



# Empirical causal asset pricing with trading costs

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# Agenda

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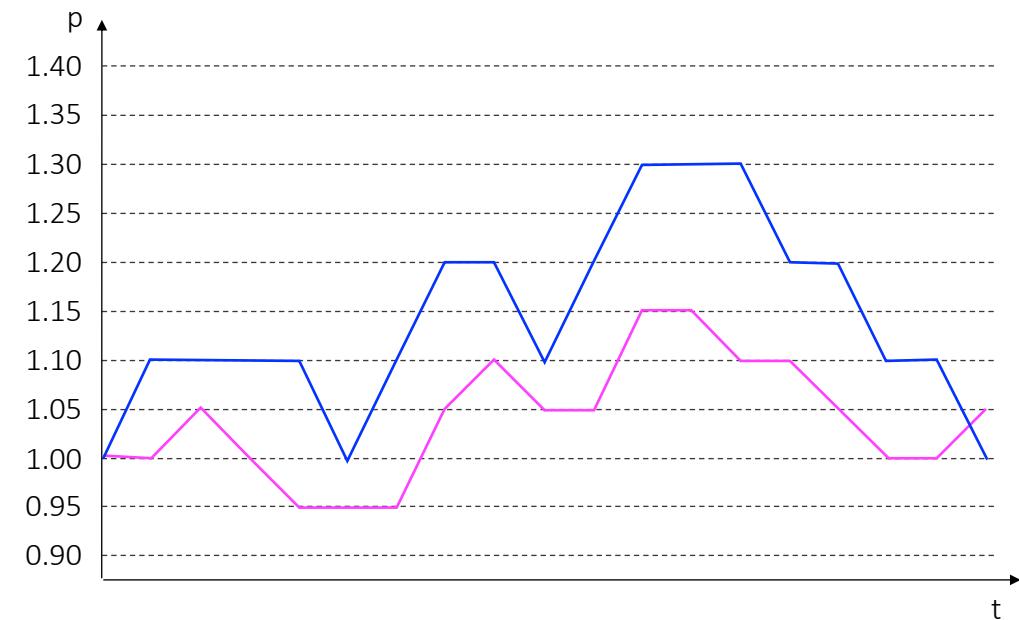
- 1) Introduction
- 2) Our setting: MiFID II
- 3) Identification and Data
- 4) Results

# 1) Introduction: what is the causal effect of trading costs on asset prices?

Trading cost —————→ Asset prices

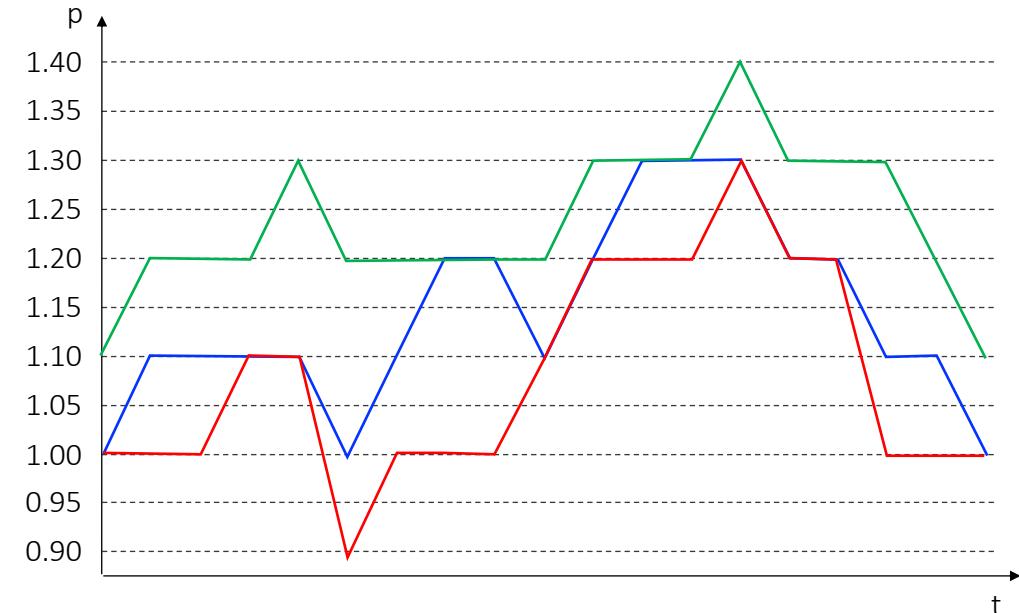
# 1) Introduction: Tick size and trading costs

- Tick size is the minimum increment an asset's price is quoted in and traded at.



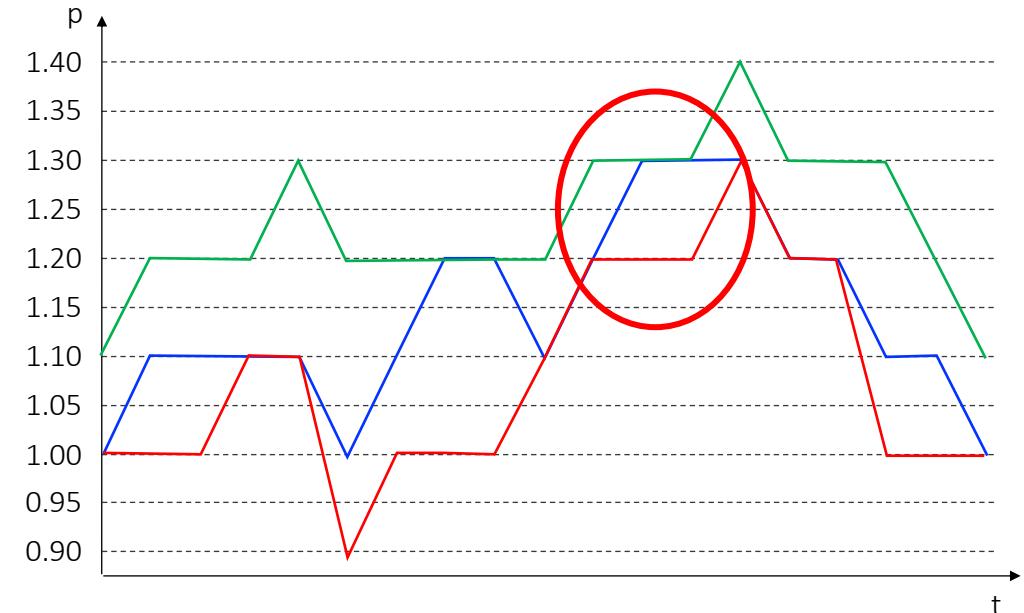
# 1) Introduction: Tick size and trading costs

- Tick size is the minimum increment an asset's price is quoted in and traded at.
- Important tool for regulators and policymakers.
- Tick size influences bid-ask spreads.
  - Tick size  $\uparrow(\downarrow) \Rightarrow$  BA spread  $\uparrow(\downarrow) \Rightarrow$  Cost  $\uparrow(\downarrow)$



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# 1) Introduction: A brief literature review

## What effect direction can we expect?

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### Positive effect

- Theory:
  - Buss & Dumas (2019): consumption smoothing effect.
  - Vayanos & Vila (1999): spillover effect.
- Empirical:
  -

### No effect

- Theory:
  -
- Empirical:
  - Albuquerque et al. (2020): effect was anticipated.

### Negative effect

- Theory:
  - Constantinides (1986), Heaton & Lucas (1996), Vayanos (1998), ...: small effect.
- Empirical:
  - Amihud & Mendelson (1986): **direct price effect**.
  - Easley & O'Hara (2004), O'Hara (2004): indirect information risk effect.
  - Amihud & Mendelson (1986): indirect investor horizon clientele effect.
  - Acharya and Pedersen (2005): **indirect liquidity effect**.

Others: Chung, Lee, and Rösch (2020) and Fang, Noe, and Tice (2009)

# 2) Our setting: MiFID II

## The EU's tick size program

EU implemented tick-size schedule for all assets traded on EU exchanges.

Liquidity bands Price ranges	Average Daily Number of Transactions					
	< 10	< 80	< 600	< 2000	< 9000	9000 ≤
0 ≤ price < 0.1	0.0005	0.0002	0.0001	0.0001	0.0001	0.0001
0.1 ≤ price < 0.2	0.001	0.0005	0.0002	0.0001	0.0001	0.0001
0.2 ≤ price < 0.5	0.002	0.001	0.0005	0.0002	0.0001	0.0001
0.5 ≤ price < 1	0.005	0.002	0.001	0.0005	0.0002	0.0001
1 ≤ price < 2	0.01	0.005	0.002	0.001	0.0005	0.0002
2 ≤ price < 5	0.02	0.01	0.005	0.002	0.001	0.0005
5 ≤ price < 10	0.05	0.02	0.01	0.005	0.002	0.001
10 ≤ price < 20	0.1	0.05	0.02	0.01	0.005	0.002
20 ≤ price < 50	0.2	0.1	0.05	0.02	0.01	0.005
50 ≤ price < 100	0.5	0.2	0.1	0.05	0.02	0.01
100 ≤ price < 200	1	0.5	0.2	0.1	0.05	0.02
200 ≤ price < 500	2	1	0.5	0.2	0.1	0.05
500 ≤ price < 1 000	5	2	1	0.5	0.2	0.1
1 000 ≤ price < 2 000	10	5	2	1	0.5	0.2
2 000 ≤ price < 5 000	20	10	5	2	1	0.5
5 000 ≤ price < 10 000	50	20	10	5	2	1
10 000 ≤ price < 20 000	100	50	20	10	5	2
20 000 ≤ price < 50 000	200	100	50	20	10	5
50 000 ≤ price	500	200	100	50	20	10

- Price  $\uparrow \Rightarrow$  Tick size  $\uparrow$
- Liquidity  $\uparrow \Rightarrow$  Tick size  $\downarrow$

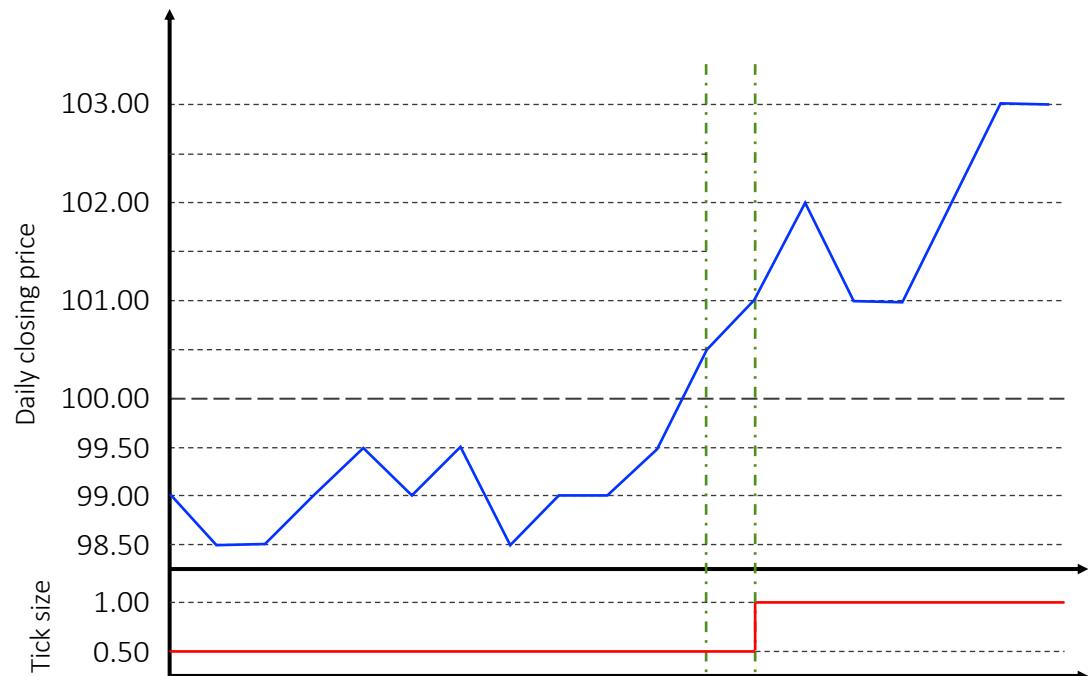
# 2) Our setting: MiFID II

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0.5 ≤ price < 1	0.005	0.002	0.001	0.0005	0.0002	0.0001
1 ≤ price < 2	0.01	0.005	0.002	0.001	0.0005	0.0002
2 ≤ price < 5	0.02	0.01	0.005	0.002	0.001	0.0005
5 ≤ price < 10	0.05	0.02	0.01	0.005	0.002	0.001
10 ≤ price < 20	0.1	0.05	0.02	0.01	0.005	0.002
20 ≤ price < 50	0.2	0.1	0.05	0.02	0.01	0.005
50 ≤ price < 100	0.5	0.2	0.1	0.05	0.02	0.01
100 ≤ price < 200	1	0.5	0.2	0.1	0.05	0.02
200 ≤ price < 500	2	1	0.5	0.2	0.1	0.05
500 ≤ price < 1 000	5	2	1	0.5	0.2	0.1
1 000 ≤ price < 2 000	10	5	2	1	0.5	0.2
2 000 ≤ price < 5 000	20	10	5	2	1	0.5
5 000 ≤ price < 10 000	50	20	10	5	2	1
10 000 ≤ price < 20 000	100	50	20	10	5	2
20 000 ≤ price < 50 000	200	100	50	20	10	5
50 000 ≤ price	500	200	100	50	20	10

- Price ↑ ⇒ Tick size ↑
- Liquidity ↑ ⇒ Tick size ↓

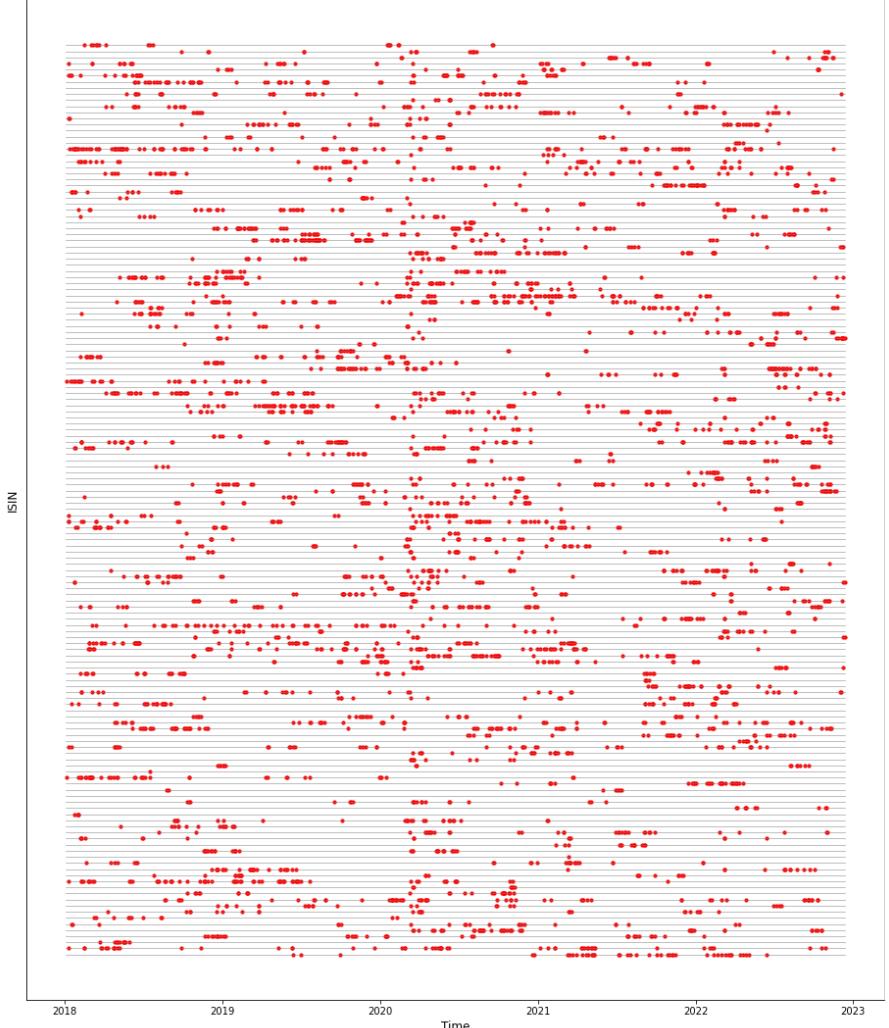


## 2) Our setting: MiFID II

### Benefits of the tick-size program as an RCT

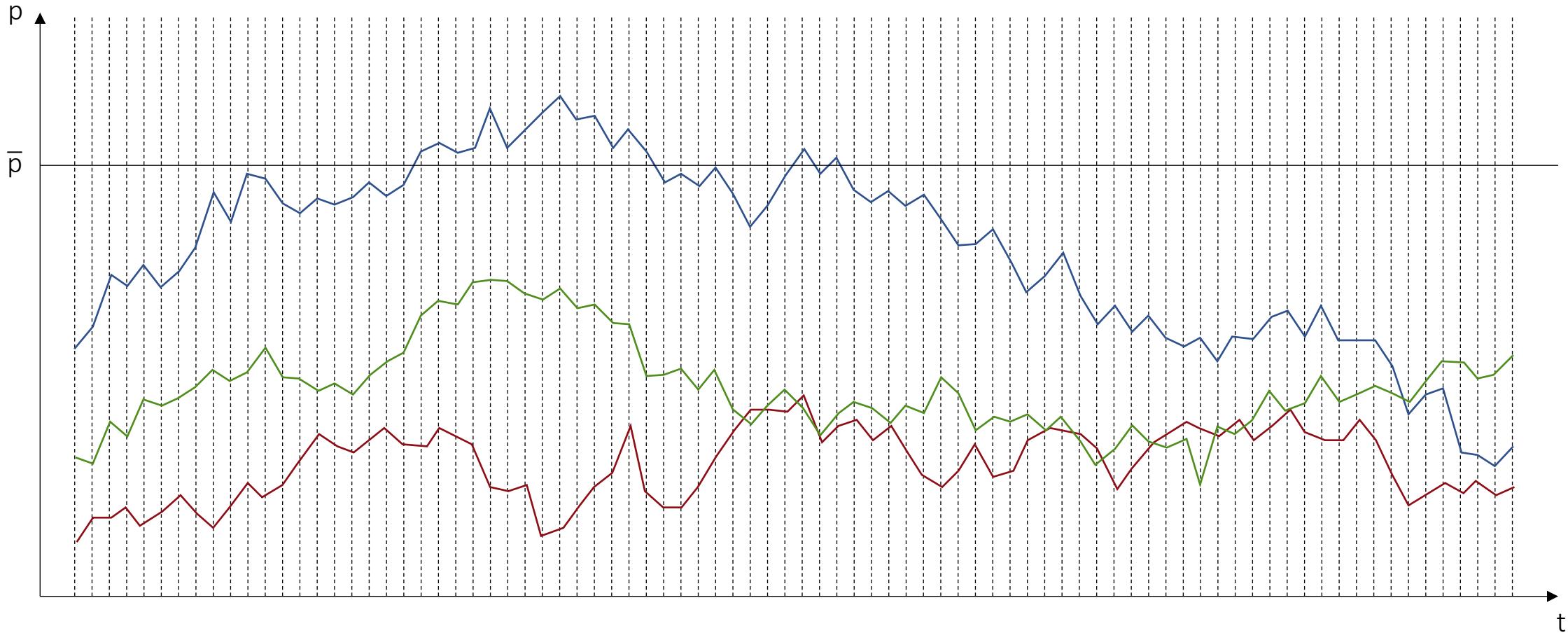
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- Tick-size program is permanent.
- Entire European stock universe.
- Tick-size increases and decreases.
- RCT framework:
  - Price thresholds are economically arbitrary.
  - Prices are sufficiently random.
    - ⇒ Tick-size change is not predictable.
    - ⇒ Treated and control groups are “unknown”.



### 3) Identification and Data

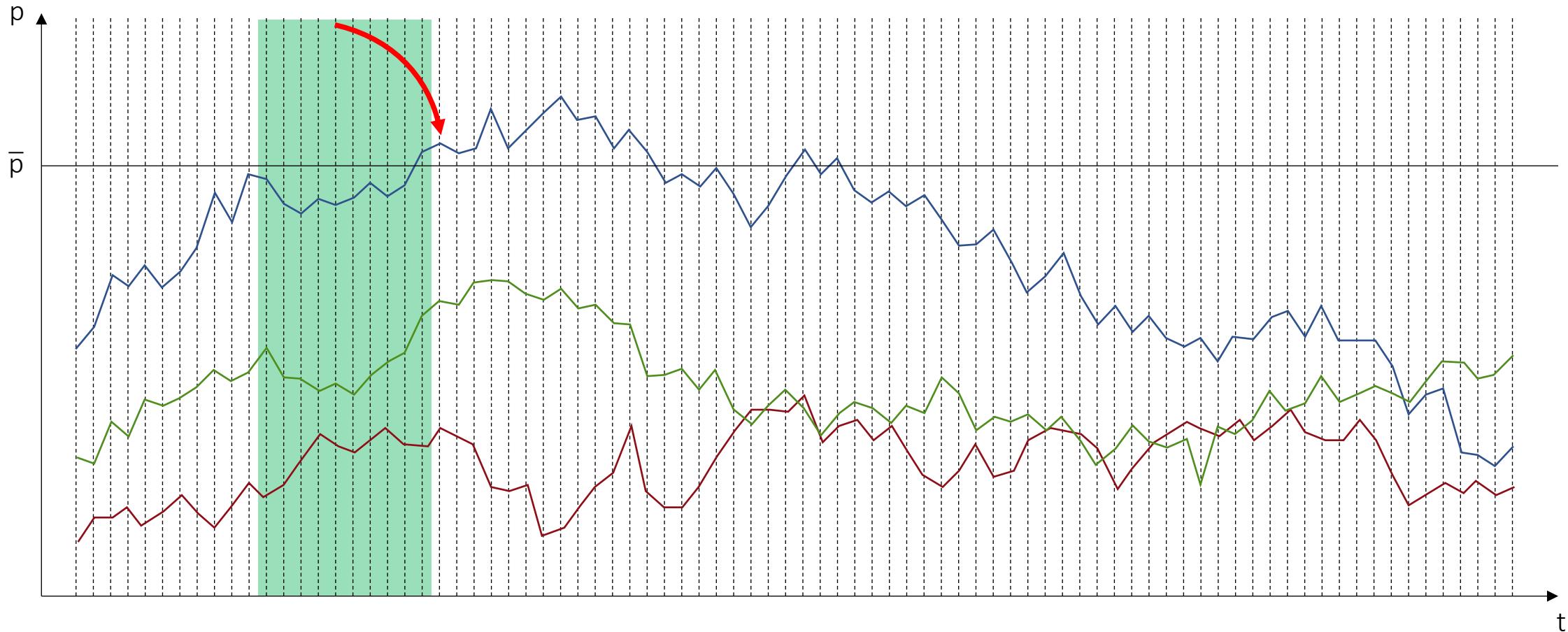
Stocks are treated with a TS change after crossing a price threshold



### 3) Identification and Data: Diff-in-diff

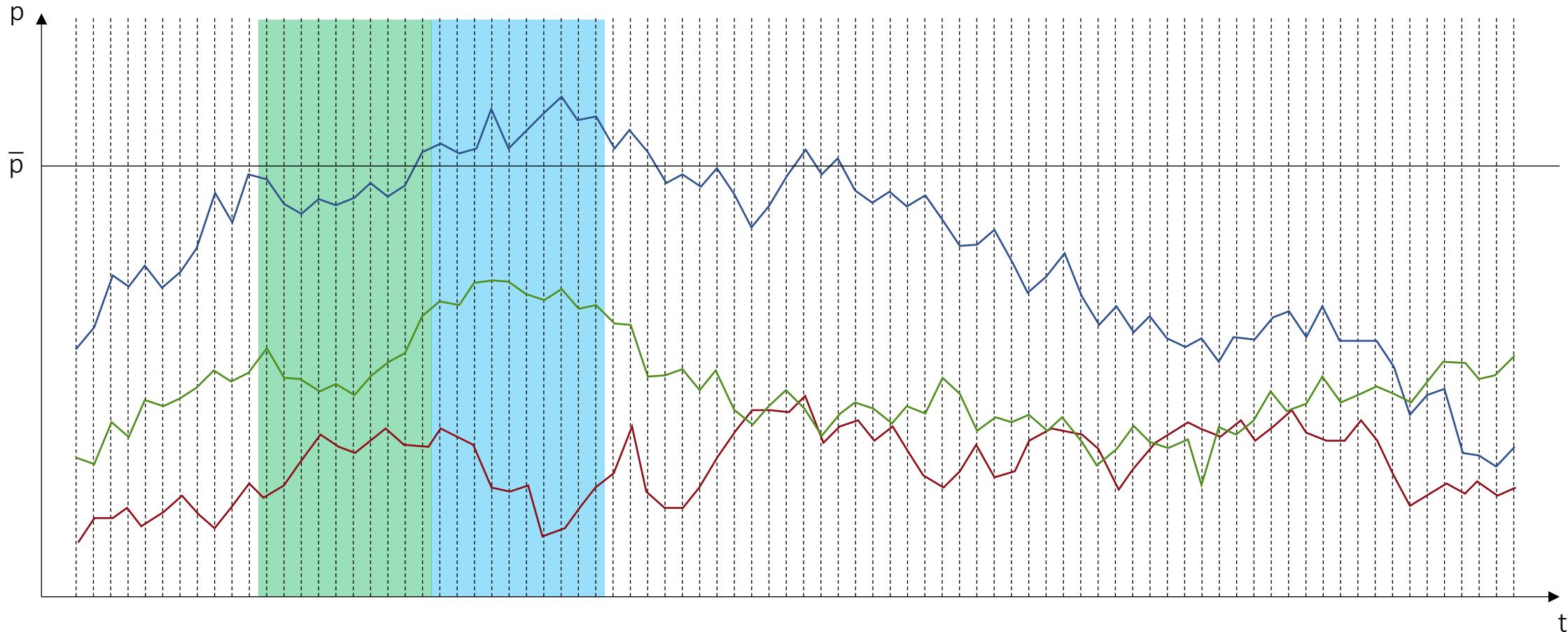
Stocks are treated with a TS change after crossing a price threshold

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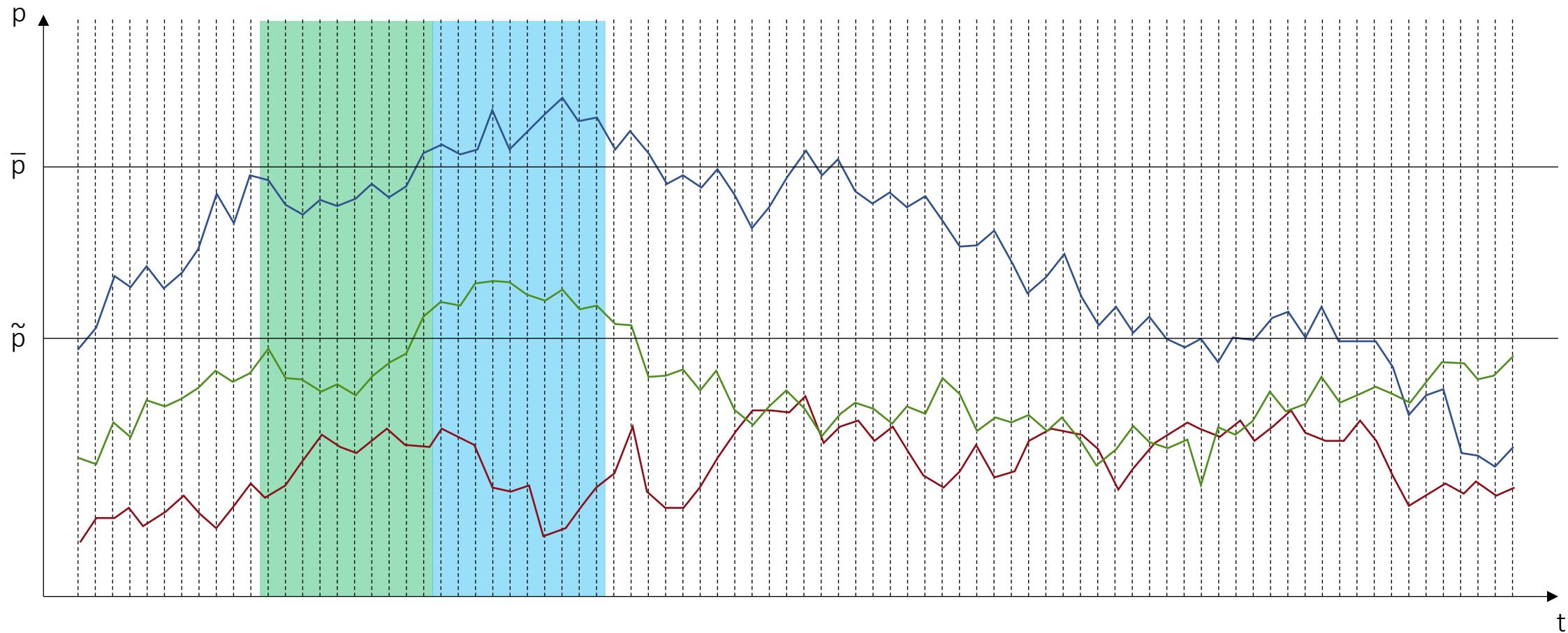
### 3) Identification and Data: Diff-in-diff

Stocks are treated with a TS change after crossing a price threshold



### 3) Identification and Data: Diff-in-diff

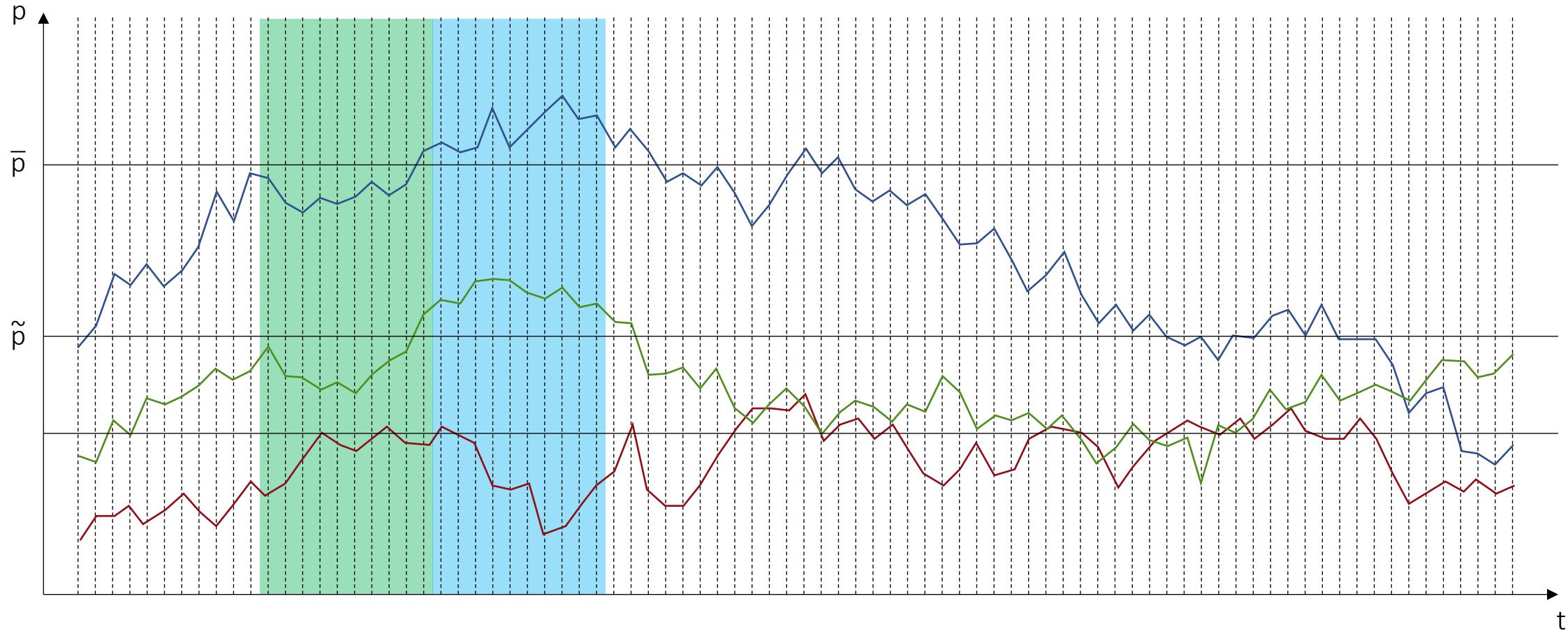
Compare treated stocks to untreated (no TS change)



### 3) Identification and Data: Diff-in-diff

Compare treated stocks to untreated (no TS change)

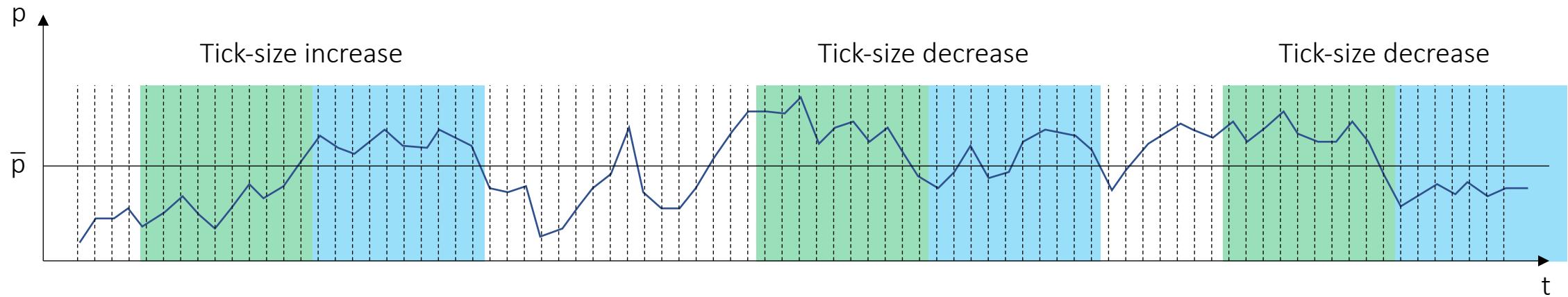
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### 3) Identification and Data: Diff-in-diff

Compare treated stocks to untreated (no TS change)

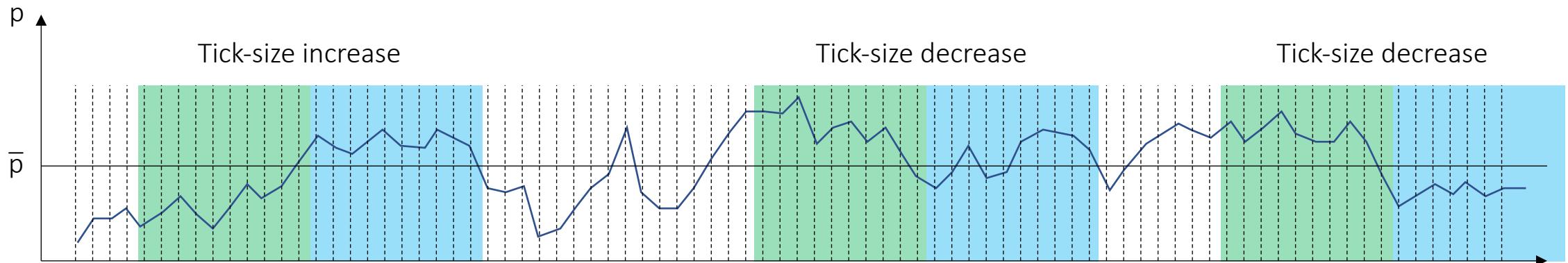
Treatment:



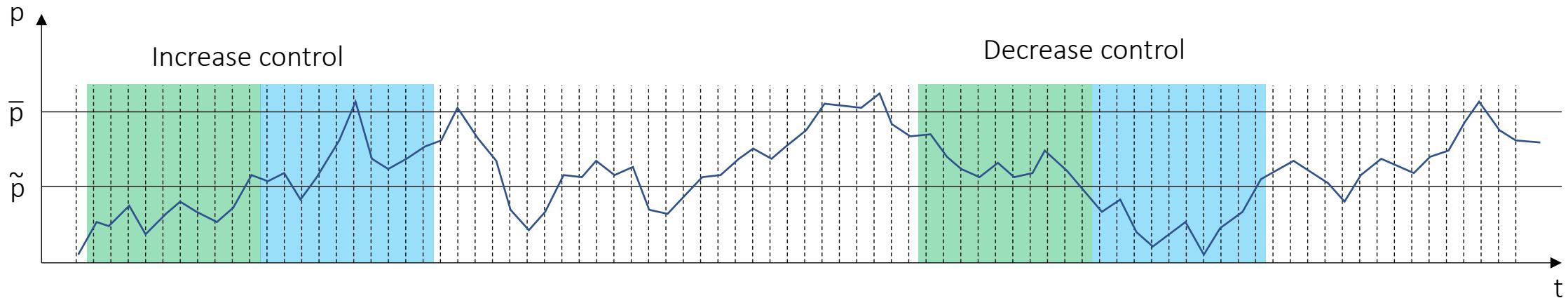
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Compare treated stocks to untreated (no TS change)

Treatment:

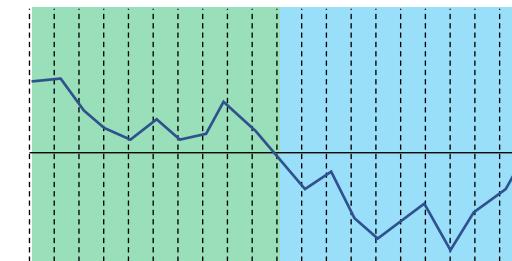
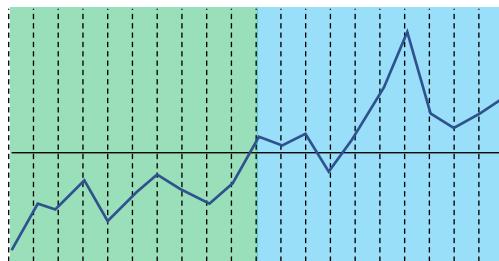
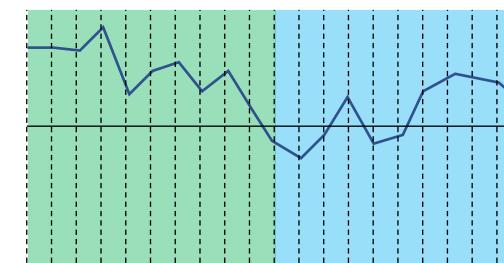
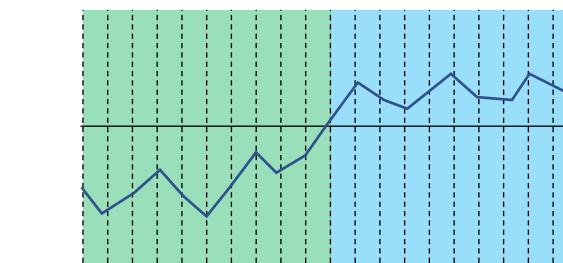


Control:



### 3) Identification and Data: Diff-in-diff

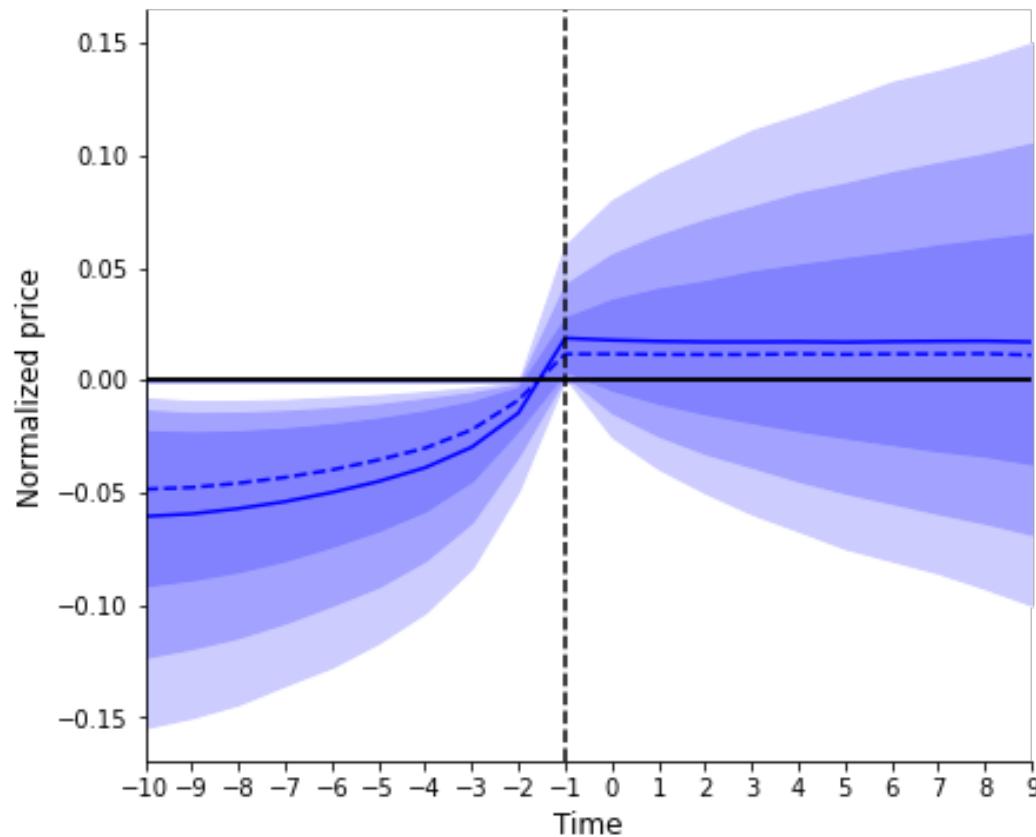
Compare treated stocks to untreated (no TS change)



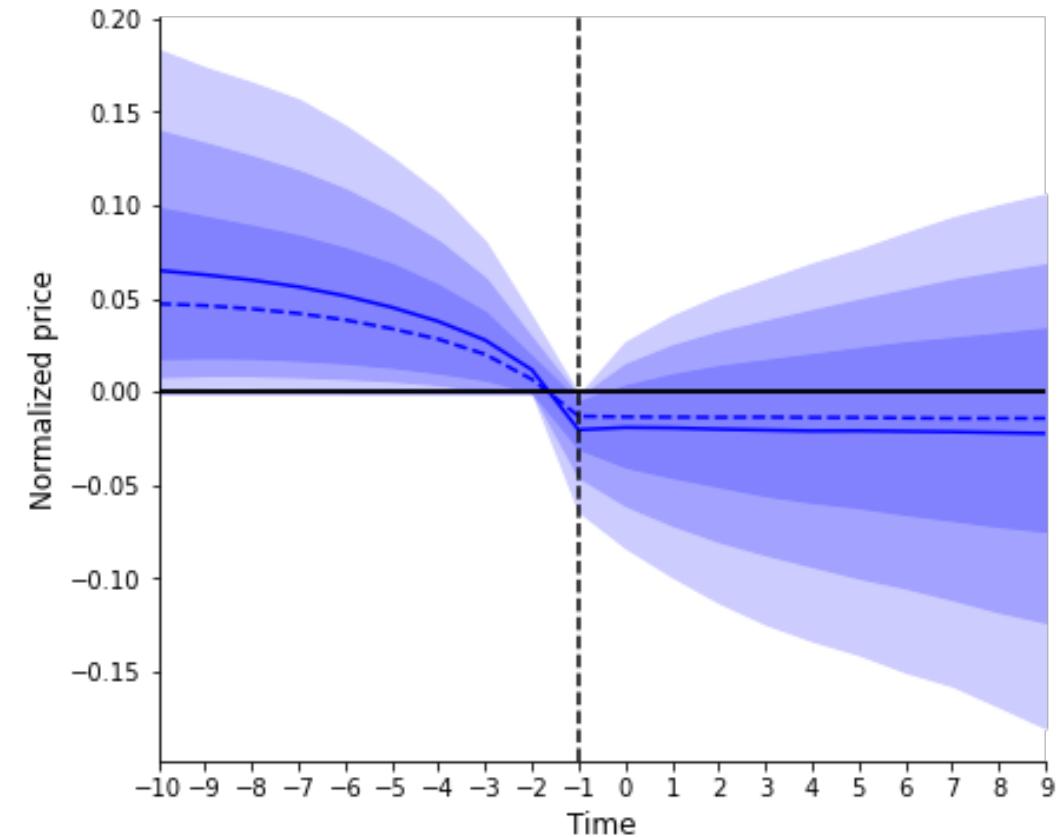
### 3) Identification and Data

Treated group price distribution across event window

Tick-size increase



Tick-size decrease



### 3) Identification and Data

#### Main equation

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$$E(y_{i,t}|i,t) = \alpha_i + \gamma_t + \beta^{\text{Cross}} * T * \text{Cross} + \beta^{\text{Week1}} * T * \text{Week1} + \beta^{\text{Week2}} * T * \text{Week2}$$

# 4) Results

## Main results: inverse price effect

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(A) Tick-size increase	$\beta^{Cross}$	$\beta^{Week1}$	$\beta^{Week2}$	# Treated	# Obs.
Full sample	2.530*** (0.000)	-0.128*** (0.000)	-0.127*** (0.000)	5,765	1,022,940
(B) Tick-size decrease					
Full sample	-1.884*** (0.000)	0.320*** (0.000)	0.346*** (0.000)	7,161	1,422,920

NOTES: This table presents estimates for the  $\beta$  coefficients, which correspond to Equation (3.1), with the stock return as the dependent variable. Panels A and B present the results for tick-size increases and decreases, respectively. p-values, based on stock and time-clustered standard errors, are given in parentheses. \*\*\*, \*\*, and \* denote statistical significance at the 1%, 5%, and 10% level, respectively.

Findings:

- Full sample:

- $\uparrow$ TS: negative price effect (in line with existing research\*).
- $\downarrow$ TS: negative price effect (contrasting existing research).

\*Albuquerque, et al. (2020))

# 4) Results

## Subgroup analysis

(A) Tick-size increase	$\beta^{Cross}$	$\beta^{Week1}$	$\beta^{Week2}$	# Treated	# Obs.
Tick constrained	1.545*** (0.000)	-0.028 (0.525)	-0.149*** (0.000)	1,124	202,500
Tick unconstrained	3.258*** (0.000)	-0.209*** (0.000)	-0.142* (0.083)	1,177	212,400
Market cap, smallest 20%	2.650*** (0.000)	-0.238** (0.037)	-0.186** (0.012)	1,150	204,400
Market cap, top 20%	1.752*** (0.000)	-0.111** (0.018)	-0.128*** (0.002)	1,206	214,580

(B) Tick-size decrease					
Tick constrained	-1.299*** (0.000)	0.081 (0.119)	0.195** (0.011)	1,394	278,500
Tick unconstrained	-2.779*** (0.000)	0.570*** (0.000)	0.626*** (0.000)	1,462	292,180
Market cap, smallest 20%	-2.147*** (0.000)	0.518*** (0.000)	0.286*** (0.000)	1,429	283,980
Market cap, top 20%	-2.017*** (0.000)	0.202*** (0.006)	0.385*** (0.000)	1,500	298,160

NOTES: This table presents estimates for the  $\beta$  coefficients, which correspond to Equation (3.1), with the stock return as the dependent variable. Panels A and B present the results for tick-size increases and decreases, respectively. p-values, based on stock and time-clustered standard errors, are given in parentheses. \*\*\*, \*\*, and \* denote statistical significance at the 1%, 5%, and 10% level, respectively.

### Findings:

- Full sample:
  - $\uparrow$ TS: negative price effect (in line with existing research\*).
  - $\downarrow$ TS: negative price effect (contrasting existing research).
- Subgroups:
  - Unconstrained has larger effect than constrained (contrasting existing research).
  - Asymmetric effect on company size (direction in line with existing research).
- Robustness:
  - $\uparrow$ TS: 0.65%–1.3% .
  - $\downarrow$ TS: 1.8%–3.35%.

\*Albuquerque, et al. (2020))

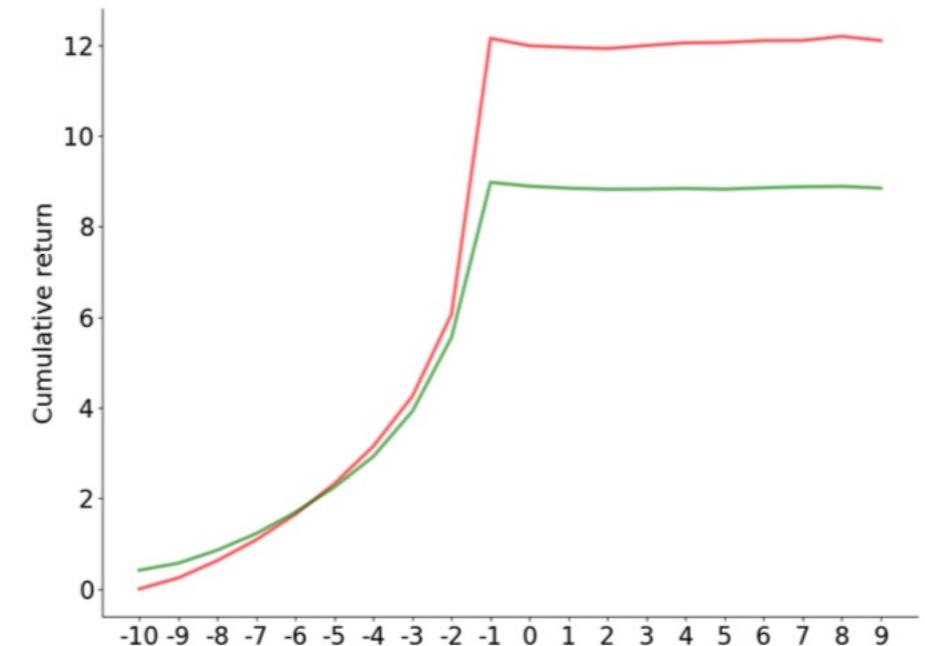
# 4) Results

## Excess returns on the day the price threshold is crossed

Main results

(A) Tick-size increase	$\beta^{Cross}$	$\beta^{Week1}$	$\beta^{Week2}$	# Treated	# Obs.
Full sample	2.530*** (0.000)	-0.128*** (0.000)	-0.127*** (0.000)	5,765	1,022,940
(B) Tick-size decrease					
Full sample	-1.884*** (0.000)	0.320*** (0.000)	0.346*** (0.000)	7,161	1,422,920

NOTES: This table presents estimates for the  $\beta$  coefficients, which correspond to Equation (3.1), with the stock return as the dependent variable. Panels A and B present the results for tick-size increases and decreases, respectively. p-values, based on stock and time-clustered standard errors, are given in parentheses. \*\*\*, \*\*, and \* denote statistical significance at the 1%, 5%, and 10% level, respectively.



# 4) Results

## Behavioral effect of round prices

Main results

(A) Tick-size increase	$\beta^{Cross}$	$\beta^{Week1}$	$\beta^{Week2}$	# Treated	# Obs.
Full sample	2.530*** (0.000)	-0.128*** (0.000)	-0.127*** (0.000)	5,765	1,022,940

(B) Tick-size decrease					
Full sample	-1.884*** (0.000)	0.320*** (0.000)	0.346*** (0.000)	7,161	1,422,920

NOTES: This table presents estimates for the  $\beta$  coefficients, which correspond to Equation (3.1), with the stock return as the dependent variable. Panels A and B present the results for tick-size increases and decreases, respectively. p-values, based on stock and time-clustered standard errors, are given in parentheses. \*\*\*, \*\*, and \* denote statistical significance at the 1%, 5%, and 10% level, respectively.

Results using behavioral control thresholds

(A) Tick-size increase	$\beta^{Cross}$	$\beta^{Week1}$	$\beta^{Week2}$	# Treated	# Obs.
Full sample	1.336*** (0.000)	-0.080** (0.022)	-0.076** (0.020)	5,765	311,680

(B) Tick-size decrease					
Full sample	-0.551*** (0.000)	0.251*** (0.000)	0.306*** (0.000)	7,161	424,520

NOTES: This table presents estimates for the  $\beta$  coefficients, which correspond to Equation (3.1) with the stock return as the dependent variable, using the reduced set on controls. That is, the treatment effect is estimated relative to behavioral synthetic thresholds. Panels A and B present the results for tick-size increases and decreases, respectively. p-values, based on stock and time-clustered standard errors, are given in parentheses. \*\*\*, \*\*, and \* denote statistical significance at the 1%, 5%, and 10% level, respectively.

# 4) Results

## Strategic trading incentives around tick-size thresholds

Main treated group vs pre-MiFID control thresholds

(A) Tick-size increase	$\beta^{Cross}$	$\beta^{Week1}$	$\beta^{Week2}$	# Instances	# Obs.
Full sample	1.454*** (0.000)	-0.444*** (0.000)	-0.491*** (0.000)	5,765 6,386	243,020
(B) Tick-size decrease					
Full sample	-1.061*** (0.000)	0.394*** (0.000)	0.515*** (0.000)	7,161 5,661	256,440

Main treated group vs pre-MiFID behavioral thresholds

(A) Tick-size increase	$\beta^{Cross}$	$\beta^{Week1}$	$\beta^{Week2}$	# Instances	# Obs.
Full sample	0.575*** (0.000)	-0.097*** (0.001)	-0.164*** (0.001)	5,765 1,308	141,500
(B) Tick-size decrease					
Full sample	-0.243*** (0.000)	-0.029 (0.687)	0.204*** (0.002)	7,161 1,050	164,200

# Bibliography

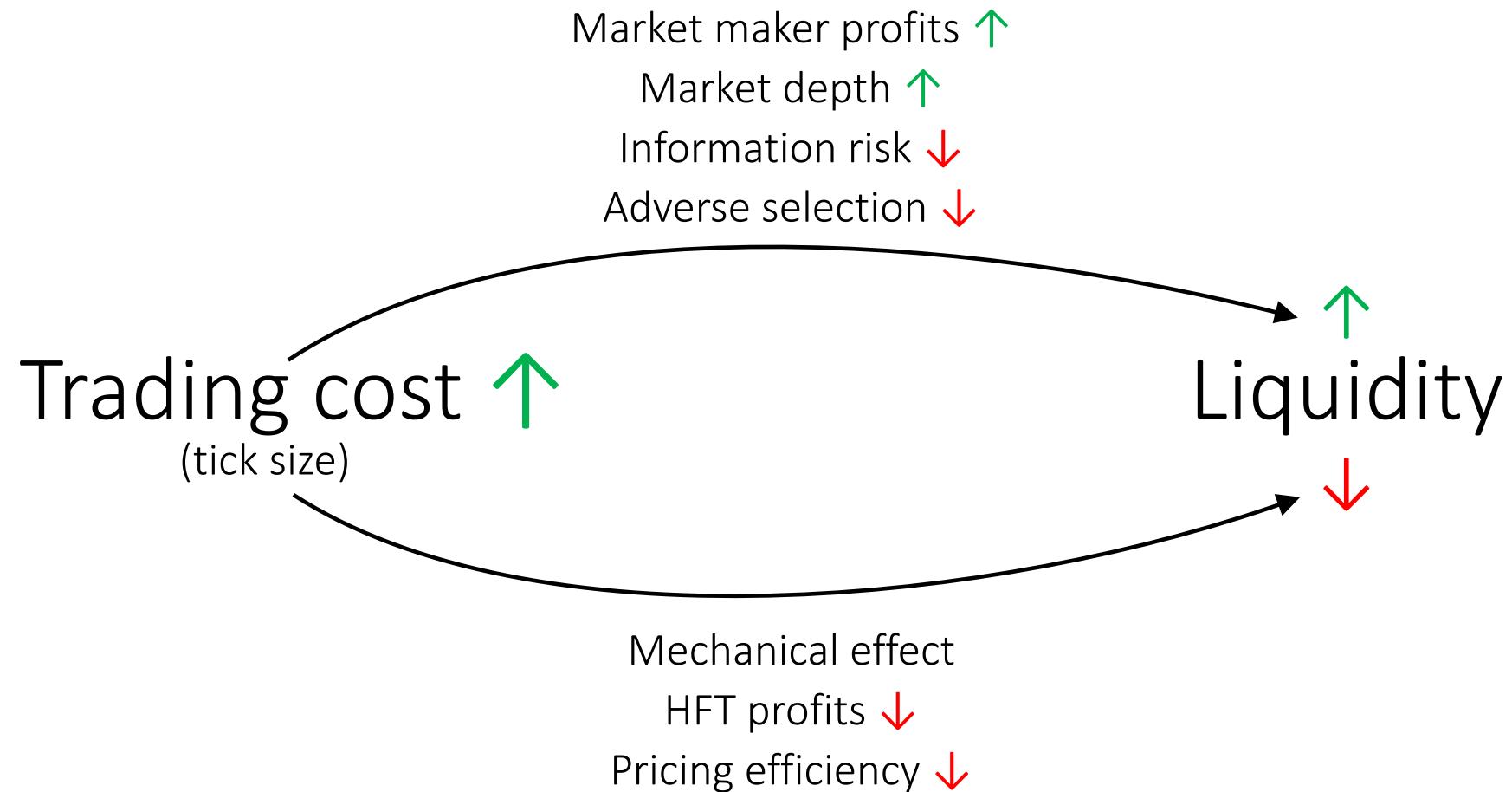
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# Appendix

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# The effect of increasing trading cost or tick sizes on liquidity

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# A brief critique of the SEC's tick size pilot program

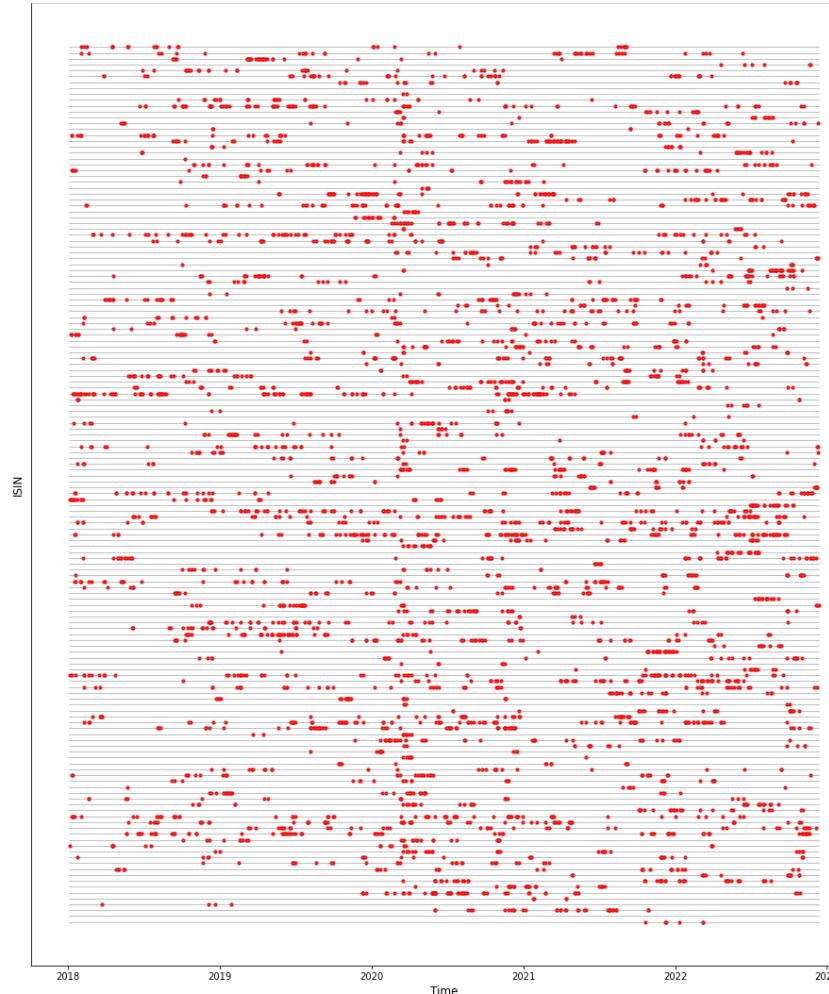
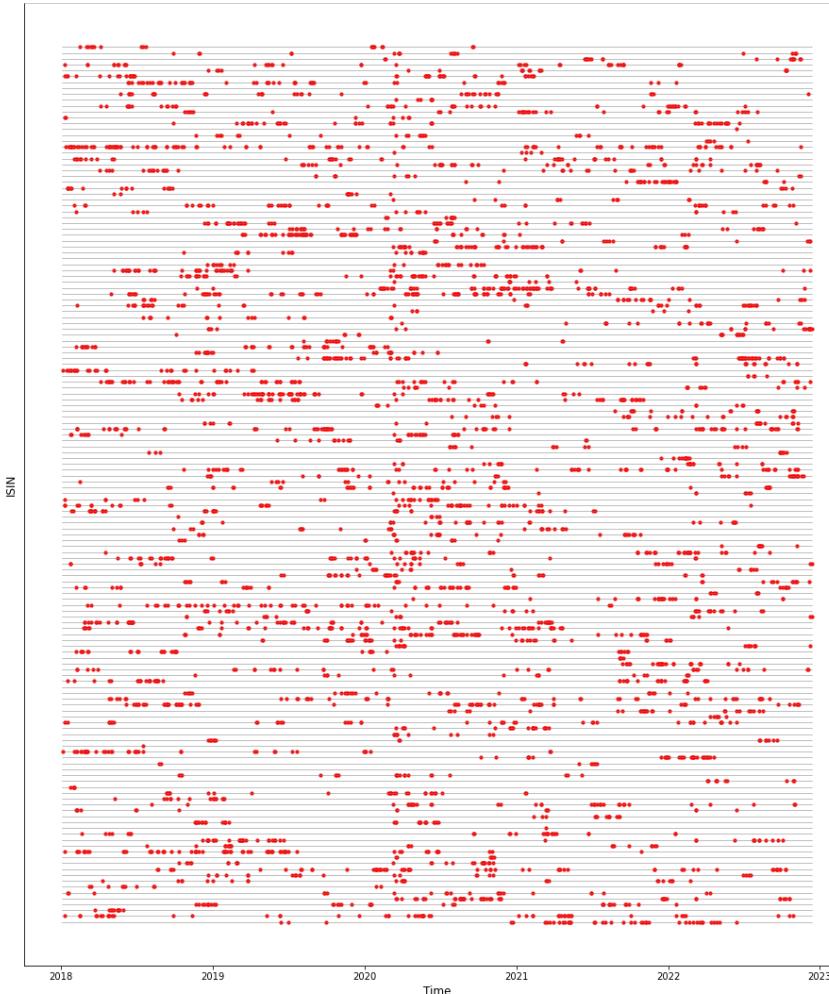
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Abuquerque et al. (2020)

- SEC's tick size pilot program: stock universe split into treatment and control group to study the effect of a one-time tick size change on asset prices.
- Effect:
  - Negative (tick-size increase) or no effect (tick-size decrease).
  - Stock price decrease between 1.75% and 3.2% for small spread stocks affected by the larger tick size relative to a control group.
- Critiques:
  - Small number of stocks,
  - Small stocks by price and market cap,
  - Only tick size increase,
  - One-time treatment,
  - Untreated and treated groups were known before treatment,
  - Tick-size wasn't permanent (only 2 years)
  - Pilot takes place during Trump election (generalizable results?)

# MiFID II price threshold crossings for all French stocks

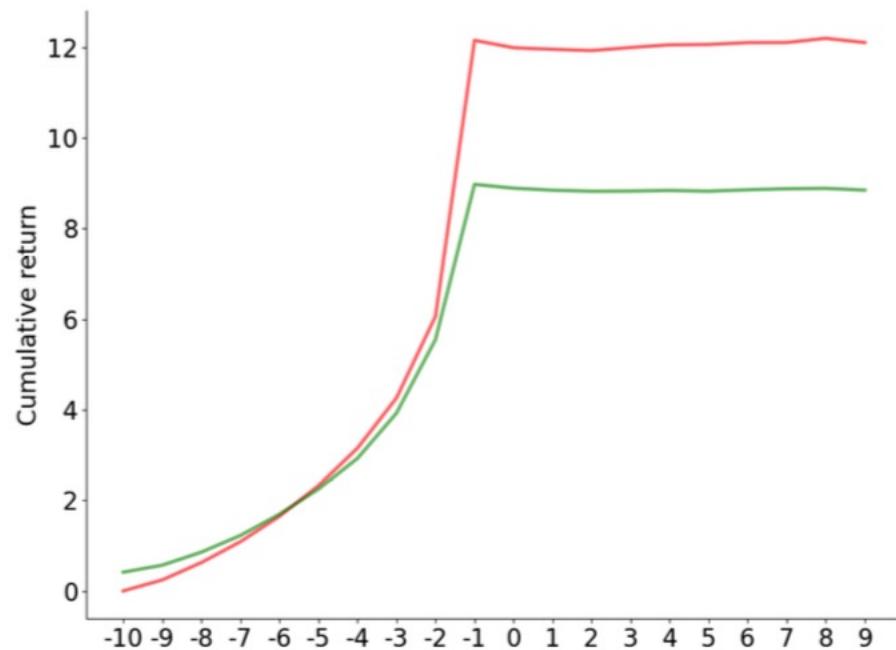
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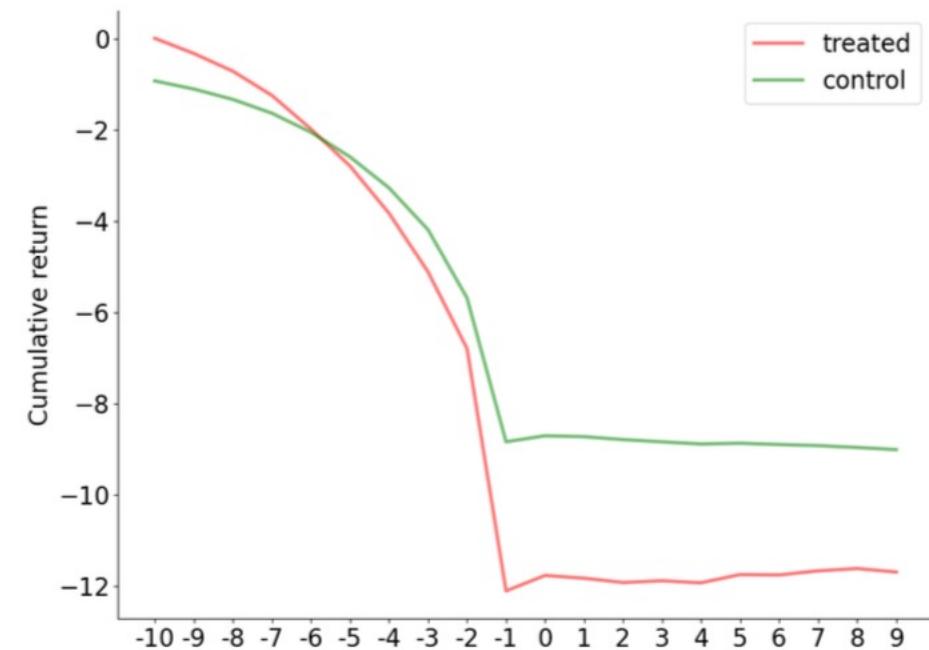
# Excess returns on the day the price threshold is crossed

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(A) Tick-size increase



(B) Tick-size decrease



# Full behavioral results

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## Main results

Tick size increase	$\beta_1^{crossing}$	$\beta_2^{1st\ week}$	$\beta_3^{2nd\ week}$	# Treated	# Obs.
Full sample	2.530*** (0.027)	-0.128*** (0.030)	-0.127*** (0.029)	5'765	1'022'940
Tick constrained	1.545*** (0.037)	-0.028 (0.044)	-0.149*** (0.040)	1'124	202'500
Tick unconstrained	3.258*** (0.062)	-0.209*** (0.055)	-0.142* (0.082)	1'177	212'400
Market cap, smallest 20%	2.650*** (0.067)	-0.238** (0.114)	-0.186** (0.074)	1'150	204'400
Market cap, top 20%	1.752*** (0.036)	-0.111** (0.047)	-0.128*** (0.041)	1'206	214'580

Tick size decrease	$\beta_1^{crossing}$	$\beta_2^{1st\ week}$	$\beta_3^{2nd\ week}$	# Treated	# Obs.
Full sample	-1.884*** (0.032)	0.320*** (0.053)	0.346*** (0.045)	7'161	1'422'920
Tick constrained	-1.299*** (0.032)	0.081 (0.052)	0.195** (0.077)	1'394	278'500
Tick unconstrained	-2.779*** (0.043)	0.570*** (0.080)	0.626*** (0.083)	1'462	292'180
Market cap, smallest 20%	-2.147*** (0.055)	0.518*** (0.083)	0.286*** (0.063)	1'429	283'980
Market cap, top 20%	-2.017*** (0.029)	0.202*** (0.073)	0.385*** (0.084)	1'500	298'160

## Results using behavioral control thresholds

Tick size increase	$\beta_1^{crossing}$	$\beta_2^{1st\ week}$	$\beta_3^{2nd\ week}$	# Treated	# Obs.
Full sample	1.069*** (0.047)	-0.106*** (0.036)	-0.085** (0.035)	5'765	311'680
Tick constraint	0.581*** (0.062)	-0.015 (0.074)	-0.110* (0.059)	1'124	67'720
Tick unconstraint	1.876*** (0.125)	-0.181* (0.107)	-0.128 (0.122)	1'177	63'960
Market cap, smallest 20%	1.613*** (0.119)	-0.131*** (0.050)	-0.106* (0.055)	1'150	62'240
Market cap, top 20%	0.691*** (0.062)	-0.056 (0.060)	-0.083 (0.056)	1'206	65'300

Tick size decrease	$\beta_1^{crossing}$	$\beta_2^{1st\ week}$	$\beta_3^{2nd\ week}$	# Treated	# Obs.
Full sample	-1.149*** (0.041)	0.336*** (0.047)	0.367*** (0.058)	7'161	424'520
Tick constraint	-0.433*** (0.038)	0.057 (0.038)	0.160*** (0.060)	1'394	85'920
Tick unconstraint	-2.514*** (0.090)	0.740*** (0.176)	0.648*** (0.172)	1'462	90'160
Market cap, smallest 20%	-1.792*** (0.086)	0.593*** (0.110)	0.418*** (0.134)	1'429	88'600
Market cap, top 20%	-1.009*** (0.026)	0.197*** (0.061)	0.290*** (0.072)	1'500	93'000

# Full strategic results

Main treated group vs pre-MiFID control thresholds

(I) pre-MiFID II, full sample control group

(A) Tick-size increase	$\beta^{Cross}$	$\beta^{Week1}$	$\beta^{Week2}$	# Instances	# Obs.
Full sample	1.454*** (0.000)	-0.444*** (0.000)	-0.491*** (0.000)	5,765	243,020
Market cap, smallest 20%	1.520*** (0.000)	-0.331*** (0.002)	-0.472*** (0.000)	1,149	48,480
Market cap, top 20%	0.882*** (0.000)	-0.395*** (0.000)	-0.435*** (0.000)	1,205	50,860
(B) Tick-size decrease					
Full sample	-1.061*** (0.000)	0.394*** (0.000)	0.515*** (0.000)	7,161	256,440
Market cap, smallest 20%	-0.424*** (0.000)	0.439*** (0.000)	0.401*** (0.000)	1,429	51,160
Market cap, top 20%	-1.558*** (0.000)	0.333*** (0.001)	0.603*** (0.000)	1,500	53,680

Main treated group vs pre-MiFID behavioral thresholds

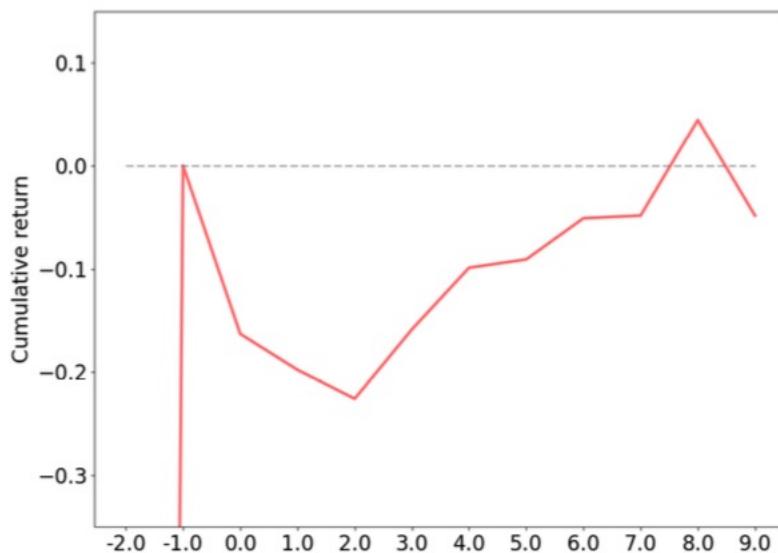
(II) pre-MiFID II, behavioral threshold control group

(A) Tick-size increase	$\beta^{Cross}$	$\beta^{Week1}$	$\beta^{Week2}$	# Instances	# Obs.
Full sample	0.575*** (0.000)	-0.097*** (0.001)	-0.164*** (0.001)	5,765	141,500
Market cap, smallest 20%	0.413*** (0.001)	0.027*** (0.020)	-0.284*** (0.023)	1,150	28,240
Market cap, top 20%	0.404*** (0.000)	-0.101* (0.053)	-0.211*** (0.000)	1,206	29,600
(B) Tick-size decrease					
Full sample	-0.243*** (0.000)	-0.029 (0.687)	0.204*** (0.002)	7,161	164,200
Market cap, smallest 20%	-0.397*** (0.005)	0.009 (0.944)	0.006 (0.971)	1,429	32,780
Market cap, top 20%	-0.838*** (0.000)	-0.070 (0.544)	0.320* (0.094)	1,500	34,380

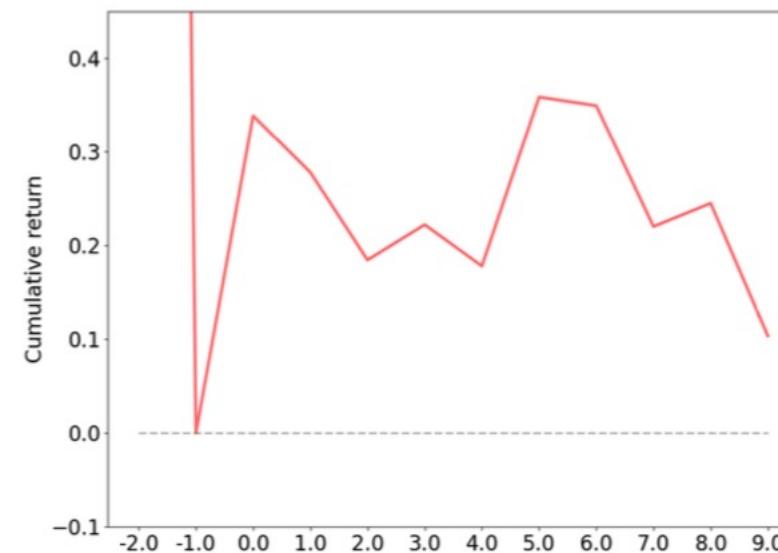
# Returns stabilizing post tick-size change

34

(A) Tick-size increase



(B) Tick-size decrease



NOTES: This figure plots the average cumulative returns for the treated group over the 2-week window after the treatment event. Panels A and B present the results for tick-size increases and decreases, respectively.

# Distribution of events over MiFID II categories

Table 7: Total number of threshold crossings by price and liquidity

Direction	Price threshold	Average Daily Number of Transactions						Total
		< 10	< 80	< 600	< 2000	< 9000	9000 ≤	
Tick size increase	0.1	238	188	128	0	0	0	554
	0.2	300	216	161	16	0	0	693
	0.5	455	328	242	29	27	0	1081
	1.0	814	715	326	81	51	2	1989
	2.0	1019	947	520	154	64	32	2736
	5.0	1136	963	774	288	187	19	3367
	10.0	1024	906	820	392	419	79	3640
	20.0	704	811	1080	678	397	48	3718
	50.0	323	448	705	448	457	149	2530
	100.0	321	244	303	283	411	106	1668
	200.0	61	32	109	47	101	40	390
	500.0	79	22	15	22	19	29	186
	1000.0	29	15	16	0	5	0	65
	2000.0	0	8	1	2	1	5	17
	5000.0	12	0	7	1	0	0	20
	Total	6515	5843	5207	2441	2139	509	22654
Tick size decrease	0.1	249	204	146	0	0	0	599
	0.2	316	237	186	22	0	0	761
	0.5	462	360	273	41	29	0	1165
	1.0	829	757	361	98	54	3	2102
	2.0	1030	993	573	172	68	34	2870
	5.0	1126	1001	831	311	193	21	3483
	10.0	1007	921	874	433	436	83	3754
	20.0	691	823	1126	710	418	48	3816
	50.0	322	434	709	468	475	155	2563
	100.0	314	242	297	284	409	107	1653
	200.0	57	30	105	44	98	39	373
	500.0	76	22	14	21	17	27	177
	1000.0	29	17	16	0	3	0	65
	2000.0	0	9	1	2	1	5	18
	5000.0	13	0	6	1	0	0	20
	Total	6521	6050	5518	2607	2201	522	23419

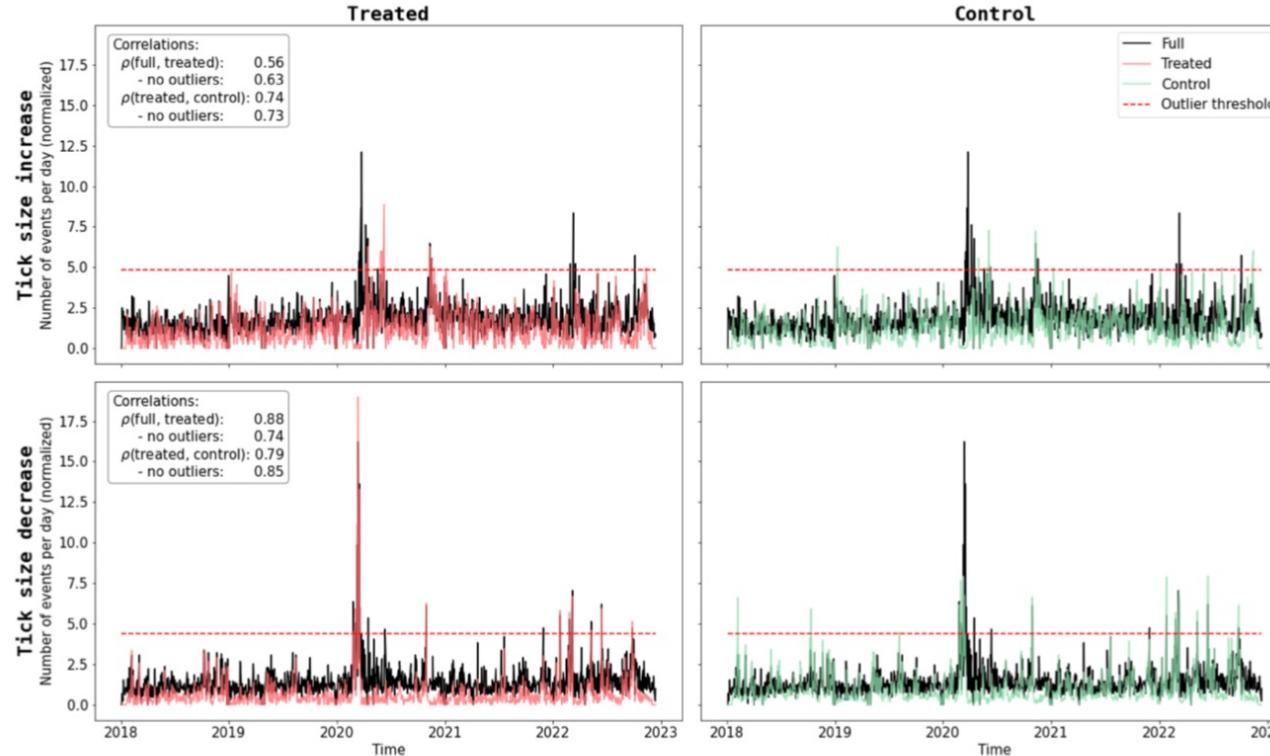
Table 3.A.4: Synthetic threshold crossings by price and liquidity in the control group

Direction	Price threshold	Average Daily Number of Transactions						Total
		< 10	< 80	< 600	< 2000	< 9000	9000 ≤	
(A) Tick-size increase	0.0	110	47	48	6	0	3	214
	0.1	109	187	128	45	0	0	469
	0.2	135	279	157	31	21	5	628
	0.5	177	268	178	49	32	6	710
	1.0	163	176	145	35	26	0	545
	2.0	229	243	175	66	20	3	736
	5.0	652	594	608	298	132	37	2321
	10.0	917	1143	1494	844	597	169	5164
	20.0	1163	2496	3676	2542	2122	345	12344
	50.0	514	1678	3013	2841	3246	748	12040
	100.0	146	509	1441	2331	2879	687	7993
	200.0	5	46	424	606	854	385	2320
	500.0	8	0	45	133	234	233	653
	1000.0	0	0	0	1	67	11	79
	2000.0	0	0	0	0	8	24	32
	5000.0	0	0	0	0	0	0	0
	Total	4328	7666	11532	9828	10238	2656	46248
(B) Tick-size decrease	0.0	231	120	105	20	0	6	482
	0.1	332	396	257	121	9	3	1118
	0.2	341	484	259	55	51	17	1207
	0.5	376	425	319	69	38	14	1241
	1.0	276	220	142	33	25	0	696
	2.0	384	387	279	102	35	5	1192
	5.0	1058	981	871	425	167	45	3547
	10.0	1647	1869	2167	1150	740	178	7751
	20.0	2234	3910	5396	3067	2523	379	17509
	50.0	1490	2714	3802	3110	3411	904	15431
	100.0	1261	1424	1860	2106	2437	650	9738
	200.0	749	379	637	480	522	278	3045
	500.0	456	211	63	186	118	145	1179
	1000.0	136	176	61	1	58	18	450
	2000.0	97	191	9	10	8	23	338
	5000.0	199	10	26	25	0	0	260
	Total	11267	13897	16253	10960	10142	2665	65184

NOTES: A heatmap of the total number of synthetic threshold crossings (rounded to the nearest MiFID II price thresholds) with liquidity buckets corresponding to Tab. 3.1. Panels A and B present the results for tick-size increases and decreases, respectively. The intensity of the color indicates the frequency of crossings, with darker shades representing higher values.

Table 7 presents the total number of threshold crossings as a heatmap. The intensity of the color indicates the frequency of crossings, with darker shades representing higher numbers. Panel A shows the number of tick size increases and panel B the number of decreases. Table 7, in accordance with the original tick size table (see Table 1), includes two dimensions: price and liquidity, which is measured by the average daily number of transactions.

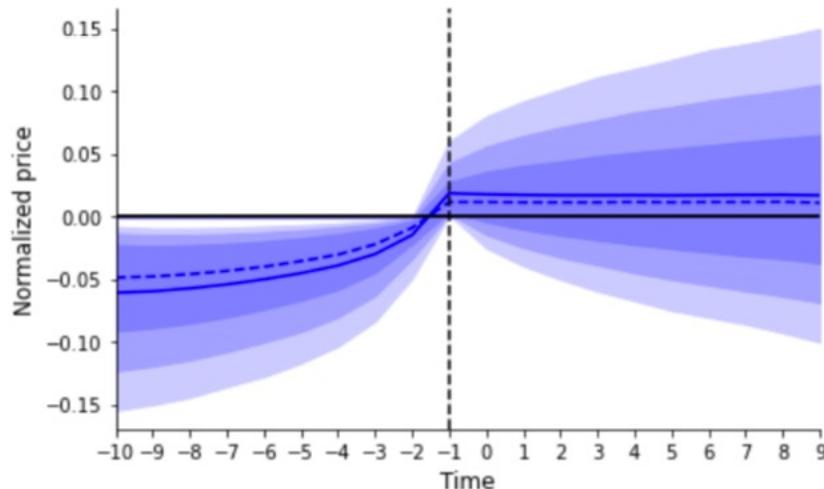
# Temporal distribution of events



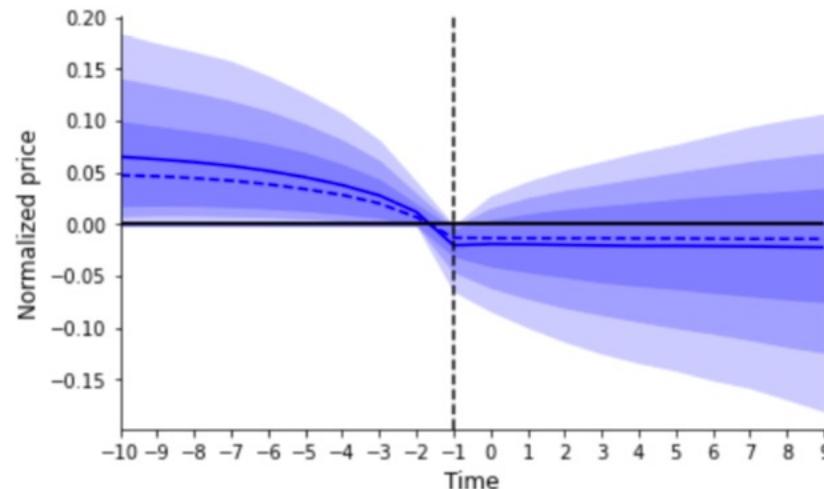
NOTES: This figure illustrates the temporal distribution of events—price-driven tick-size changes. The columns represent the treated and control groups, while rows plot the events related to tick-size increases and decreases, respectively. The black, blue, and red lines represent the normalized number of events in the complete raw dataset, treatment group, and control group, respectively. The red dashed horizontal line marks the outlier threshold applied in robustness analyses, with days exceeding  $3\sigma$  events—where  $\sigma$  denotes the standard deviation of event counts in the full dataset—being excluded. The annotated correlations indicate a consistent representation across the samples.

# Control price distribution across event window

(A) Tick-size increase



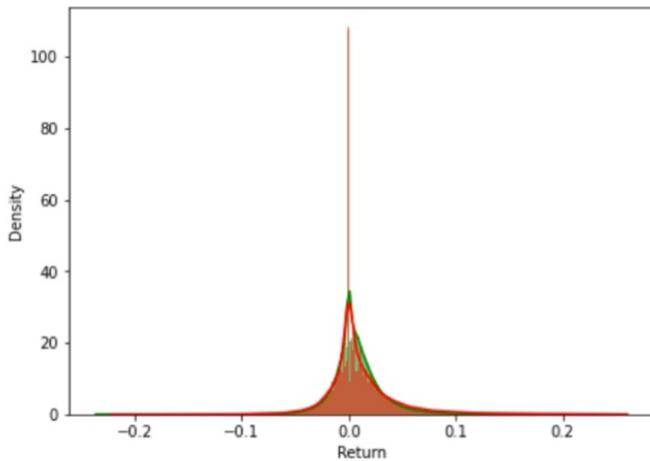
(B) Tick-size decrease



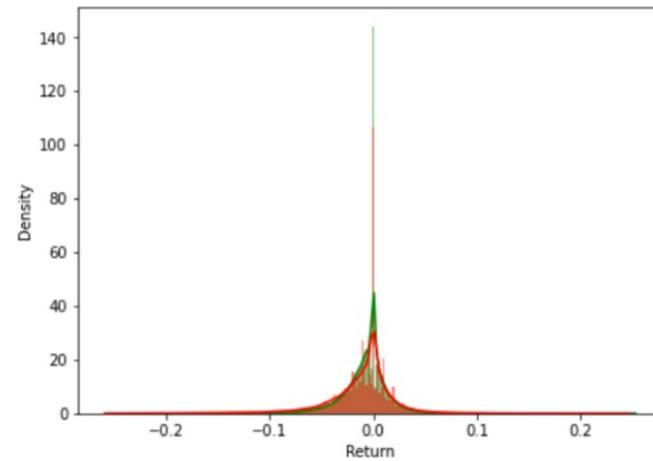
NOTES: Normalized prices over the 4-week window for the control group. Panels A and B present the results for tick-size increases and decreases, respectively. The price mean and median are represented by the solid and dashed lines, respectively. From inside to outside, the shaded areas represent the 20–80, 10–90, and 5–95 percentile ranges. The black horizontal line represents the normalized synthetic price threshold. Prices stay bound by the thresholds before crossing and can move freely after crossing. All prices cross the threshold at  $t = -1$ .

# Pre-event return distribution

(A) Tick-size increase



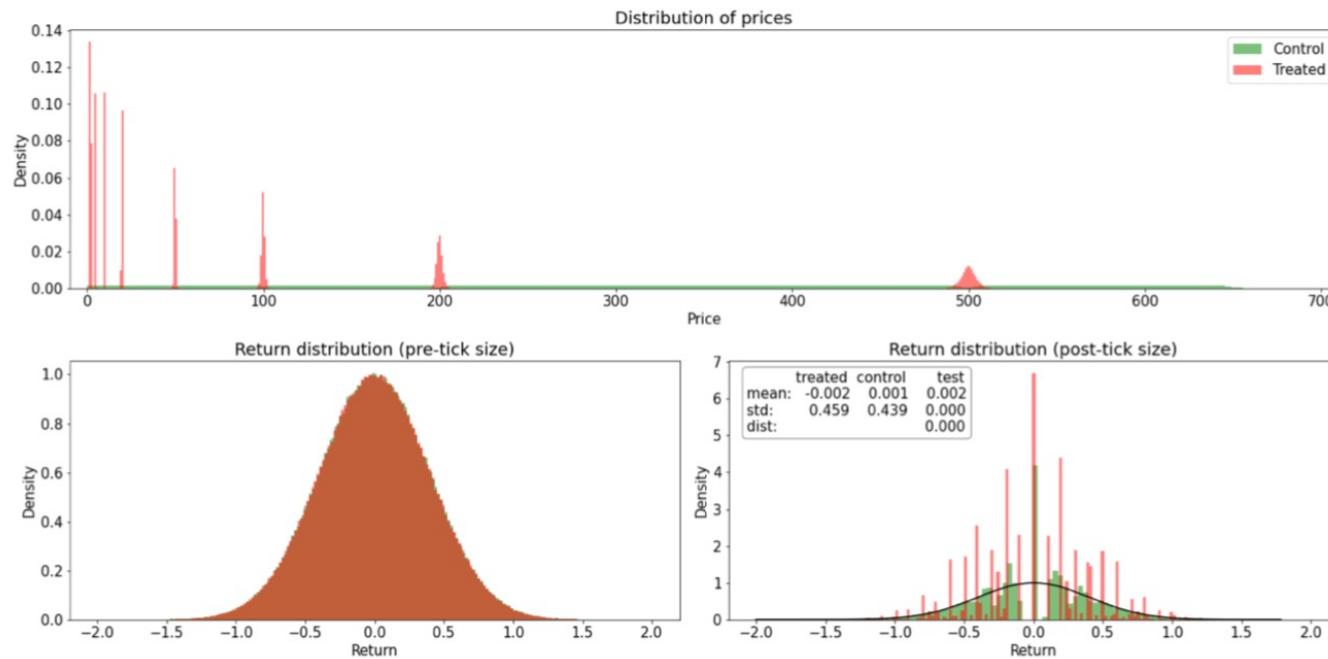
(B) Tick-size decrease



	(A) Tick-size increase			(B) Tick-size decrease		
	Treated	Control	Hypothesis test	Treated	Control	Hypothesis test
Mean	1.242	1.098	0.000	-1.252	-1.009	0.000
Std	3.668	3.127	0.000	3.488	2.907	0.000
Min	-21.212	-24.681		-25.000	-25.000	
25	-0.407	-0.358		-2.381	-2.000	
50	0.328	0.518	0.000	-0.526	-0.462	0.000
75	2.139	2.113		0.196	0.126	
Max	25.000	25.000		23.810	24.481	

# Tick-size induced distortion of return distribution

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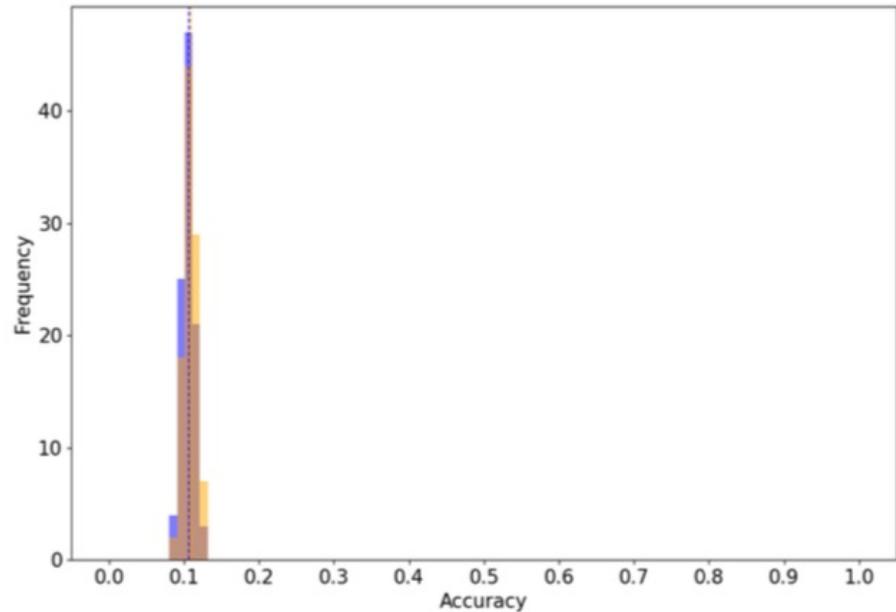


NOTES: This figure demonstrates the impact of tick sizes on return distributions using simulated data. The top panel displays the distribution of 160,000 simulated 10-day price trajectories, each generated with normally distributed i.i.d. returns (mean: 0.0; standard deviation: 0.4). These sequences are divided into two groups of 80,000 each: treatment (price trajectories crossing a threshold) and control. Different tick sizes apply between consecutive price thresholds (taken from the “ $< 10$  ADNTE” liquidity bucket from Tab. 3.1). The bottom left panel shows the return distribution before the tick-size application, while the bottom right panel shows the distribution after rounding to the nearest tick size. Treated and control groups are represented by red and green histograms, respectively, with the original kernel density estimation of returns shown as a black line for comparison. The key in the bottom right includes summary statistics and p-values for hypothesis tests: t-test (means), Levene test (standard deviation), and Kolmogorov-Smirnov test (distribution).

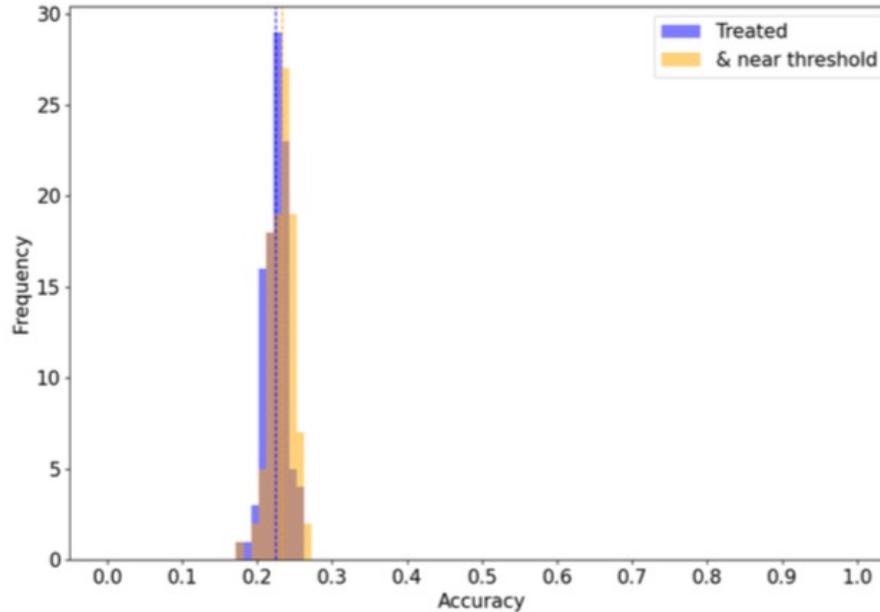
# Treatment prediction

40

(A) Tick-size increase



(B) Tick-size decrease



NOTES: This figure illustrates the accuracy distribution of neural networks in predicting treatment. The blue histogram represents the prediction performance for the treated group, with the blue dashed line indicating the average. The orange histogram shows the prediction accuracy for treated instances within 20% of a MiFID II price threshold, marked by the orange dashed line for the mean. Panels A and B present the results for tick-size increases and decreases, respectively.

# The impact of the choice of control thresholds on the results

41

(A) Tick-size increase	$\beta^{Cross}$	$\beta^{Week1}$	$\beta^{Week2}$	# Instances	# Obs.
Every price increment	2.597*** (0.000)	-0.795 <sup>x</sup> (0.135)	-0.809 <sup>x</sup> (0.128)	5,765 228,754	4,690,380
Main result thresholds	2.530*** (0.000)	-0.128*** (0.000)	-0.127*** (0.000)	5,765 45,382	1,022,940
Behavioral thresholds	1.336*** (0.000)	-0.080** (0.023)	-0.076** (0.020)	5,765 25,403	311,680
(B) Tick-size decrease					
Every price increment	-1.872*** (0.002)	0.950 <sup>x</sup> (0.108)	1.028* (0.082)	7,161 247,943	5,102,080
Main result thresholds	-1.884*** (0.000)	0.320*** (0.000)	0.346*** (0.000)	7,161 63,985	1,422,920
Behavioral thresholds	-0.551*** (0.000)	0.251*** (0.000)	0.306*** (0.000)	7,161 35,291	424,520

NOTES: This table presents estimates for the  $\beta$  coefficients that correspond to Equation (3.1), with the stock return as the dependent variable, for various choices of control groups. Panels A and B present the results for tick-size increases and decreases, respectively. “Every price increment” uses any price increment as a potential synthetic threshold; “Main results thresholds” replicates the main results from Table 3.1, which use integer values (and 1, 5, and 10-cent increments for lower priced stocks) as synthetic thresholds; “Behavioral thresholds” replicates the results from Table 3.2, which uses round integer values as synthetic thresholds. “# Instances” records the number of treated instances in the top row and number of control instances in the bottom row. p-values, based on stock and time-clustered standard errors, are given in parentheses. \*\*\*, \*\*, \*, and <sup>x</sup> denote statistical significance at the 1%, 5%, 10%, and 15% level, respectively. The results demonstrate consistent effect direction between the control thresholds and a monotonic trend in magnitude from the most relaxed choice of thresholds to the most reduced.

# Preserving the relative tick sizes in the control group relative to the treated group

42

(A) Tick-size increase	$\beta^{Cross}$	$\beta^{Week1}$	$\beta^{Week2}$	# Instances	# Obs.
thresholds within $\pm 10\%$	2.901*** (0.000)	-0.190*** (0.000)	-0.174*** (0.000)	5,765	300,020
thresholds within $\pm 20\%$	2.520*** (0.000)	-0.163*** (0.000)	-0.152*** (0.000)	5,765	584,700
				23,470	
(B) Tick-size decrease					
thresholds within $\pm 10\%$	-2.206*** (0.000)	0.407*** (0.000)	0.436*** (0.000)	7,161	386,740
thresholds within $\pm 20\%$	-1.944*** (0.000)	0.354*** (0.000)	0.385*** (0.000)	7,161	793,120
				32,495	

NOTES: This table presents estimates for the  $\beta$  coefficients that correspond to Equation (3.1), with the stock return as the dependent variable, using control instances where relative tick sizes closely align with the treated group (within a range of 0.9 to 1.1, or  $\pm 10\%$ , and 0.8 to 1.2, or  $\pm 20\%$ , of MiFID II price thresholds). Panels A and B present the results for tick-size increases and decreases, respectively. “# Instances” records the number of treated instances in the top row and number of control instances in the bottom row. p-values, based on stock and time-clustered standard errors, are given in parentheses. \*\*\*, \*\*, and \* denote statistical significance at the 1%, 5%, and 10% level, respectively. These results highlight two findings: first, the clustering of relative tick sizes does not influence the main results (see App. 3.B.1); second, stocks with prices far from MiFID II thresholds are more easily identified as controls; thus, if differences between controls and treated were to be expected, these stocks would likely differ more. However, our focus on stocks near thresholds confirms that such biases do not drive our main results (see App. 3.B.2).

# Price-stratified impact of tick-sizes on stock prices

43

Tick size increase	$\beta_1^{crossing}$	$\beta_2^{1st\ week}$	$\beta_3^{2nd\ week}$	# Treated	# Obs.
Third highest priced stocks	1.943*** (0.000)	-0.007 (0.914)	0.046 (0.472)	1,190	358,000
Middle third priced stocks	2.019*** (0.000)	-0.121*** (0.002)	-0.115** (0.021)	1,287	358,040
Third lowest priced stocks	1.076*** (0.000)	-0.119*** (0.007)	-0.134*** (0.001)	3,288	306,900
Tick size decrease					
Third highest priced stocks	-2.413*** (0.000)	0.207** (0.010)	0.233*** (0.004)	1,288	498,020
Middle third priced stocks	-1.218*** (0.000)	0.225*** (0.000)	0.320*** (0.000)	1,475	498,020
Third lowest priced stocks	-0.772*** (0.000)	0.306*** (0.000)	0.346*** (0.000)	4,398	426,880

NOTES: This table presents estimates for the  $\beta$  coefficients that correspond to Equation (3.1), with the stock return as the dependent variable, for price-level subgroups. Panels A and B present the results for tick-size increases and decreases, respectively. The rows, from top to bottom, record the results for the highest, middle, and lowest third of prices in our dataset. p-values, based on stock and time-clustered standard errors, are given in parentheses. \*\*\*, \*\*, and \* denote statistical significance at the 1%, 5%, and 10% level, respectively. The results show no significant differences in the effects on low-priced assets, thus offering limited insights for contrasting our findings with those of [Albuquerque et al. \(2020\)](#).

# Excluding days with strong market-wide fluctuations

	(I) $2\sigma$				(II) $3\sigma$			
(A) Tick-size increase	$\beta^{Cross}$	$\beta^{Week1}$	$\beta^{Week2}$	# Data	$\beta^{Cross}$	$\beta^{Week1}$	$\beta^{Week2}$	# Data.
Main result controls	2.551*** (0.000)	-0.120*** (0.000)	-0.105*** (0.000)	5,193 943,420	2.530*** (0.000)	-0.116*** (0.000)	-0.114*** (0.000)	5,559 995,920
Behavioral controls	1.349*** (0.000)	-0.070** (0.014)	-0.059** (0.034)	5,193 261,340	1.342*** (0.000)	-0.067** (0.027)	-0.064** (0.027)	5,559 278,320
(B) Tick-size decrease								
Main result controls	-1.621*** (0.000)	0.268*** (0.000)	0.181*** (0.000)	5,835 1,249,400	-1.630*** (0.000)	0.281*** (0.000)	0.199*** (0.000)	6,108 1,291,760
Behavioral controls	-0.362*** (0.000)	0.192*** (0.000)	0.167*** (0.000)	5,835 357,220	-0.369*** (0.000)	0.203*** (0.000)	0.187*** (0.000)	6,108 371,580

NOTES: This table presents estimates for the  $\beta$  coefficients that correspond to Equation (3.1), with the stock return as the dependent variable, for data where days with strong market-wide fluctuations were excluded. Using the full dataset, the total number of tick-size changes per day was counted for tick-size increases and decreases. The standard deviation  $\sigma$  of the number of events per day across the timeframe was used to clip days with too many events. Specifically, we dropped every day with more than  $2\sigma$  or  $3\sigma$  events per day. Panels A and B present the results for tick-size increases and decreases, respectively. “# Data” records the number of treated instances in the first row and the number of observations in the second row. p-values, based on stock and time-clustered standard errors, are given in parentheses. \*\*\*, \*\*, and \* denote statistical significance at the 1%, 5%, and 10% level, respectively. These results indicate that tick-size increase effects are not influenced by days with significant market-wide fluctuations. In contrast, tick-size decrease effects initially show sensitivity to such exclusions but stabilize once the most extreme outliers are removed, showing negligible differences between the  $2\sigma$  and  $3\sigma$  results. The new results suggest that extreme market conditions largely drive excess returns on crossing days, and post-change effects align more with tick-size increases when such days are excluded.

# Excluding instances with high-return days

(A) Tick-size increase	$\beta^{Cross}$	$\beta^{Week1}$	$\beta^{Week2}$	# Instances	# Obs.
< 25% returns	2.530*** (0.000)	-0.128*** (0.000)	-0.127*** (0.000)	5,765	1,022,940
< 20% returns	2.066*** (0.000)	-0.118*** (0.000)	-0.124*** (0.000)	5,573	1,014,440
< 15% returns	1.607*** (0.000)	-0.105*** (0.000)	-0.121*** (0.000)	5,289	997,160
< 10% returns	1.042*** (0.000)	-0.071*** (0.003)	-0.099*** (0.001)	4,723	957,340
<hr/>					
(B) Tick-size decrease					
< 25% returns	-1.884*** (0.000)	0.320*** (0.000)	0.346*** (0.000)	7,161	1,422,920
< 20% returns	-1.649*** (0.000)	0.307*** (0.000)	0.339*** (0.000)	7,046	1,417,920
< 15% returns	-1.277*** (0.000)	0.308*** (0.000)	0.307*** (0.000)	6,771	1,4022,40
< 10% returns	-0.834*** (0.000)	0.258*** (0.000)	0.252*** (0.000)	6,220	1,362,420

NOTES: This table presents estimates for the  $\beta$  coefficients that correspond to Equation (3.1), with the stock return as the dependent variable, for data where high return days were excluded. That is, from top to bottom, the rows present the results for data where events with returns higher than 25%, 20%, 15%, and 10% were excluded, respectively. Panels A and B present the results for tick-size increases and decreases, respectively. “# Instances” records the number of treated instances in the top row and number of control instances in the bottom row. p-values, based on stock and time-clustered standard errors, are given in parentheses. \*\*\*, \*\*, and \* denote statistical significance at the 1%, 5%, and 10% level, respectively. These results assess how our data-cleaning criteria impact our main findings, particularly our exclusion of days with returns exceeding 25%. While tightening this threshold mechanically reduces the effects, the overall economic narrative remains consistent.

# Enforcing similarity between treated and control groups

46

(A) Tick-size increase	$\beta^{Cross}$	$\beta^{Week1}$	$\beta^{Week2}$	# Instances	# Obs.
< 90 <sup>th</sup> percentile	2.385*** (0.000)	-0.122*** (0.000)	-0.101*** (0.002)	4,786	734,680
< 85 <sup>th</sup> percentile	2.179*** (0.000)	-0.100*** (0.005)	-0.096*** (0.009)	4,383	625,960
< 80 <sup>th</sup> percentile	2.061*** (0.000)	-0.095*** (0.009)	-0.101*** (0.010)	3,975	529,600
< 75 <sup>th</sup> percentile	1.966*** (0.000)	-0.091** (0.013)	-0.099** (0.014)	3,560	452,800
(B) Tick-size decrease					
< 90 <sup>th</sup> percentile	-1.799*** (0.000)	0.318*** (0.000)	0.329*** (0.000)	5,956	1,104,960
< 85 <sup>th</sup> percentile	-1.772*** (0.000)	0.323*** (0.000)	0.322*** (0.000)	5,444	979,720
< 80 <sup>th</sup> percentile	-1.718*** (0.000)	0.334*** (0.000)	0.329*** (0.000)	4,954	855,260
< 75 <sup>th</sup> percentile	-1.680*** (0.000)	0.345*** (0.000)	0.331*** (0.000)	4,429	738,320

NOTES: This table presents estimates for the  $\beta$  coefficients that correspond to Equation (3.1), with the stock return as the dependent variable, using treated and control sets whose similarity are enforced. That is, we truncate outliers in all observable variables. From top to bottom, the rows present the results using data where the 10<sup>th</sup>, 15<sup>th</sup>, 20<sup>th</sup>, and 25<sup>th</sup>-percentiles were truncated, respectively. Panels A and B present the results for tick-size increases and decreases, respectively. “# Instances” records the number of treated instances in the top row and number of control instances in the bottom row. p-values, based on stock and time-clustered standard errors, are given in parentheses. \*\*\*, \*\*, and \* denote statistical significance at the 1%, 5%, and 10% level, respectively. These results demonstrate that outliers in observable characteristics do not drive the results.

# Changing the length of the pre-event restriction

(A) Tick-size increase	$\beta^{Cross}$	$\beta^{Week1}$	$\beta^{Week2}$	# Instances	# Obs.
1 week	3.096*** (0.000)	-0.134* (0.054)	-0.086 (0.175)	7,979	2,446,700
2 week	2.530*** (0.000)	-0.128*** (0.000)	-0.127*** (0.000)	5,765	1,022,940
3 week	3.468*** (0.000)	-0.068** (0.028)	-0.036 (0.216)	4,639	1,617,060
				49,263	
(B) Tick-size decrease					
1 week	-2.390*** (0.000)	0.232** (0.021)	0.224** (0.022)	9,189	4,509,220
2 week	-1.884*** (0.000)	0.320*** (0.000)	0.346*** (0.000)	7,161	1,422,920
3 week	-2.671*** (0.000)	0.178*** (0.000)	0.231*** (0.000)	6,015	3,045,030
				95,486	

NOTES: This table presents estimates for the  $\beta$  coefficients that correspond to Equation (3.1), with the stock return as the dependent variable, for varying pre-event window lengths. Specifically, the “1 week”, “2 week”, and “3 week” results are generated using data with 1, 2, and 3-week restrictions on the number of consecutive trading days a price is forbidden to cross a threshold, respectively. The “2 week” row replicates the main results from Table 3.1. Panels A and B present the results for tick-size increases and decreases, respectively. “# Instances” records the number of treated instances in the top row and number of control instances in the bottom row. p-values, based on stock and time-clustered standard errors, are given in parentheses. \*\*\*, \*\*, and \* denote statistical significance at the 1%, 5%, and 10% level, respectively.