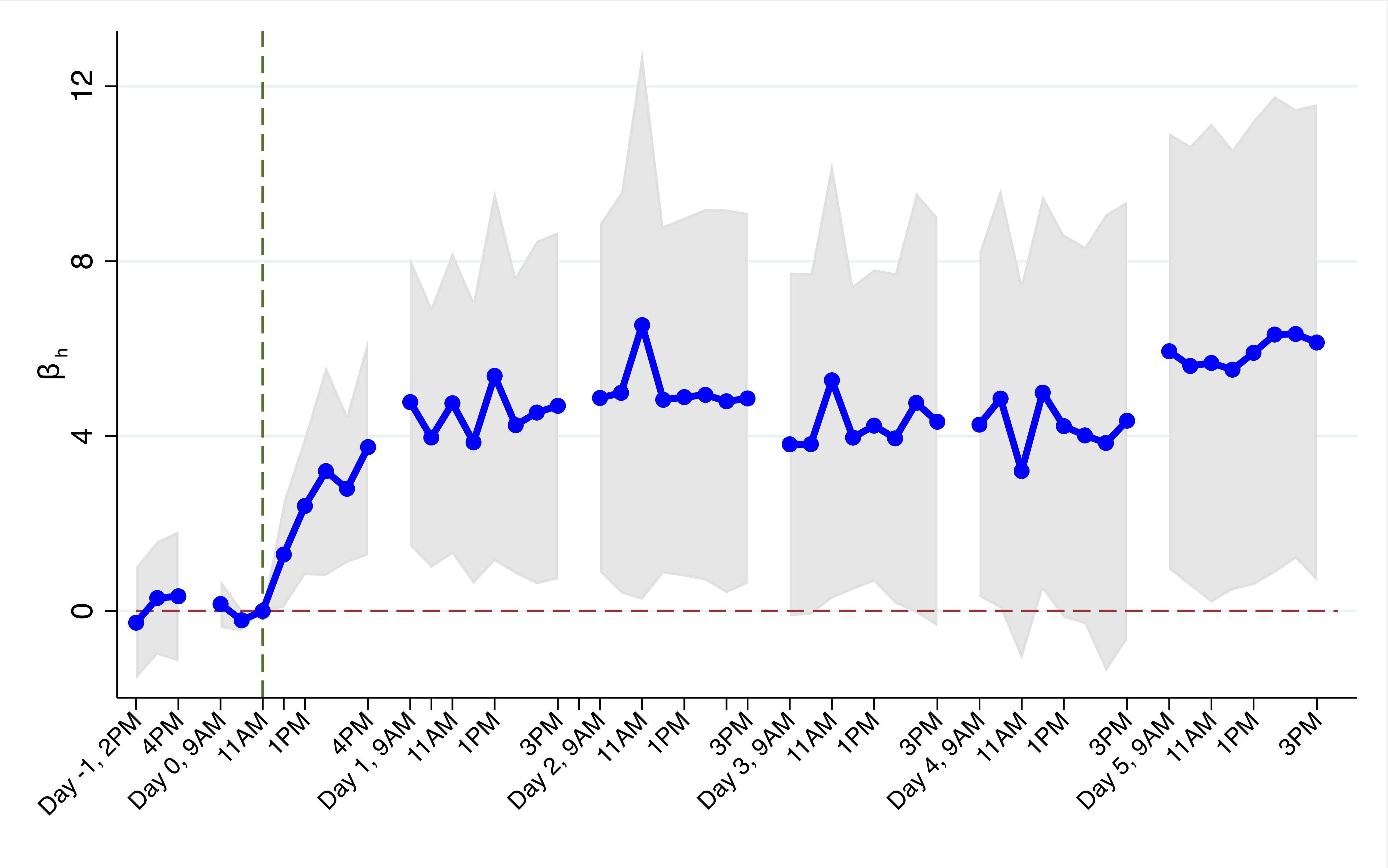
Density around the cutoff



Heterogenous Interest Rate Responses

10-year JGB Yield

Before YCC



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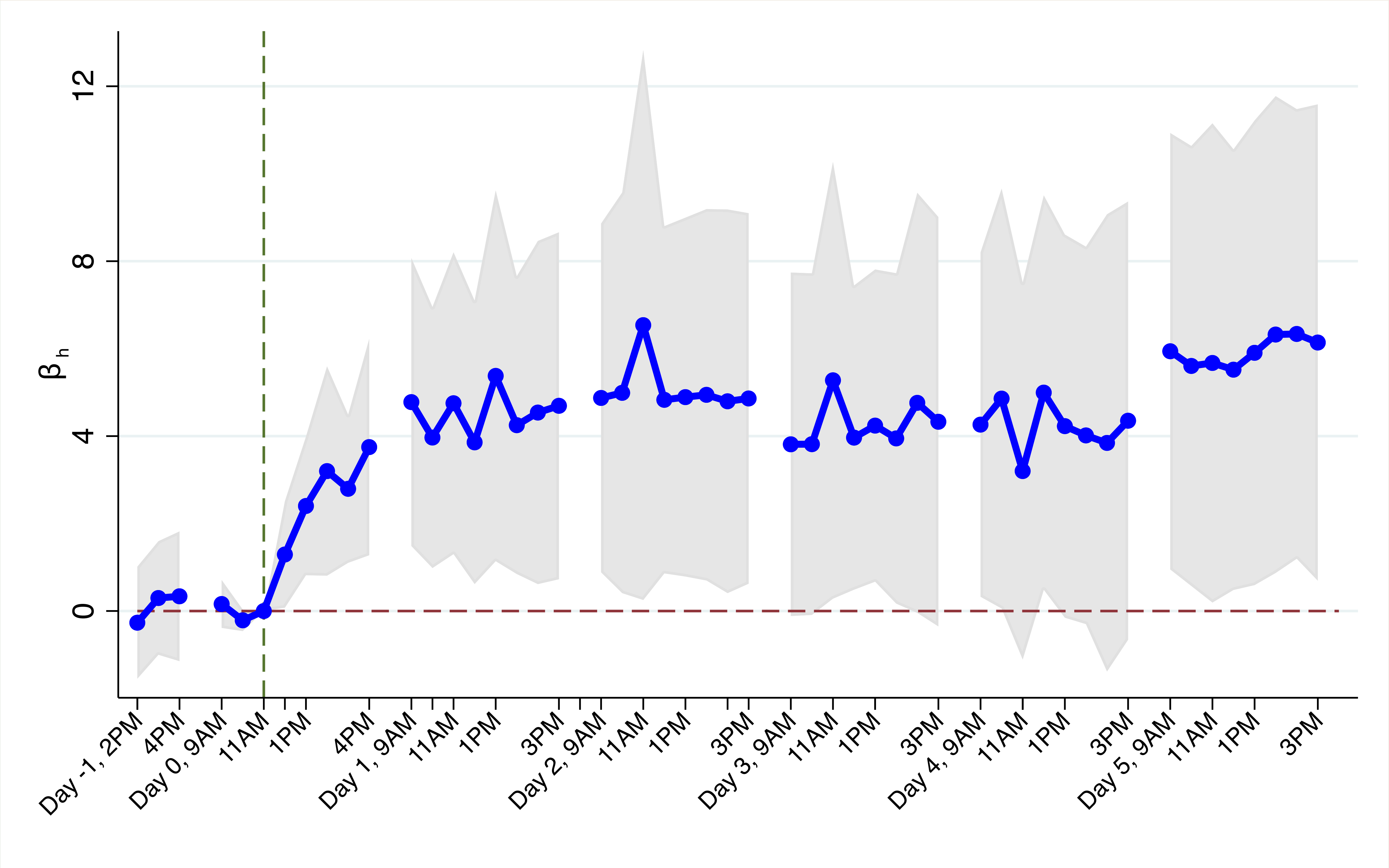
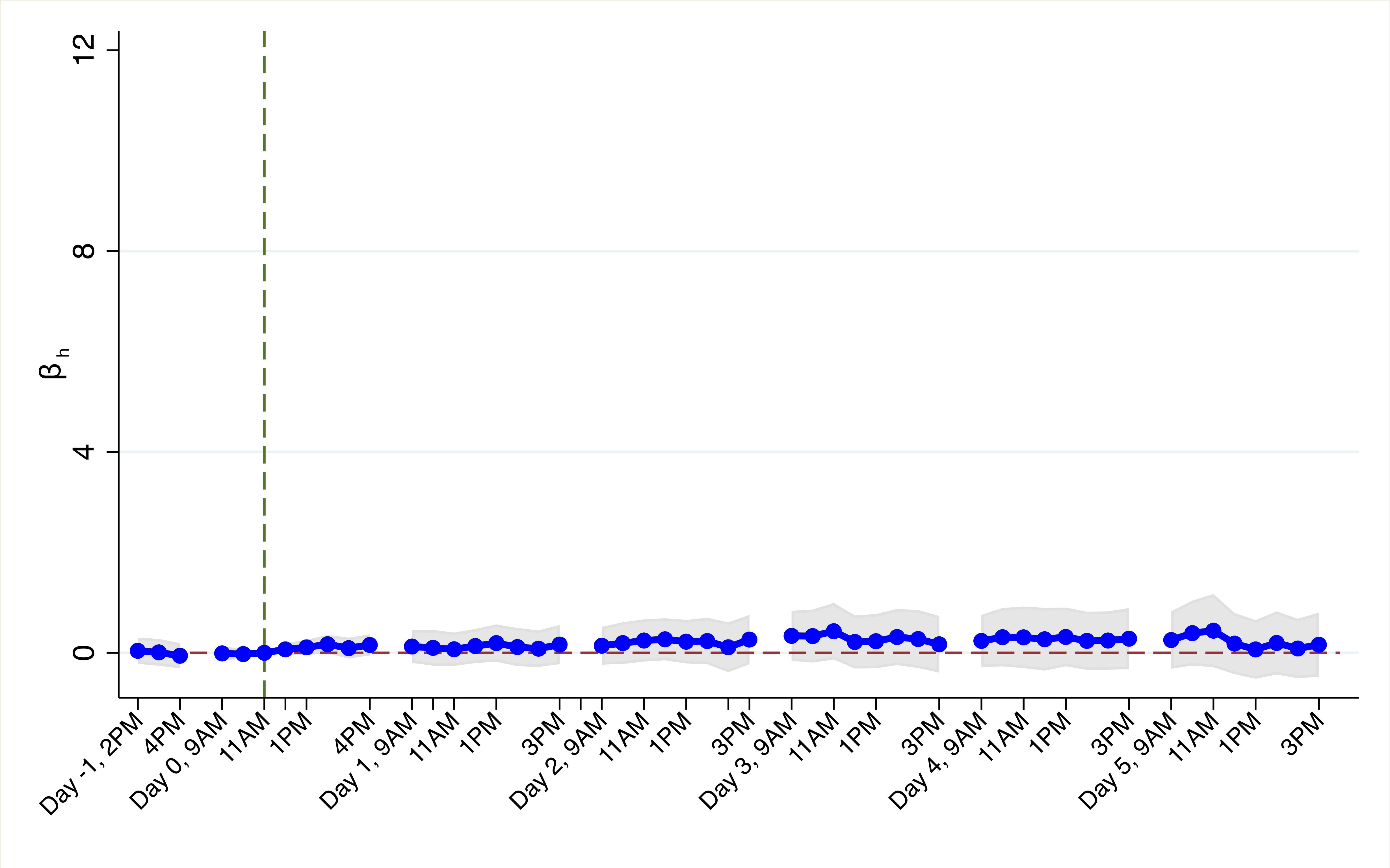


After YCC



Heterogenous Interest Rate Responses

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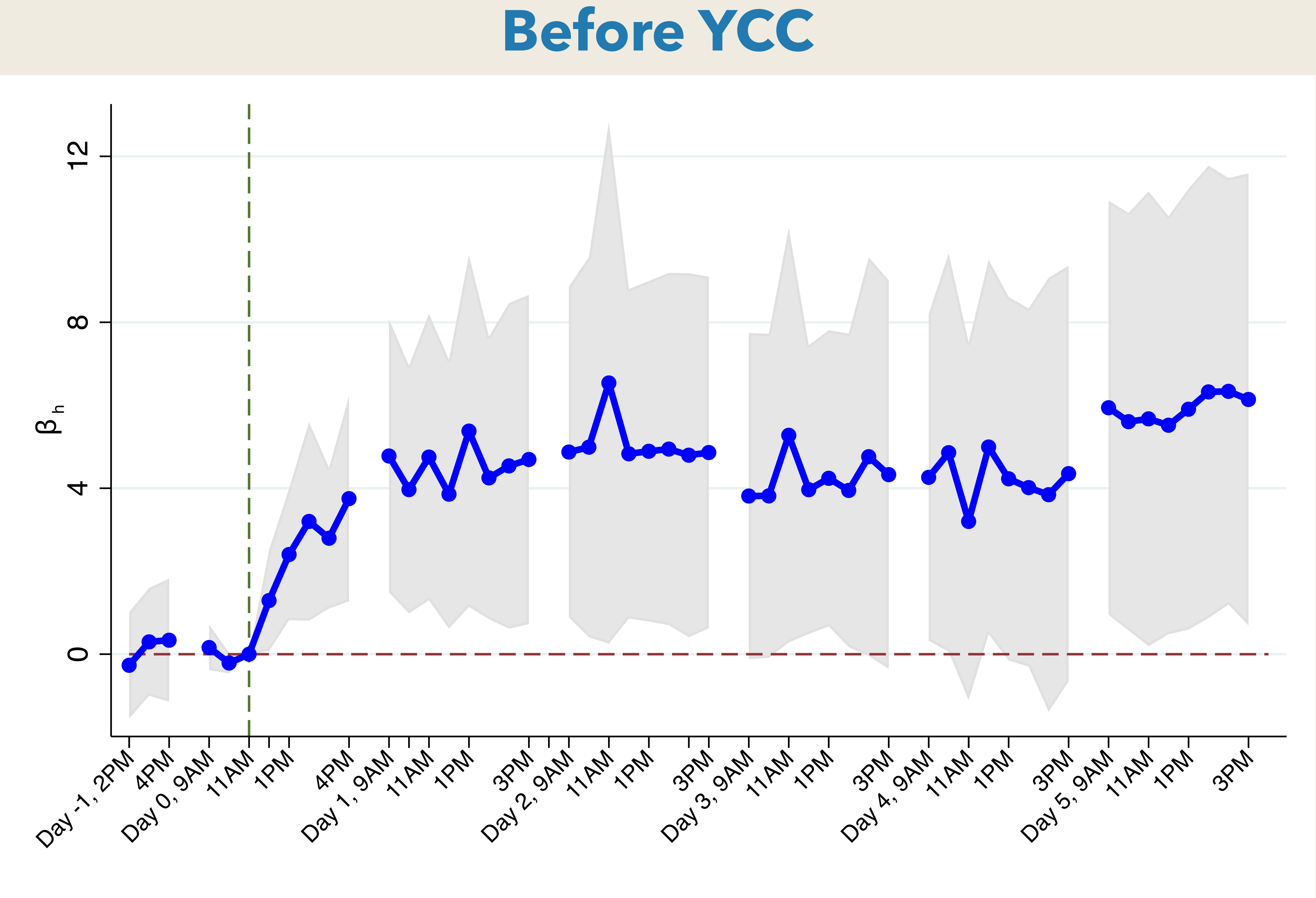
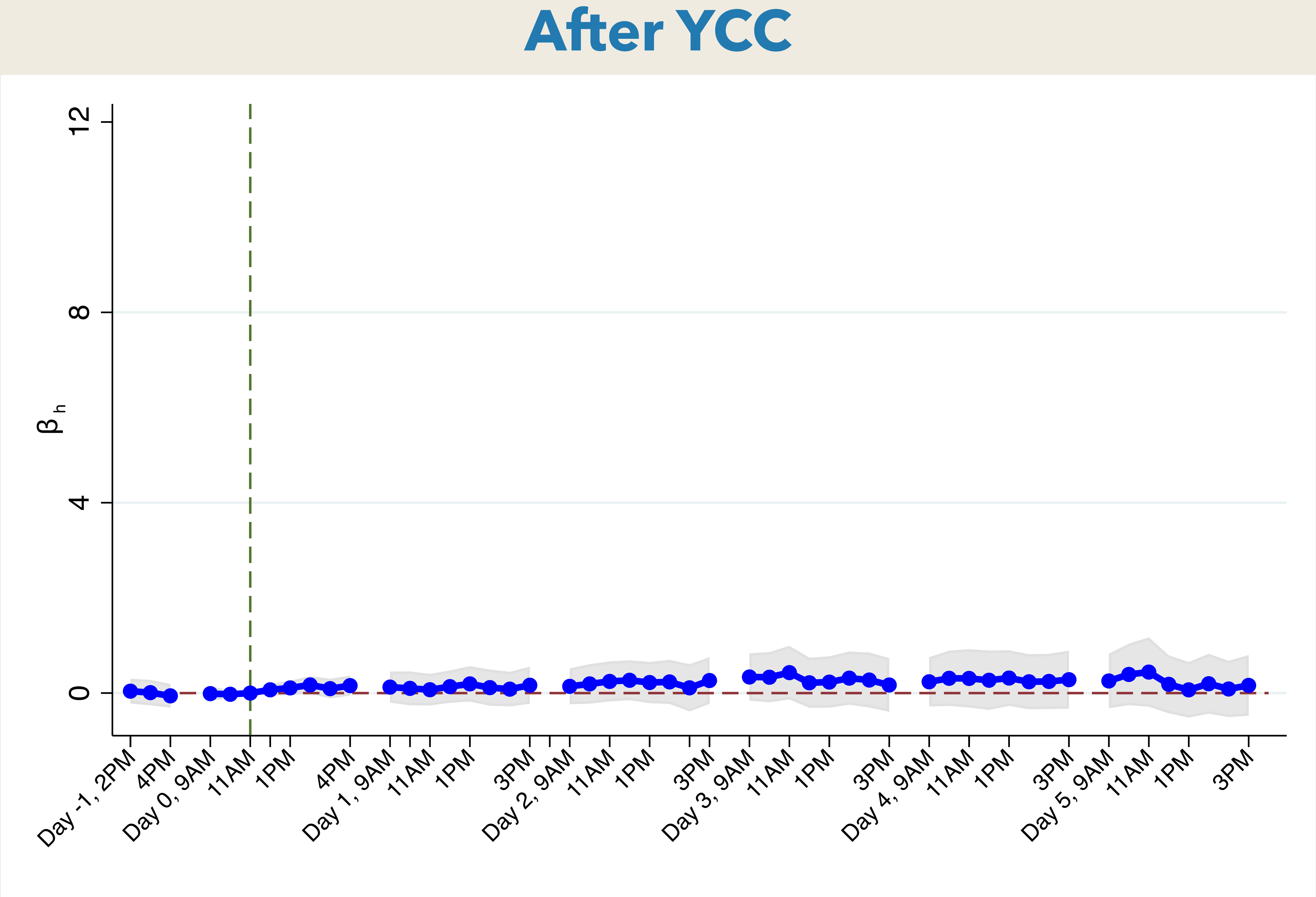
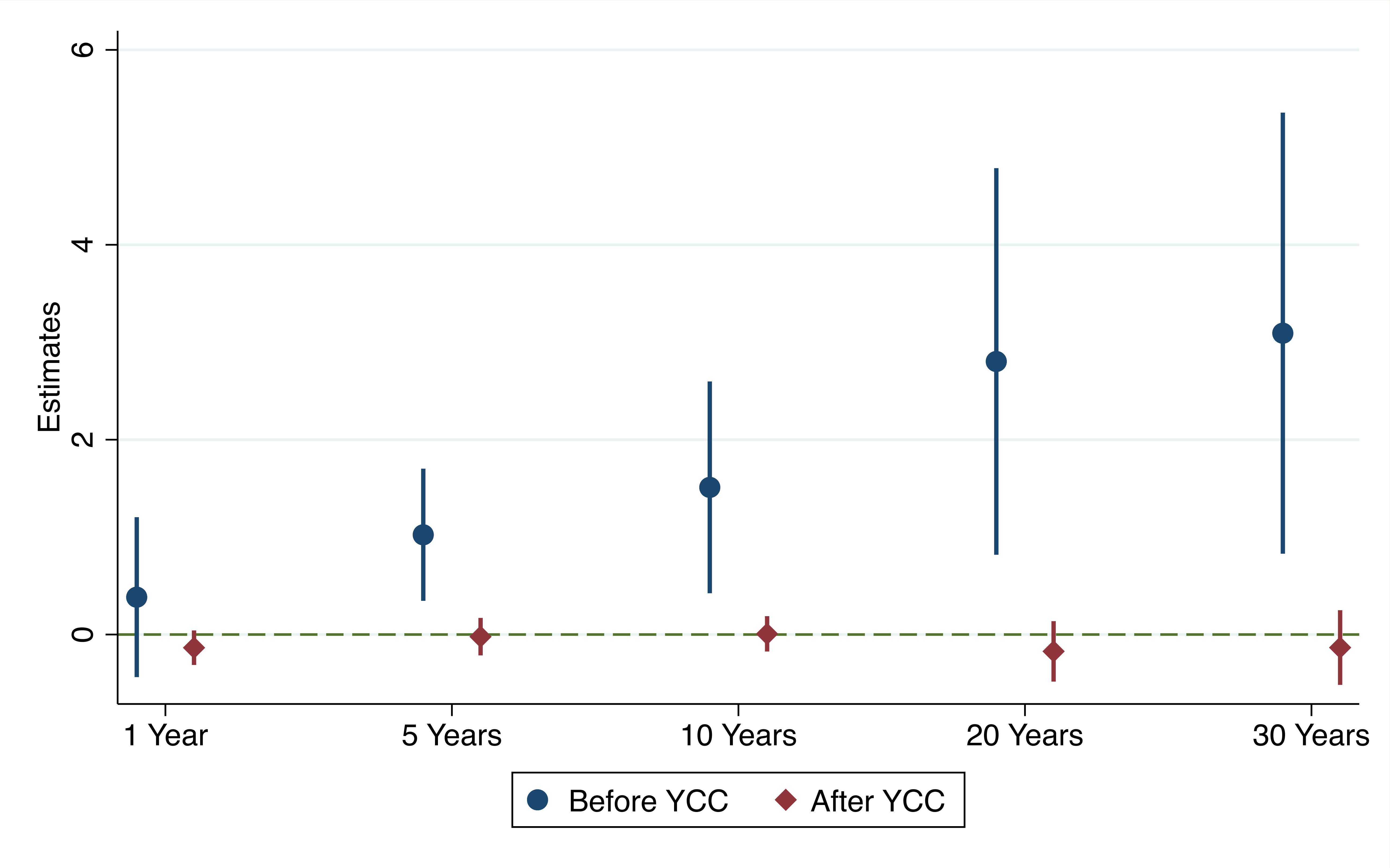




- In response to a 1% purchase of stocks by BoJ, long-term interest rate (i) rose by 4% before YCC; (ii) stopped responding after YCC

Response of Yield Curve

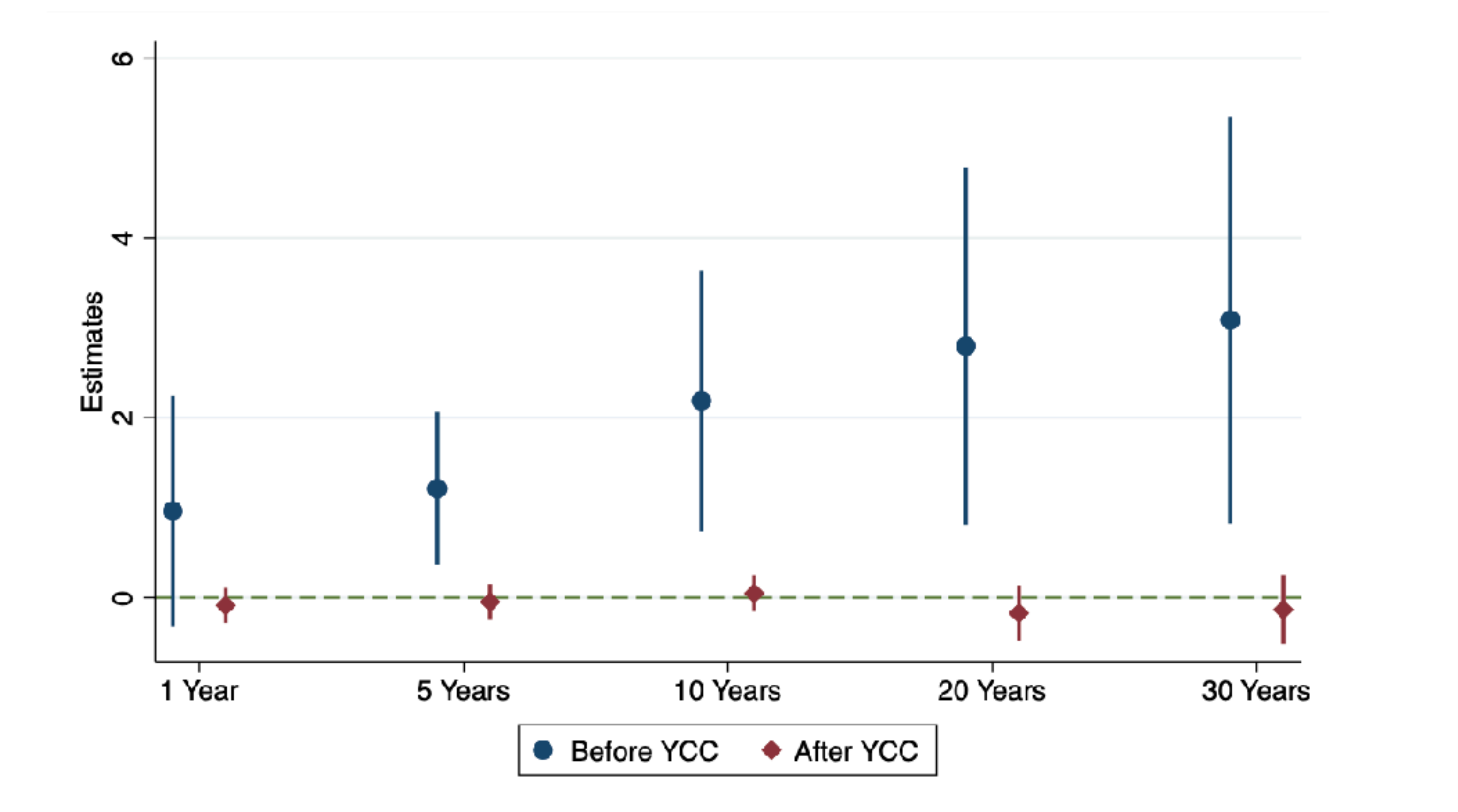
Next-day Response of Yields across Different Maturities



- Smaller responses for shorter maturity before YCC
  ⇒ Our interpretation is that ZLB prevented the response of shorter maturity

Response of Yield Curve (Yagasaki added)

Intra-day Response of Yields across Different Maturities



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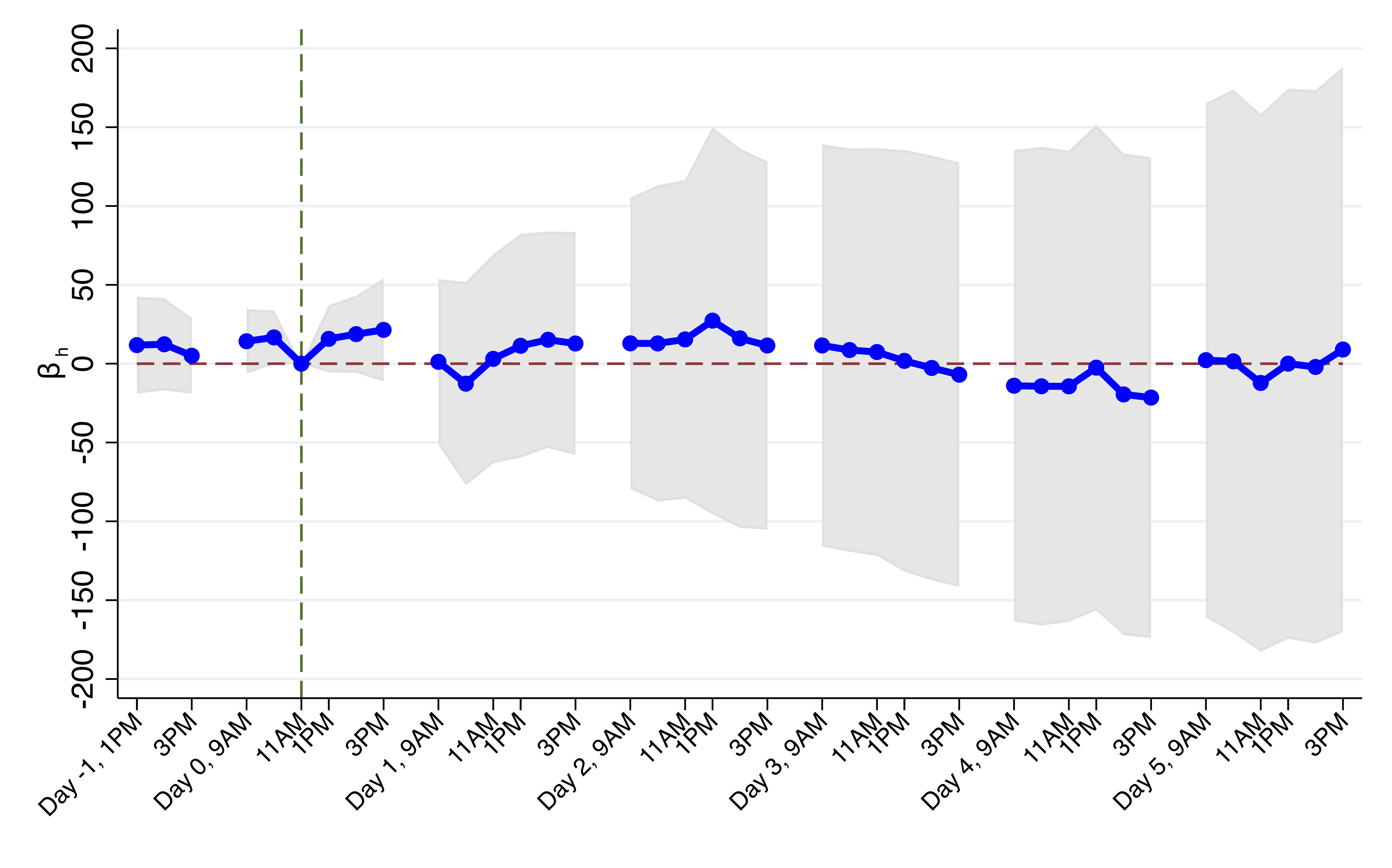
Heterogenous Stock Price Responses

Stock (TOPIX) Price Changes

Before YCC



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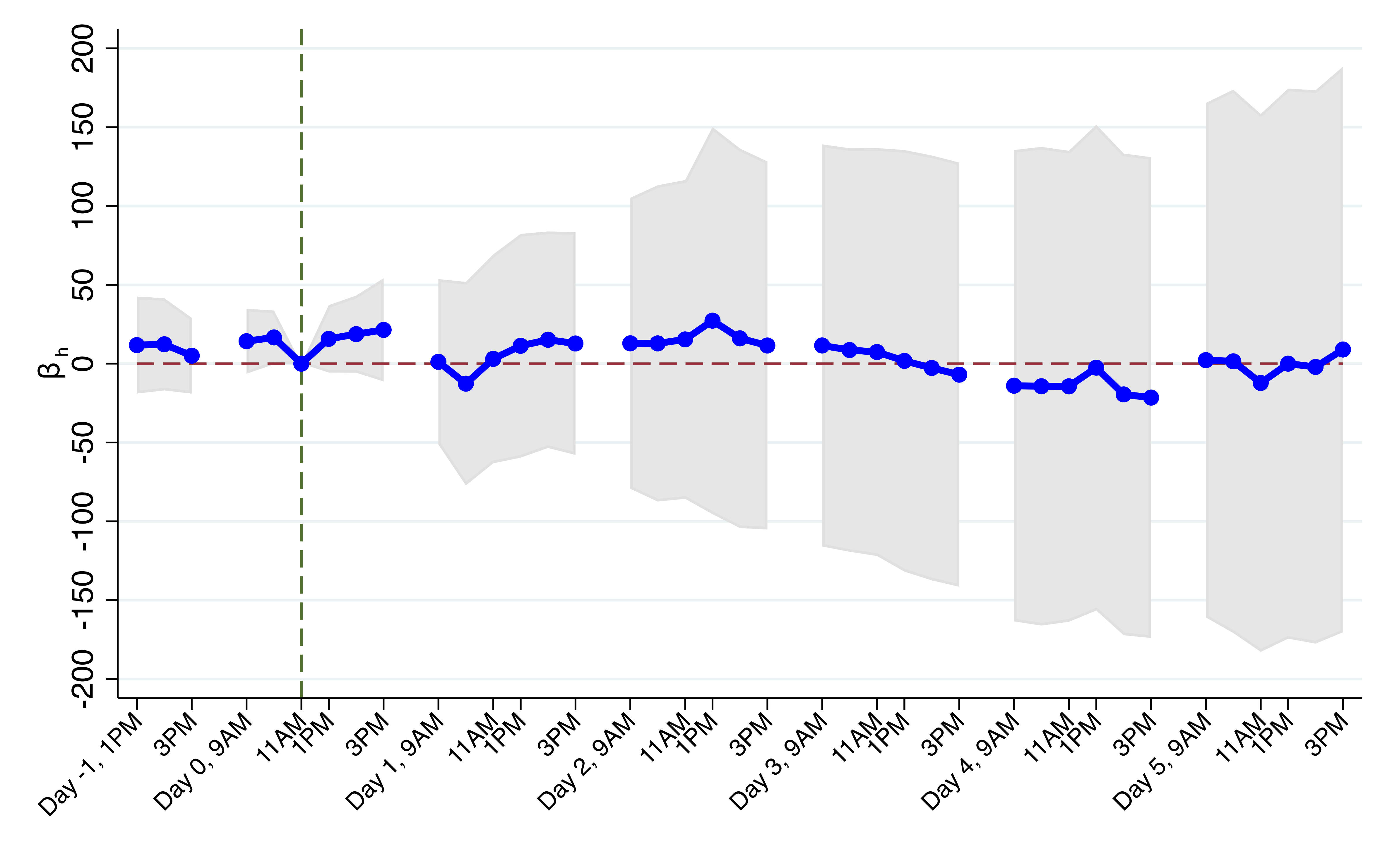

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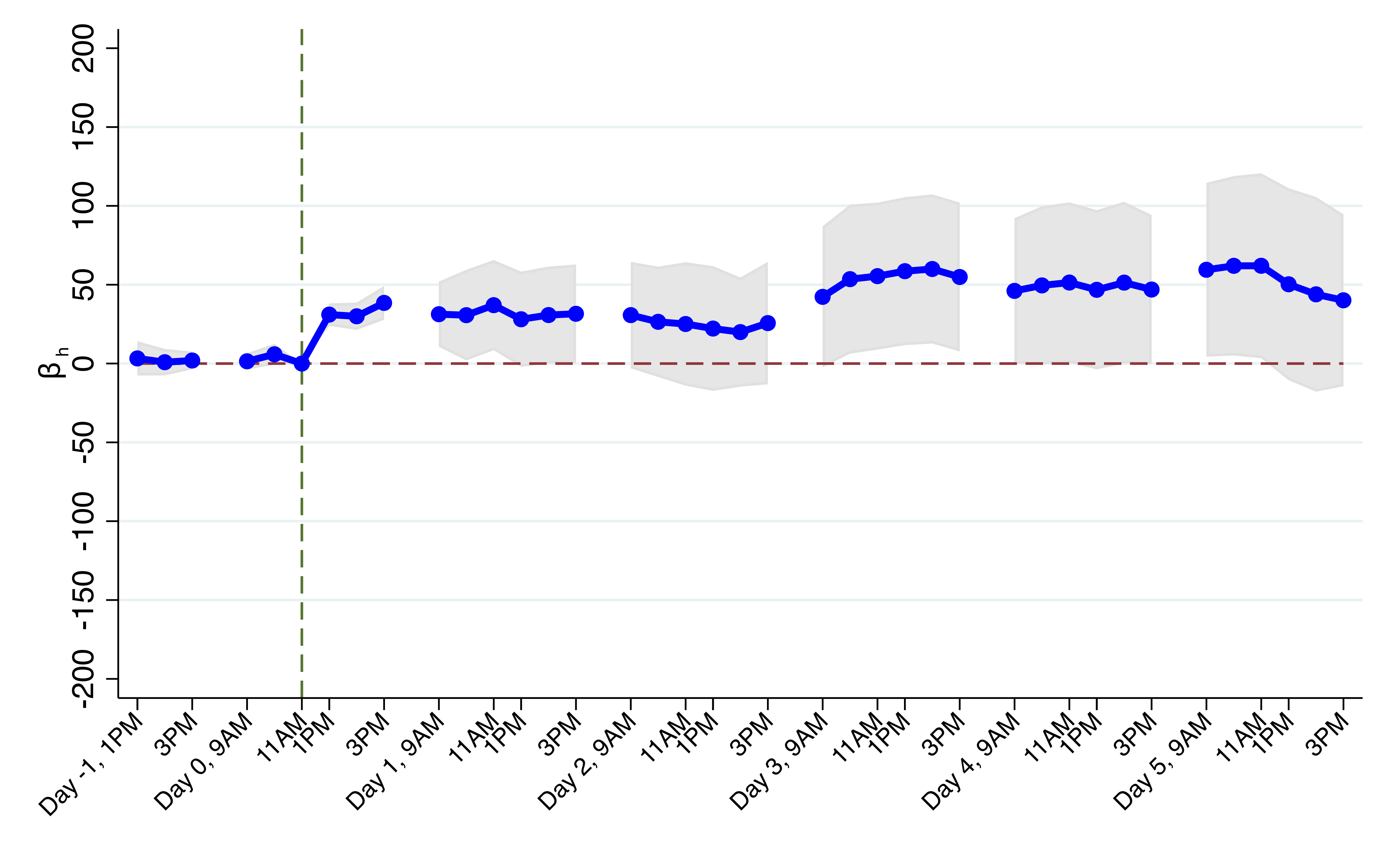

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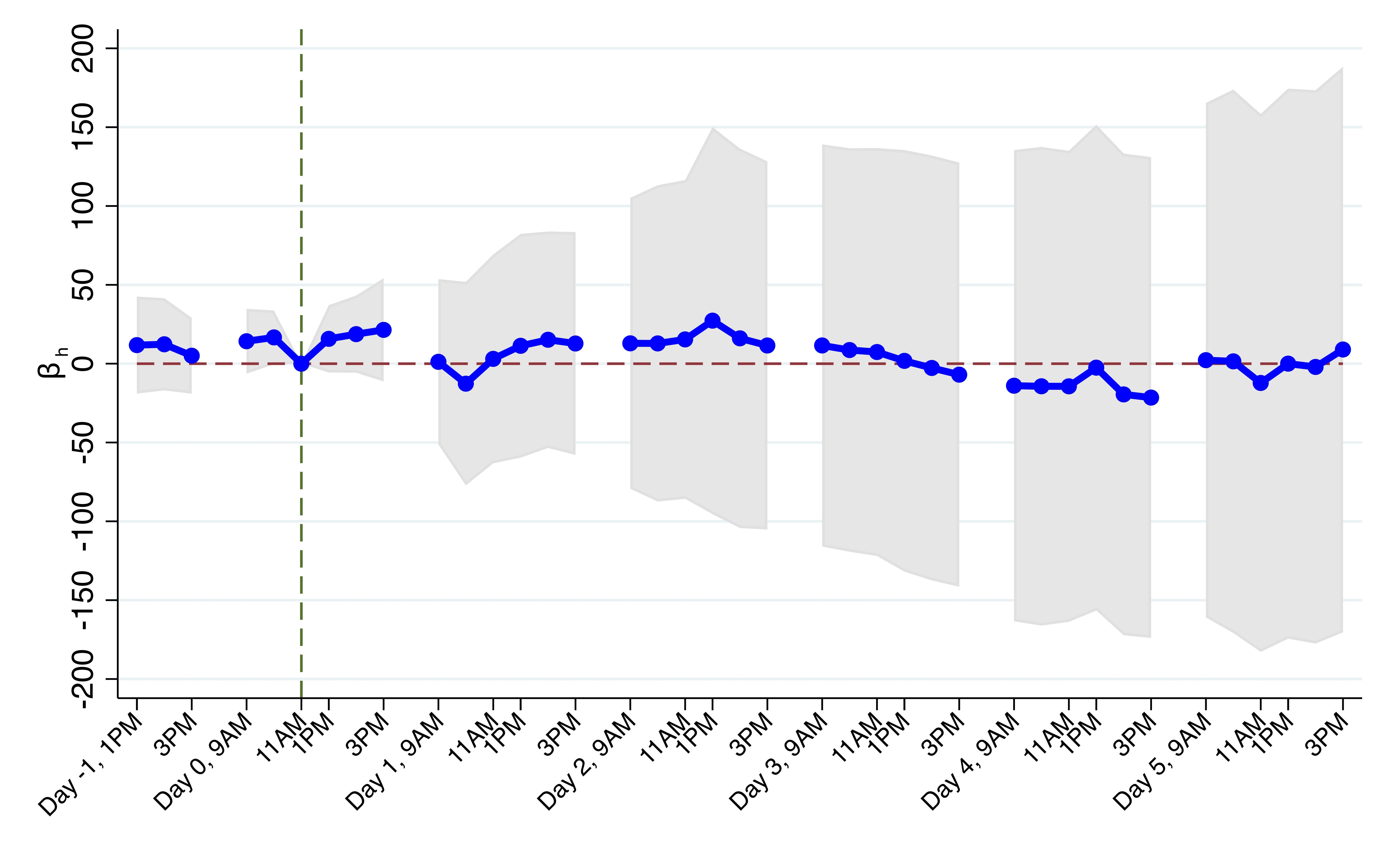

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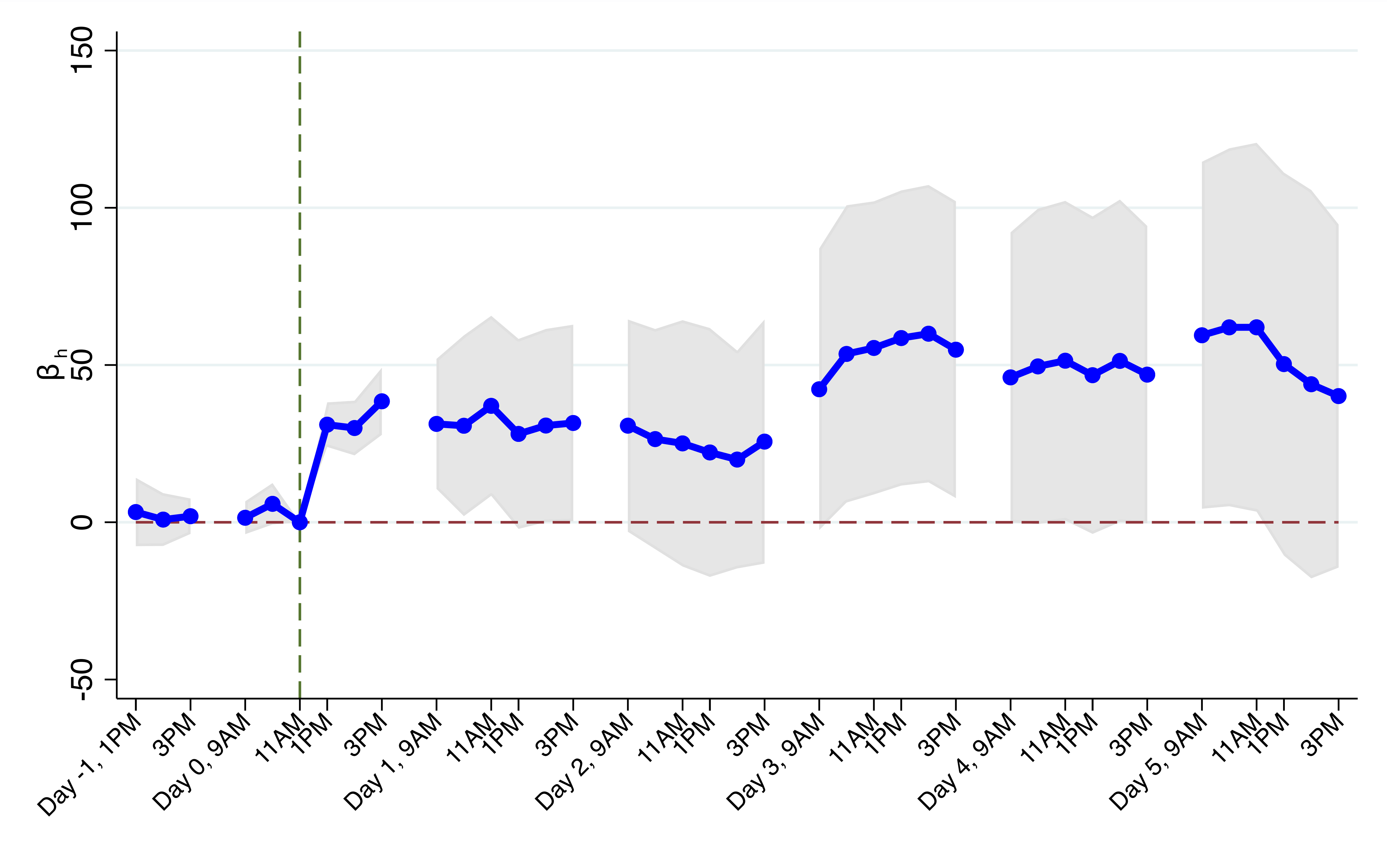

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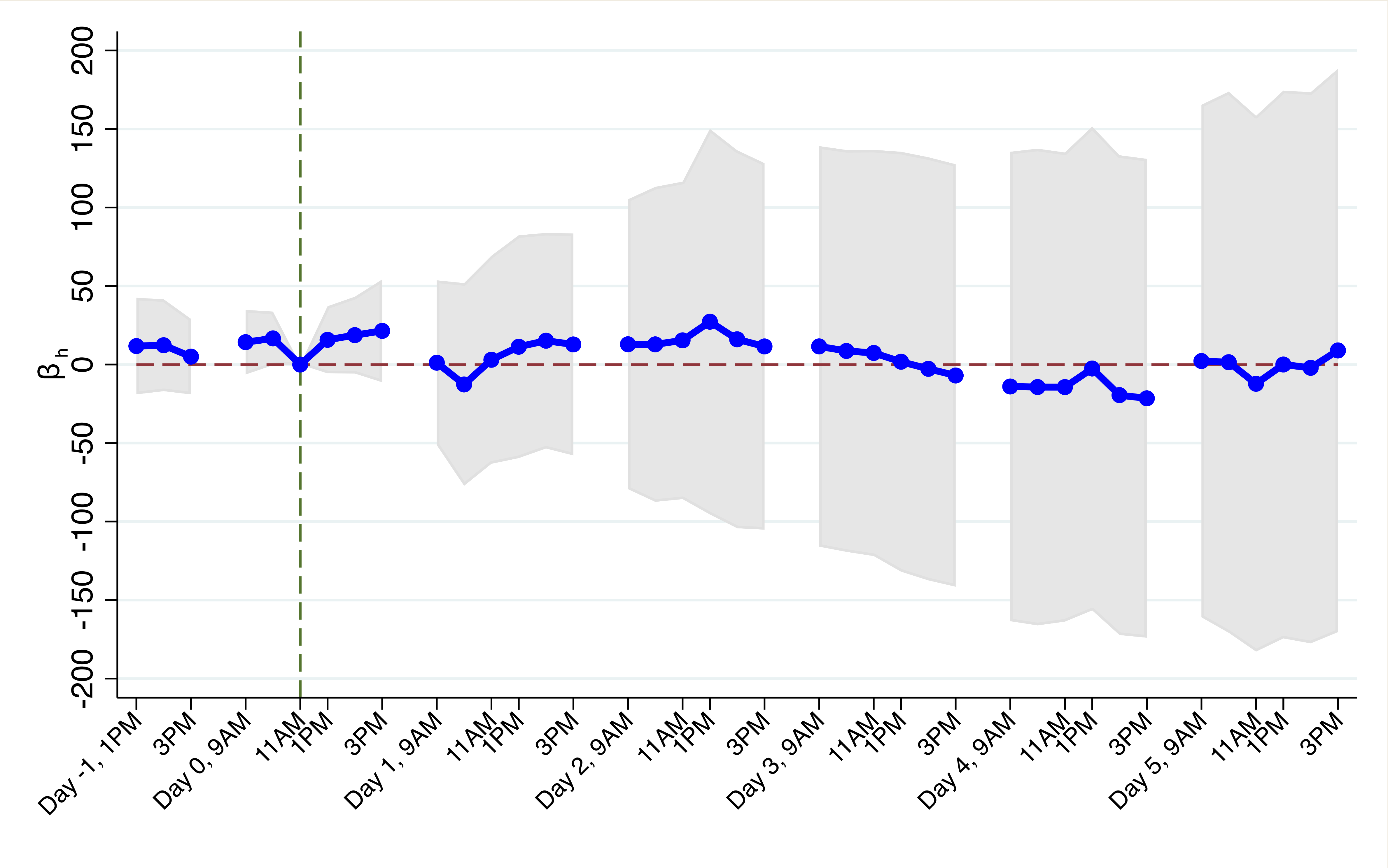

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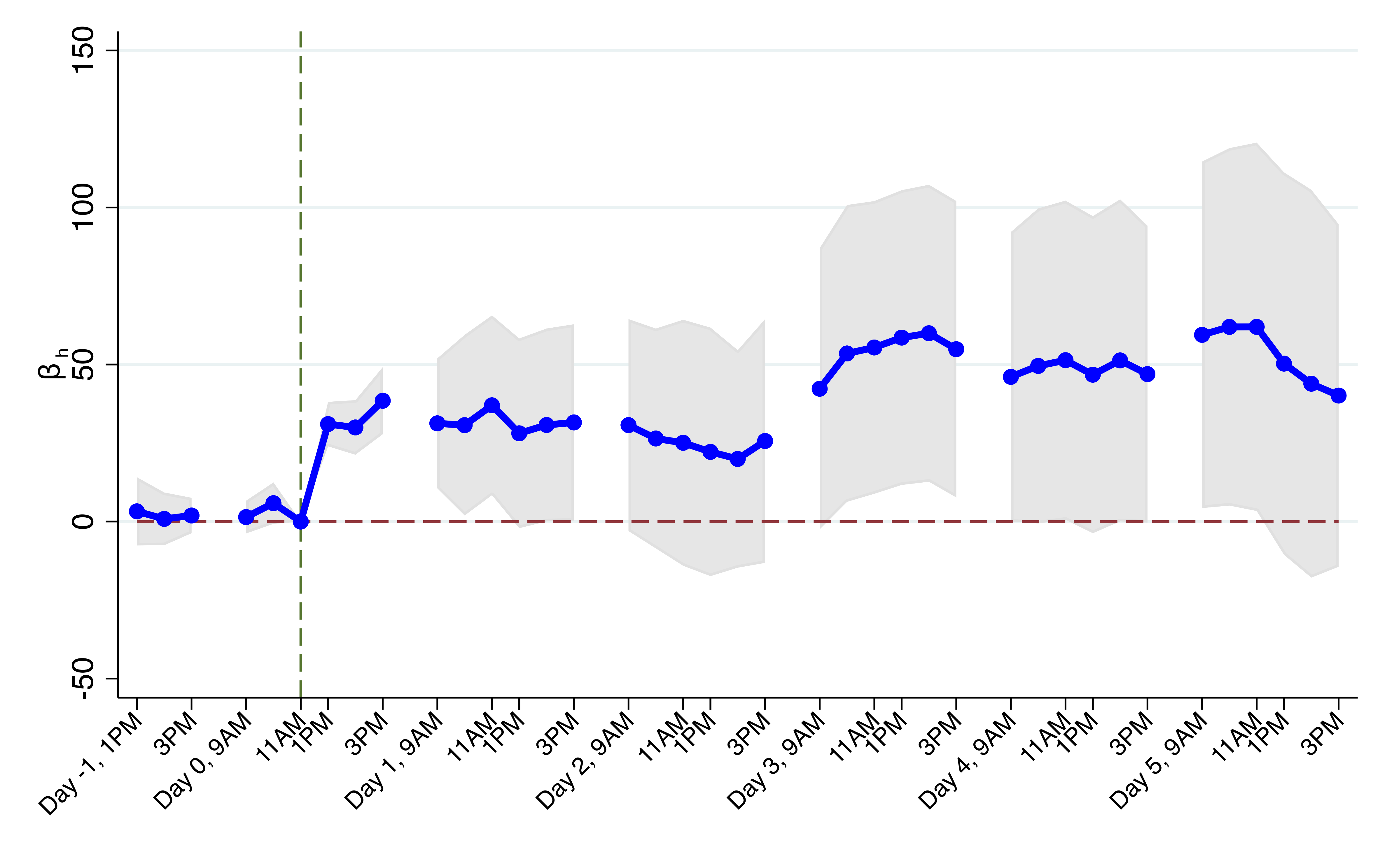
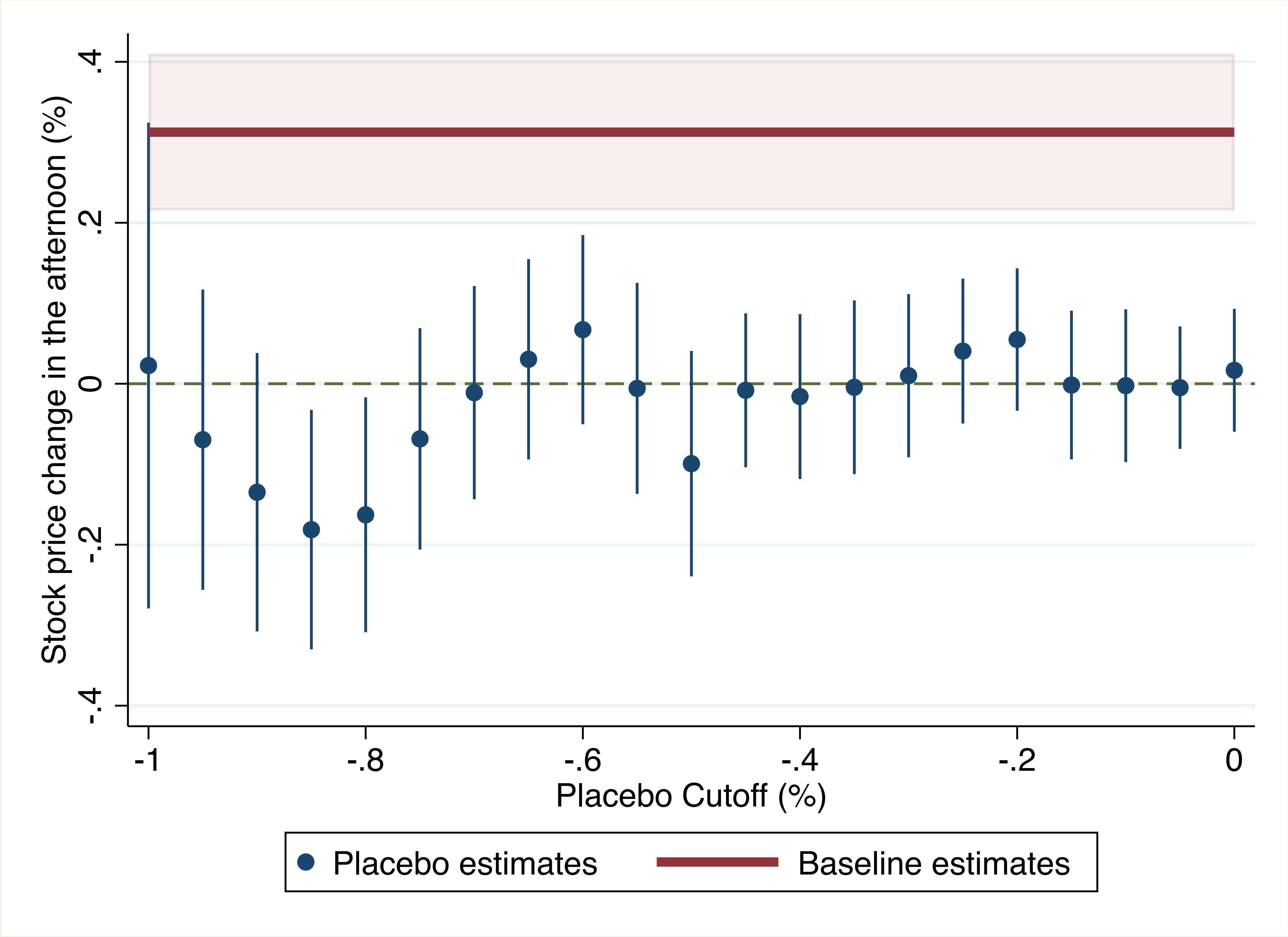


- In response to a 1% purchase of stocks by BoJ,
  (i) noisy zero effect before YCC; (ii) 40-50% increase in stock prices after YCC

Placebo Tests

- Run the same regression with arbitrary chosen cutoffs
  → no significant effect around the cutoff in which there is no policy discontinuity

Stock (TOPIX) Price



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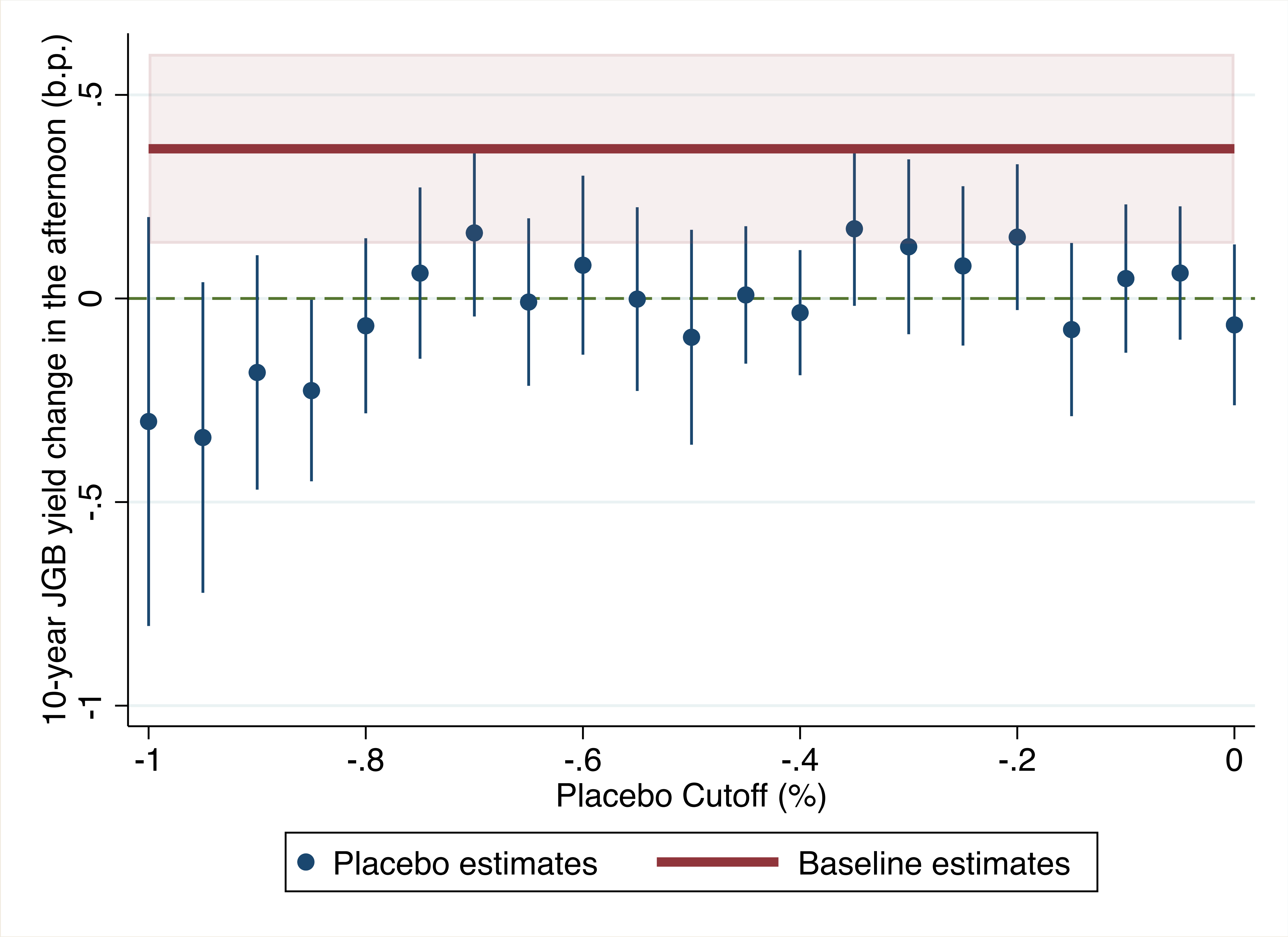

Taking Stocks

- Summary of empirical results
  1. Before YCC, BoJ stock purchases mostly ended up increasing interest rates
  2. After YCC, interest rates stopped responding and stock prices robustly rise

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  - ✓ controls for past outcomes, policies
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- Results robust to (Table)
  - ✓ alternative bandwidths & polynomial orders
  - ✓ controls for past outcomes, policies
  - ✓ dropping the periods around cut-off changes
- What do bond price responses reflect?
  - ✓ Inflation? – no significant response of inflation swap (Figure)
  - ✓ Default risk? – no significant response of credit default swap (Figure)

Preferences

- A household with preferences

$$\sum_t \beta^t [u(c_t \exp(v_b(b_t/y_t))],$$

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$$c_t + a_t = R_{t-1}a_{t-1} + D_t, \quad b_t \equiv a_t - S_t$$

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- Assets, a_t, are managed by a mutual fund:

$$\max_{S_t, w_{t+1}} \frac{(w_{t+1}\exp(-v_s(s_t - \bar{s}))^{1-\gamma}}{1-\gamma}$$

s.t. $\quad w_{t+1} = R_t^s S_t + R_t(a_t - S_t) - T_t$

$$s_t \equiv S_t/a_t, \qquad D_{t+1} \equiv w_{t+1} - R_t a_t$$

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Mandate, inattention, etc

$$v_s'(0) = 0, v_s'' > 0$$

s.t. $\quad w_{t+1} = R_t^s S_t + R_t(a_t - S_t) - T_t$

$$s_t \equiv S_t/a_t, \qquad D_{t+1} \equiv w_{t+1} - R_t a_t$$

Closing the Model

- A fixed supply of capital, k:

$$y_t = A_t k, \quad \log(A_{t+1}/A_t) \sim N(g - \sigma^2/2, \sigma^2)$$

- Return on stock is

$$R_t^s = \frac{A_{t+1} + p_{t+1}}{p_t}$$

- Central bank's budget constraint

$$S_t^{CB} + B_t^{CB} = R_{t-1}^s S_{t-1}^{CB} + R_{t-1} B_{t-1}^{CB} + T_t$$

- Market clearing

$$c_t = y_t$$

$$s_t a_t + S_t^{CB} = p_t k$$

$$b_t + B_t^{CB} = 0$$

Steady State and Shock

- Along the BGP without the Central Bank, $\{R, p_t\}$ solve

$$1 - v_b'(0) = \beta R \mathbb{E} \frac{u'(y_{t+1} \exp v_b(0))}{u'(y_t \exp v_b(0))}$$

$$p_t / A_t \approx \frac{1}{r + \gamma \sigma^2 - g} \equiv \bar{p} \,. \quad r \equiv R - 1$$

- Consider the impact of permanent Central Bank stock purchases around the BGP:

$$ds_t^{CB} \equiv \frac{dS_t^{CB}}{p_t k} = - \frac{dB_t^{CB}}{p_t k} > 0, \quad \text{for all } t \geq 0$$

Identification

κ_p: Stock market inelasticity *holding R fixed*

$$d \ln p_t \approx \frac{1}{r + \gamma\sigma^2 - g} v_s''(0) ds^{CB} - \frac{1}{r + \gamma\sigma^2 - g} d \ln R$$

γ_r: Interest rate sensitivity of stock price

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- Frictionless model: $d \ln p_t = d \ln R_t = 0$
- Inelastic stock market model (Gabaix & Koijen, 2020): $d \ln p_t > 0, d \ln R_t = 0$
- Identification using the estimates before YCC ($d \ln p_t \approx 0, d \ln R_t = 1.4$)

  $\Rightarrow \kappa_p - \gamma_r \kappa_b \approx 0$ & $\kappa_b = 1.4$

Over-identification Test

- With YCC, the Central Bank finances stock purchases with lump-sum tax

$$ds_t^{CB} \equiv \frac{dS_t^{CB}}{p_t k} > 0, \quad \frac{dB_t^{CB}}{p_t k} = 0 \qquad \Rightarrow \qquad d \ln R_t = 0$$

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- The impact on stock prices will be

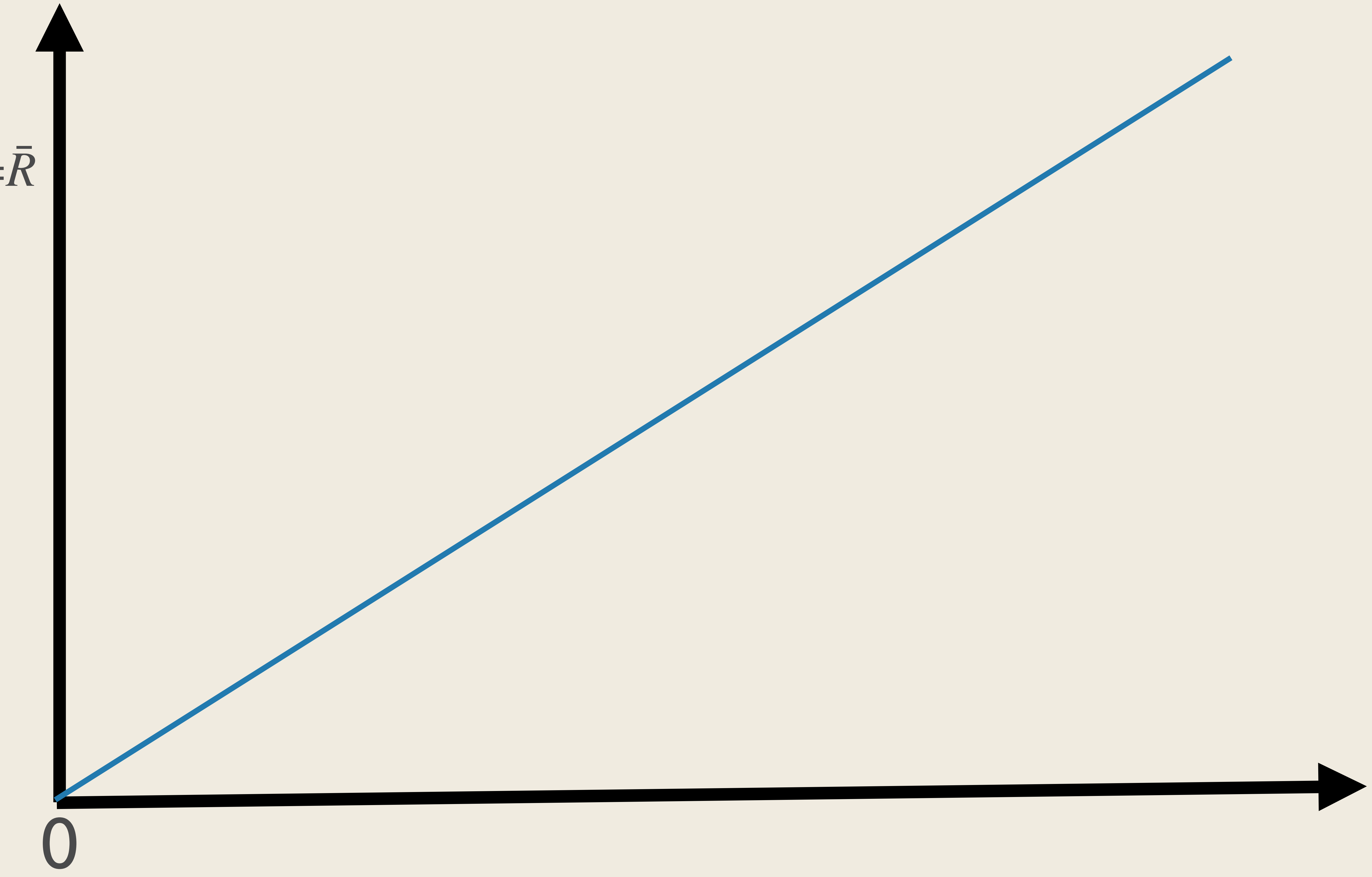
$$d \ln p_t = \kappa_s ds_t^{CB}$$

  - ✓ We found $d \ln p_t \approx 22$. This implies $\kappa_s \approx 22$
  - ✓ These moments will exactly identify $(\kappa_s, \kappa_b,) \approx (22{,}1.4)$
  - ✓ As a byproduct, we recover γ_r = -15.
    Existing estimates of γ_r range from -10 to -16 (Kubota & Shintani 2021)

Taking Stock

Stock inelasticity

$$\kappa_s \equiv \left.\frac{\partial \ln p_t}{\partial \ln s^{CB}}\right|_{R=\bar{R}}$$



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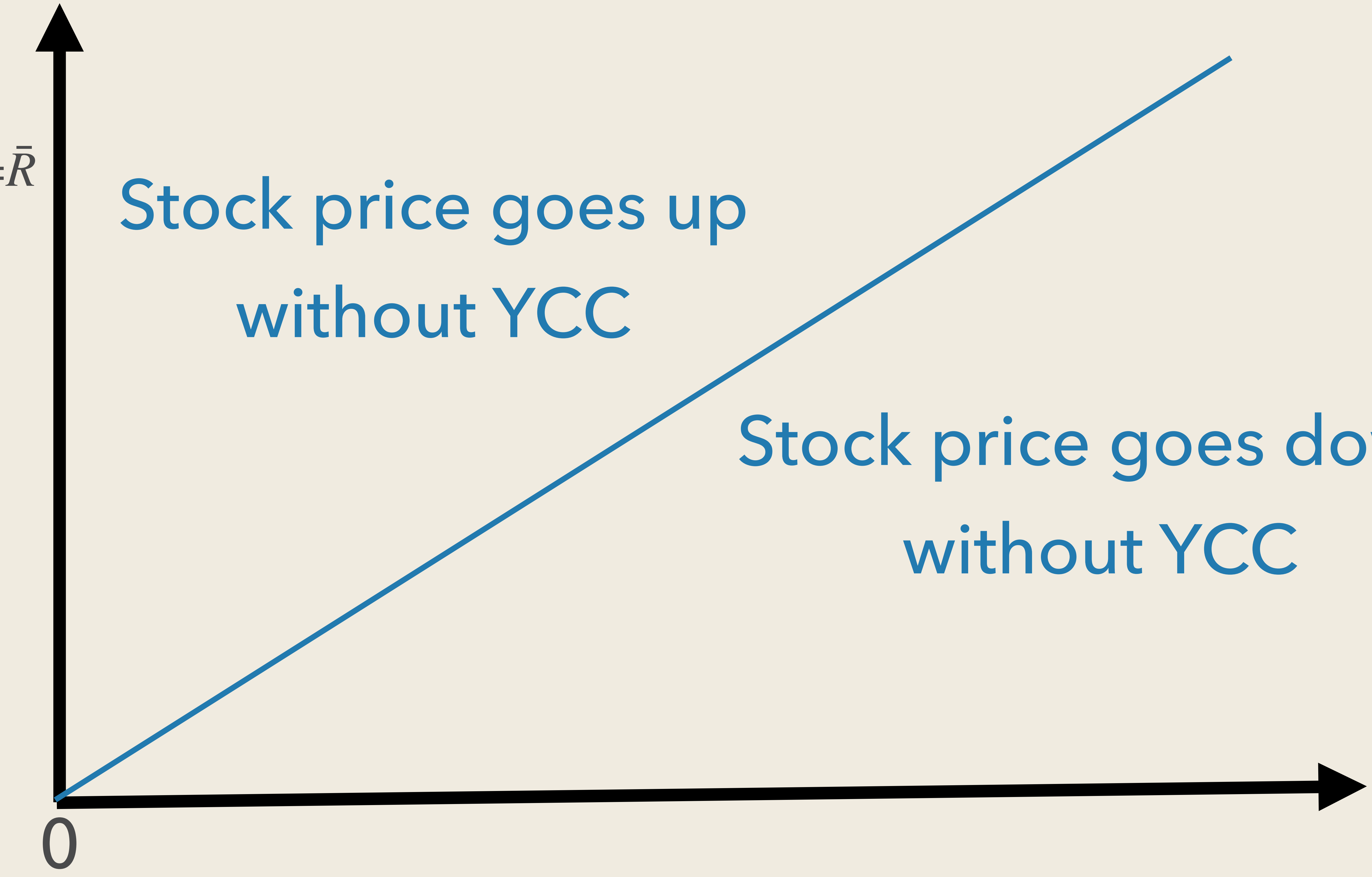

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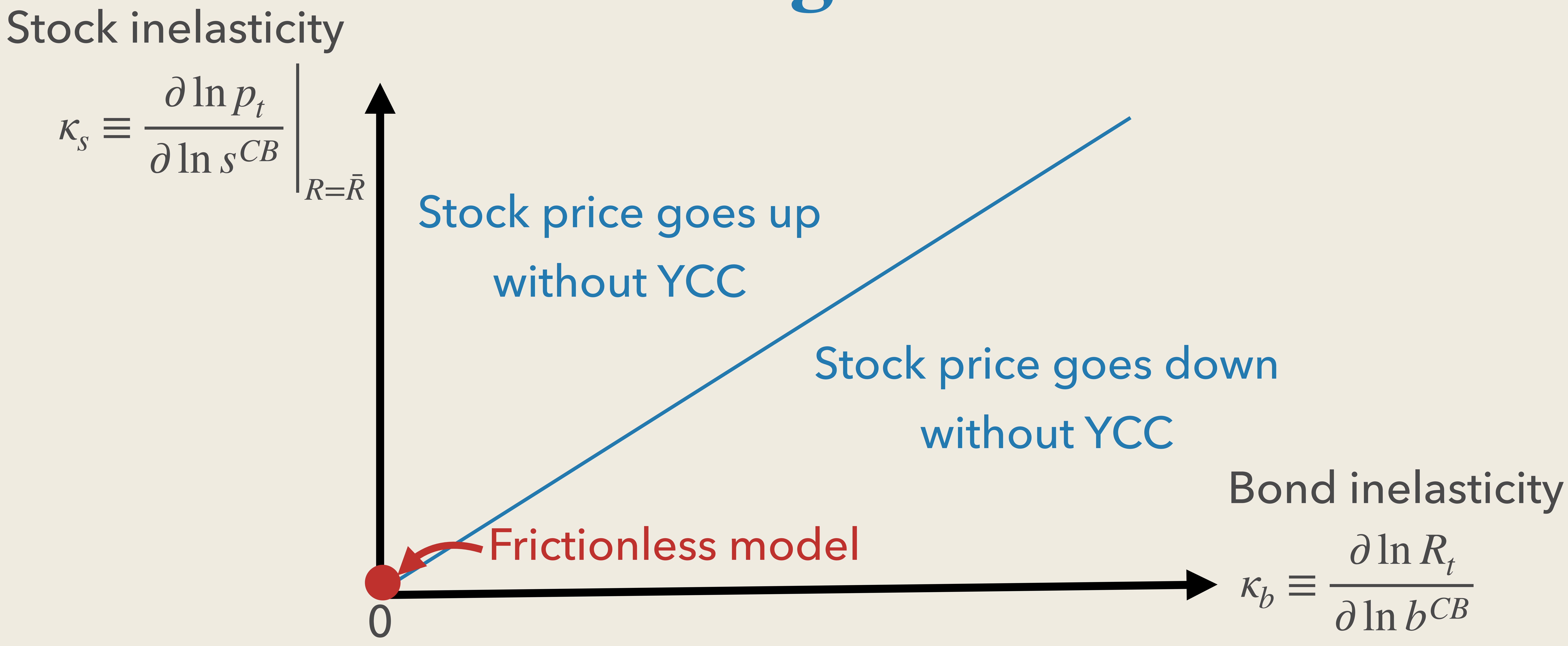

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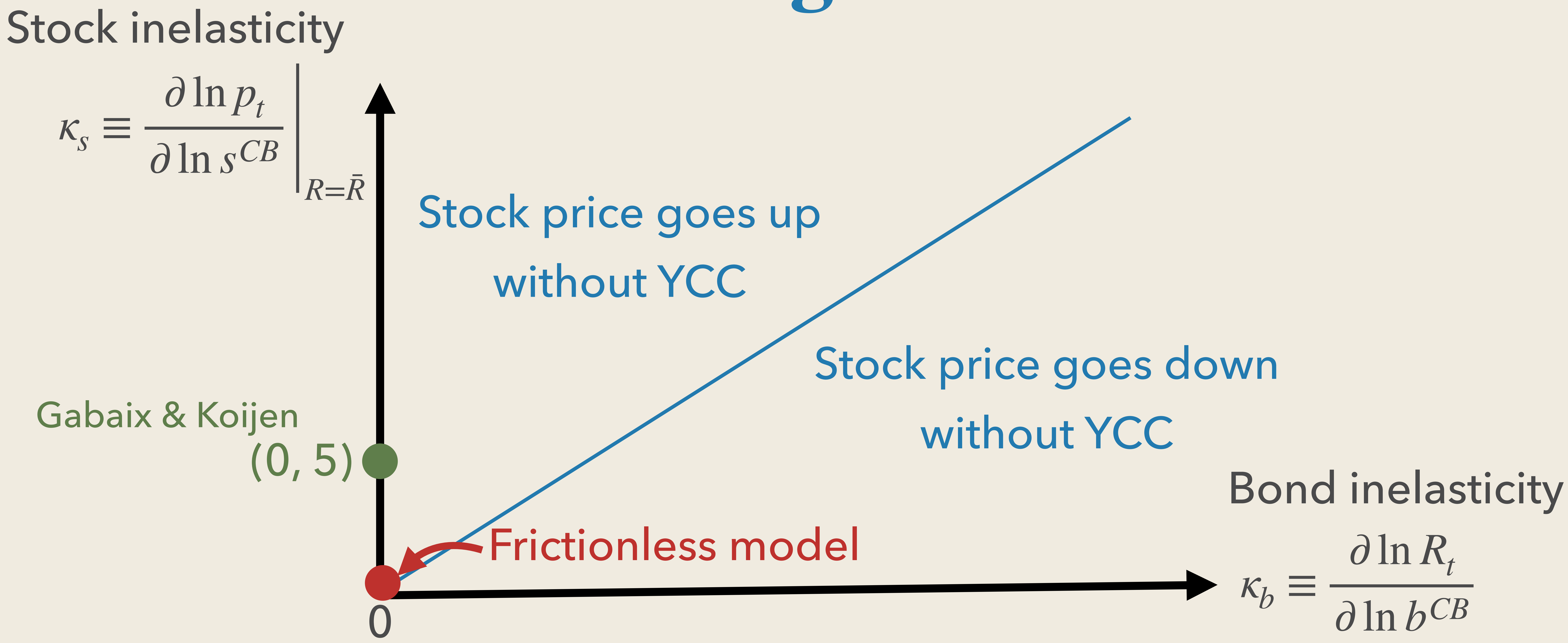

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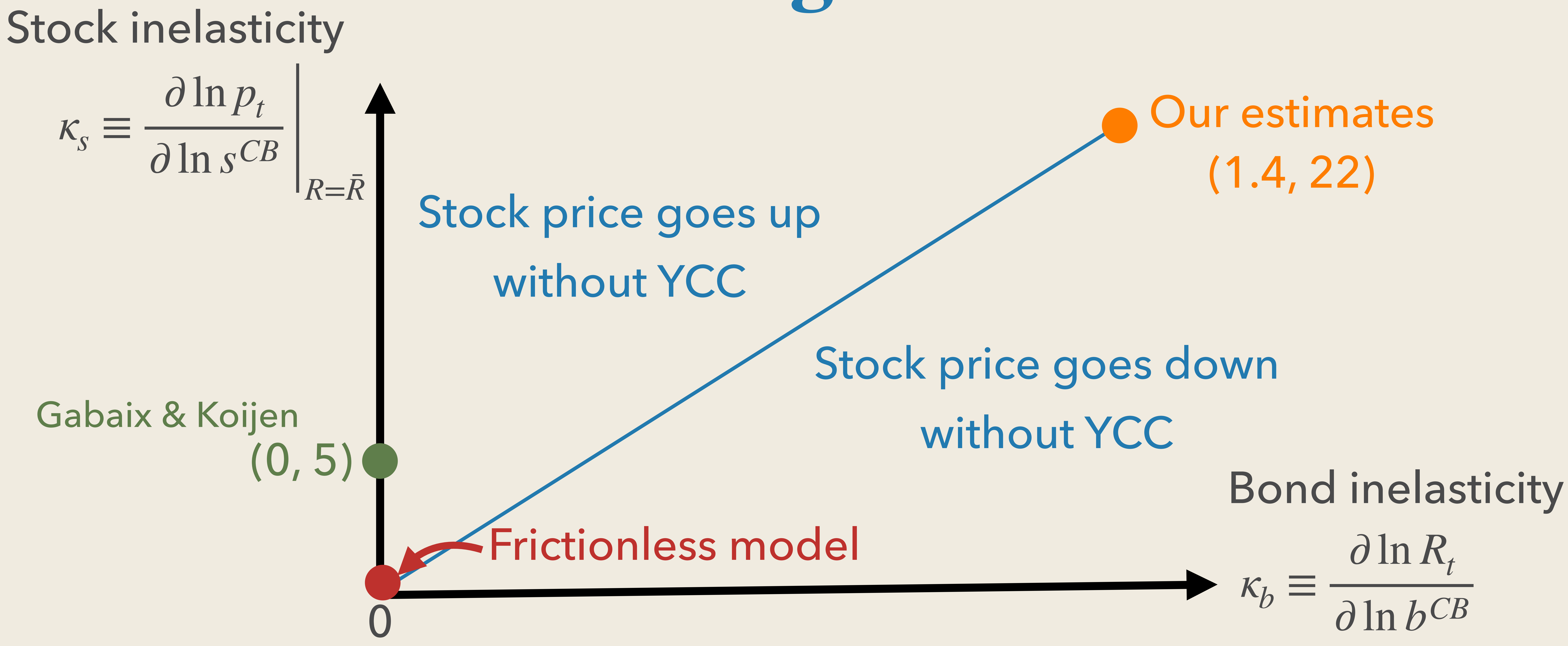

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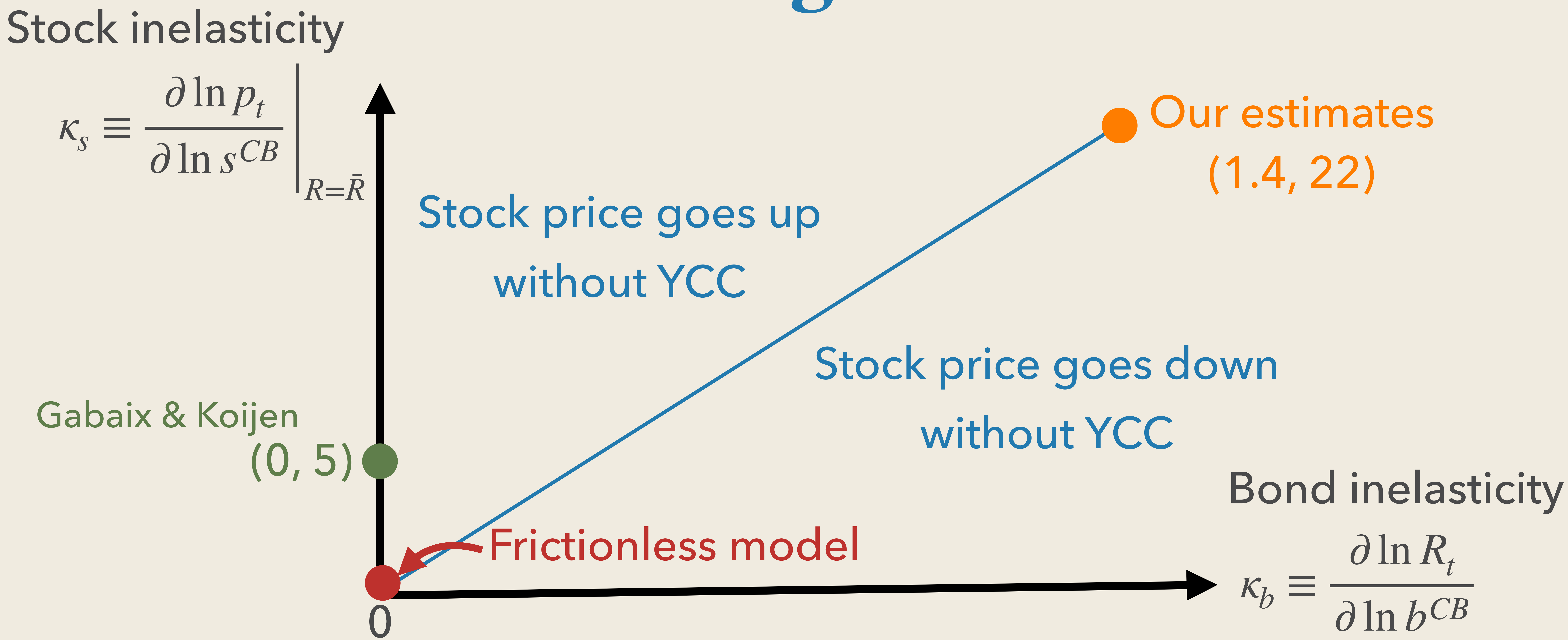

- Flows may not explain stock price volatility, without constraints on interest rates

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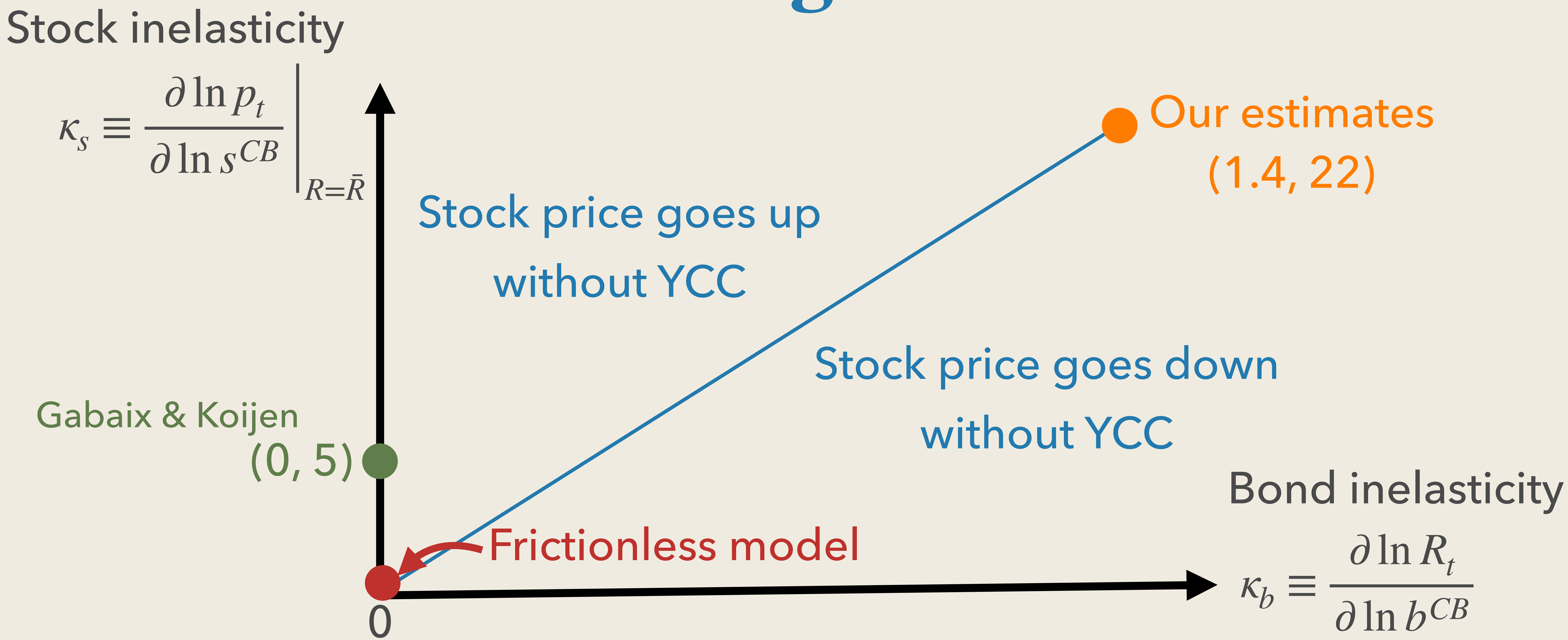
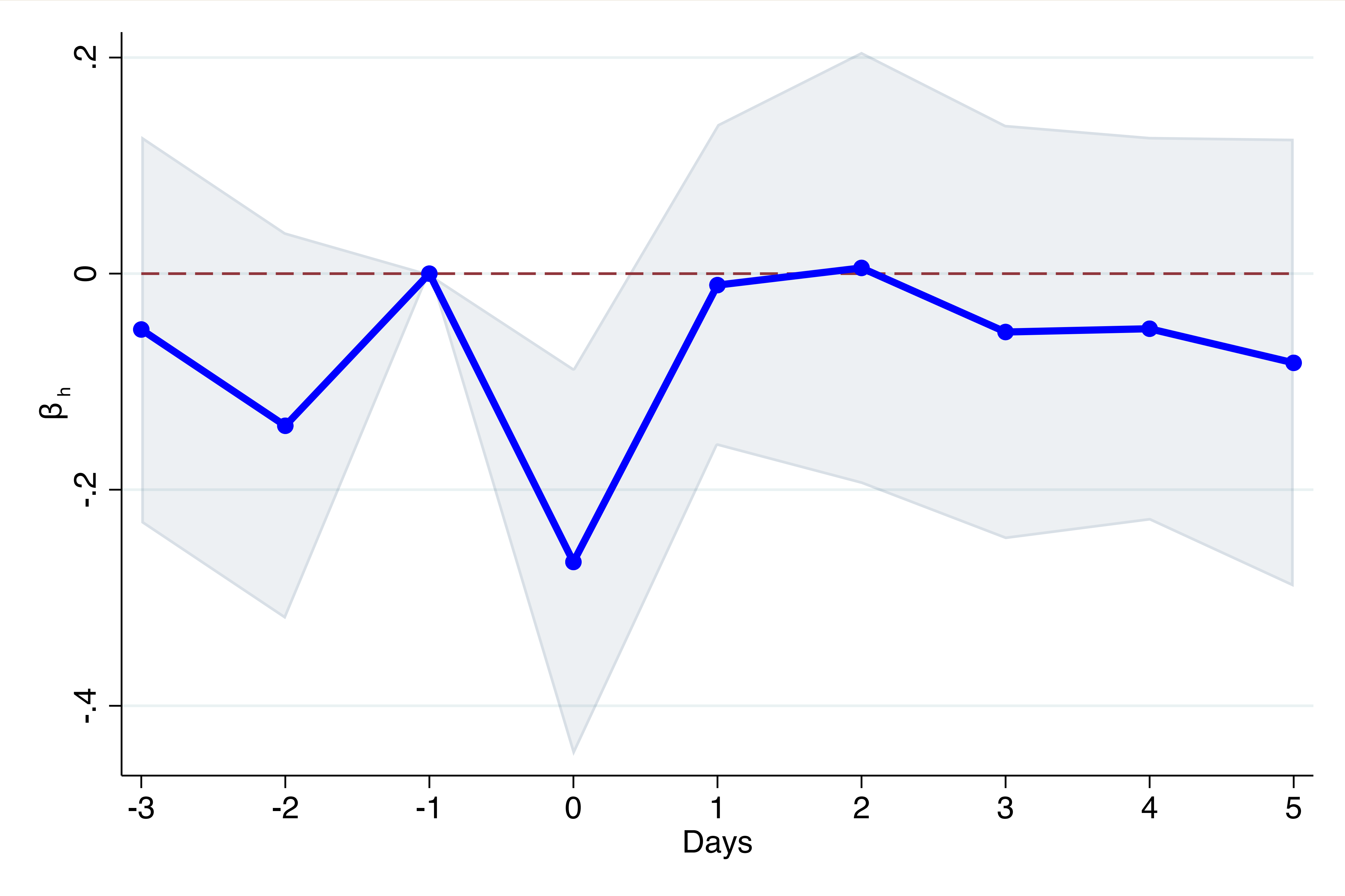


- Flows may not explain stock price volatility, without constraints on interest rates
- But it may help explain why interest rate in the data is ten times more volatile than RBC (Winberry, 2020)

Exploration of Real Effect

Response of Newspaper Sentiments

- Newspaper sentiments negatively react to interventions:

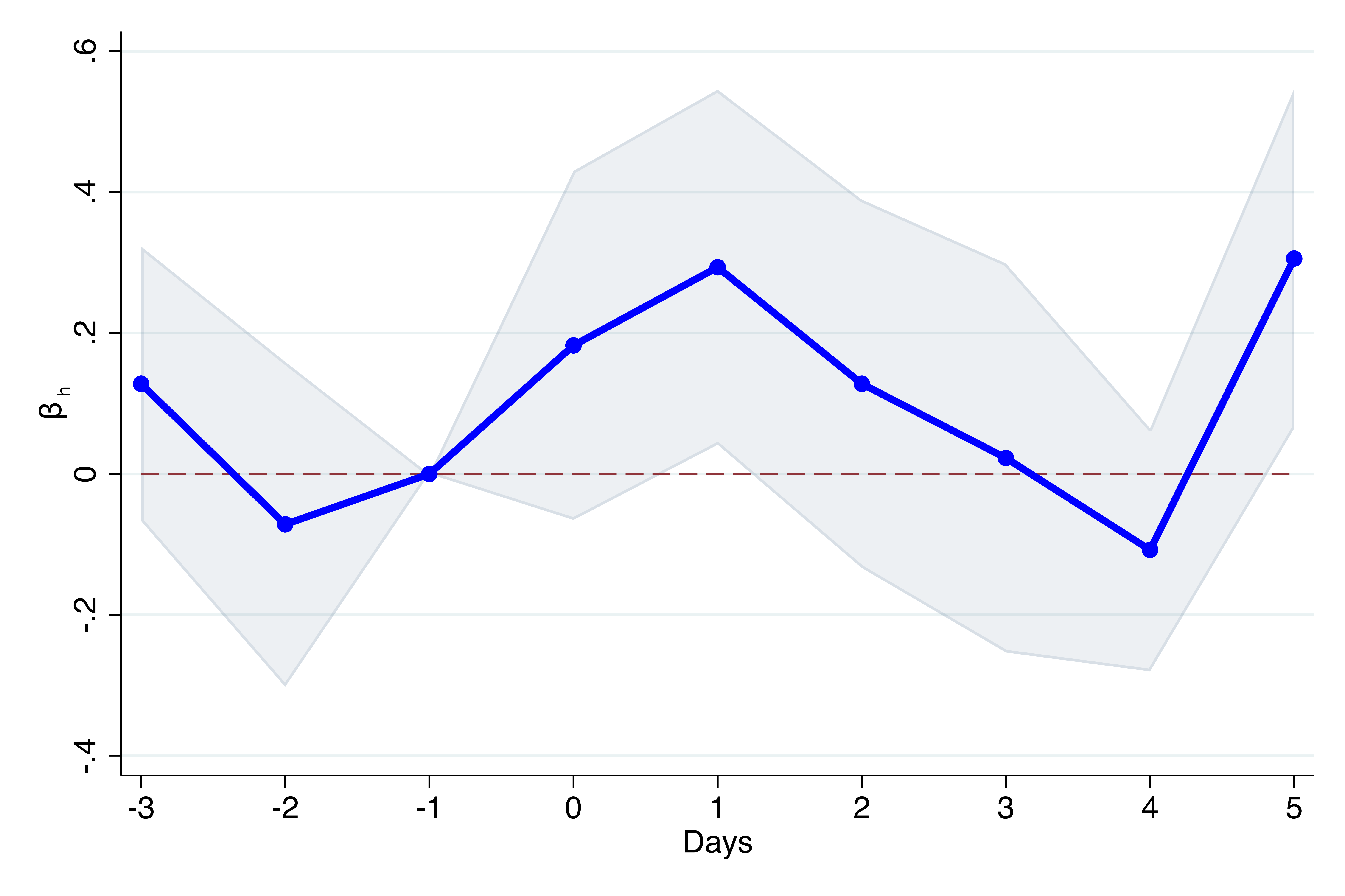


Two possibilities:

1. Growing concern for “distortion” that policy might cause
2. Stock price decline more likely to appear in the newspaper

Response of Retail Sales

- Some positive response of retail sales:



Robustness: Stocks

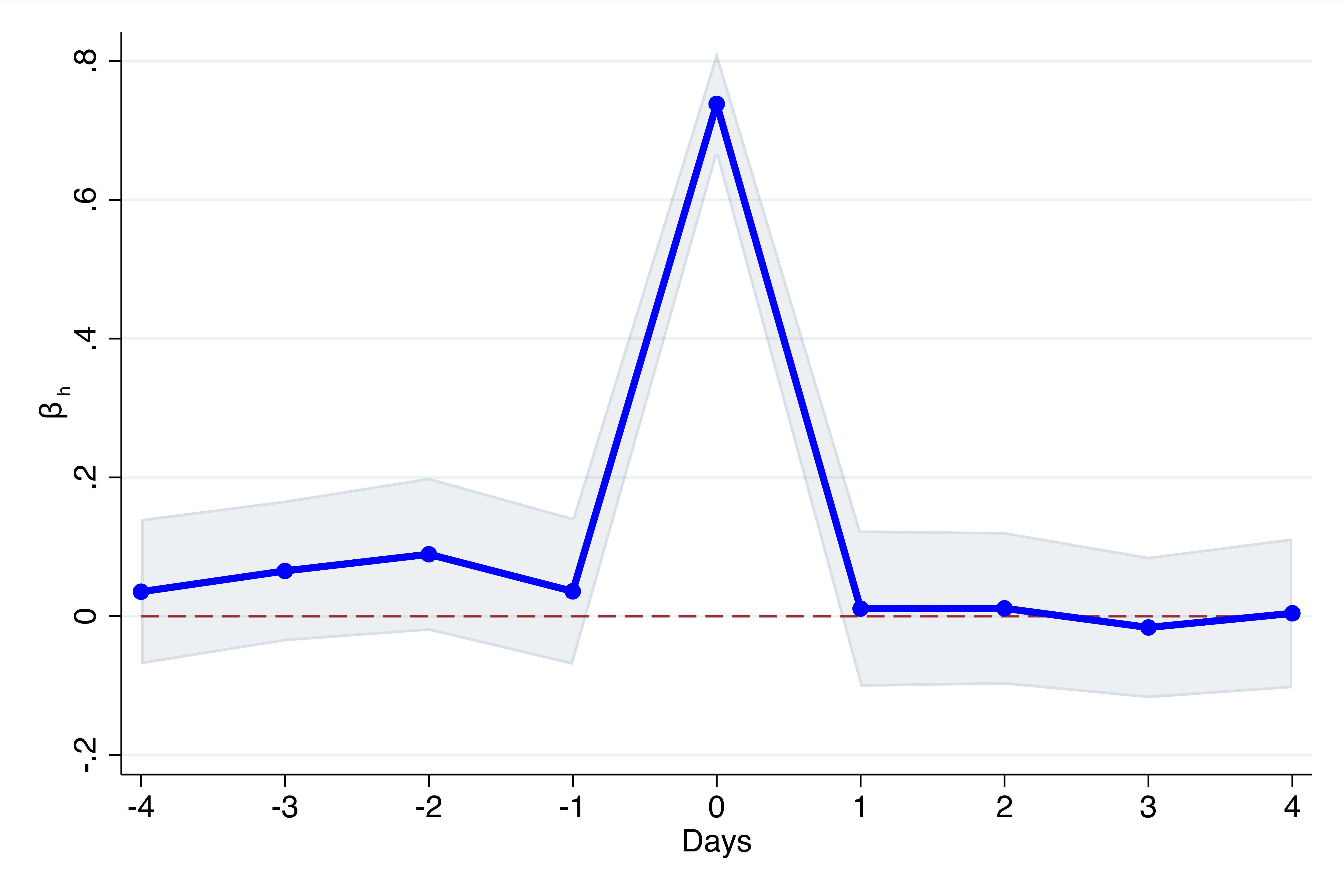
	Panel A. Stock Price Response					
	All		Before YCC		After YCC	
	Same Day	Next Day	Same Day	Next Day	Same Day	Next Day
0. Baseline	34.90	8.65	36.31	-16.95	35.24	22.23
	(5.89)	(10.18)	(17.50)	(26.27)	(4.68)	(11.13)
1. Narrower Bandwidth	41.65	16.22	30.14	-21.25	47.26	33.08
	(7.16)	(16.09)	(22.18)	(39.57)	(7.15)	(16.25)
2. Wider Bandwidth	29.49	6.07	30.63	-2.44	29.41	15.66
	(4.84)	(9.36)	(13.46)	(20.74)	(4.69)	(9.14)
3. Polynominal Order 2	43.40	16.98	41.13	-22.70	47.24	30.63
	(7.47)	(15.64)	(21.64)	(42.42)	(7.14)	(14.39)
4. Control Past Interventions	39.50	12.56	54.57	-16.44	37.32	29.65
	(8.09)	(15.10)	(25.67)	(34.04)	(6.61)	(14.48)
5. Control Past Stock Returns	34.91	8.62	36.15	-17.33	35.18	20.51
	(5.89)	(10.20)	(17.70)	(26.21)	(4.77)	(11.76)
6. Control Past 10-Year Yield	37.86	10.35	49.85	-32.66	34.71	27.41
	(6.80)	(12.53)	(25.39)	(36.34)	(4.97)	(13.66)
7. Drop Around the Cutoff Changes	34.41	7.64	28.76	-22.46	35.17	26.23
	(6.15)	(11.12)	(16.28)	(28.58)	(5.49)	(14.97)

Robustness: Bonds

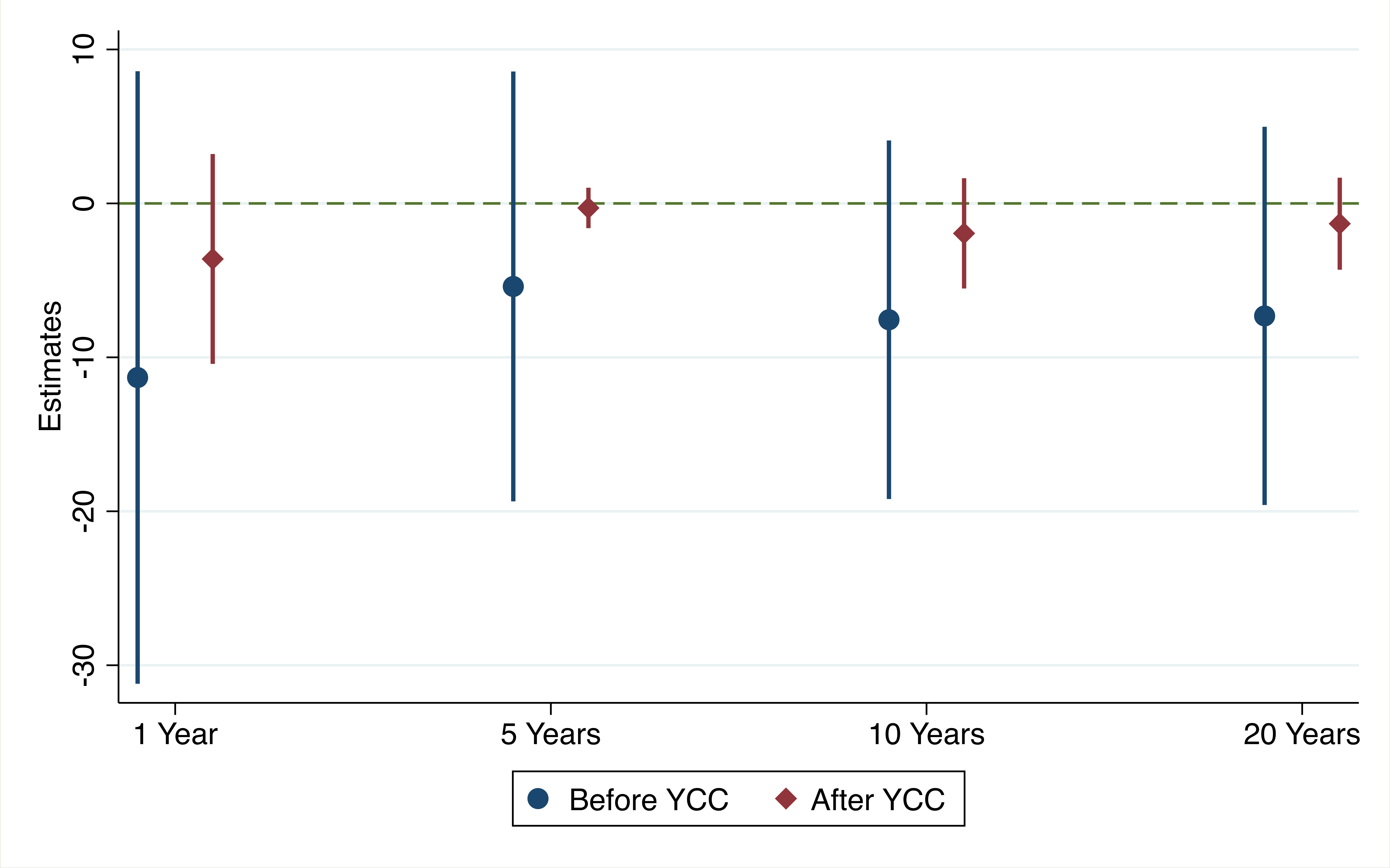
Panel B. JGB 10-Year Yield Response

	All		Before YCC		After YCC	
	Same Day	Next Day	Same Day	Next Day	Same Day	Next Day
0. Baseline	0.60	0.54	2.03	1.80	0.06	0.03
	(0.22)	(0.26)	(0.69)	(0.76)	(0.08)	(0.13)
1. Half	0.64	0.59	2.51	2.43	0.02	-0.06
Bandwidth	(0.25)	(0.32)	(0.98)	(1.02)	(0.09)	(0.20)
2. Wider	0.48	0.44	1.52	1.11	0.02	-0.04
Bandwidth	(0.18)	(0.23)	(0.56)	(0.53)	(0.06)	(0.10)
3. Polynominal	0.69	0.69	2.51	2.69	0.10	0.08
Order 2	(0.26)	(0.31)	(0.93)	(1.15)	(0.10)	(0.19)
4. Control Past	0.56	0.41	2.12	1.96	-0.04	-0.15
Interventions	(0.27)	(0.34)	(0.91)	(0.97)	(0.11)	(0.23)
5. Control Past	0.59	0.53	2.04	1.82	0.05	0.01
Stock Returns	(0.22)	(0.26)	(0.69)	(0.76)	(0.08)	(0.13)
6. Control Past	0.57	0.48	2.14	1.83	0.04	0.04
10-Year Yield	(0.22)	(0.27)	(0.78)	(0.83)	(0.08)	(0.14)
7. Drop Around	0.48	0.42	1.51	1.60	0.02	0.02
the Cutoff Changes	(0.20)	(0.25)	(0.64)	(0.79)	(0.08)	(0.17)

ETF Shock



Inflation Responses



CDS Response