Quantitative Easing and Equity Prices:

Evidence from the ETF Program of the Bank of Japan

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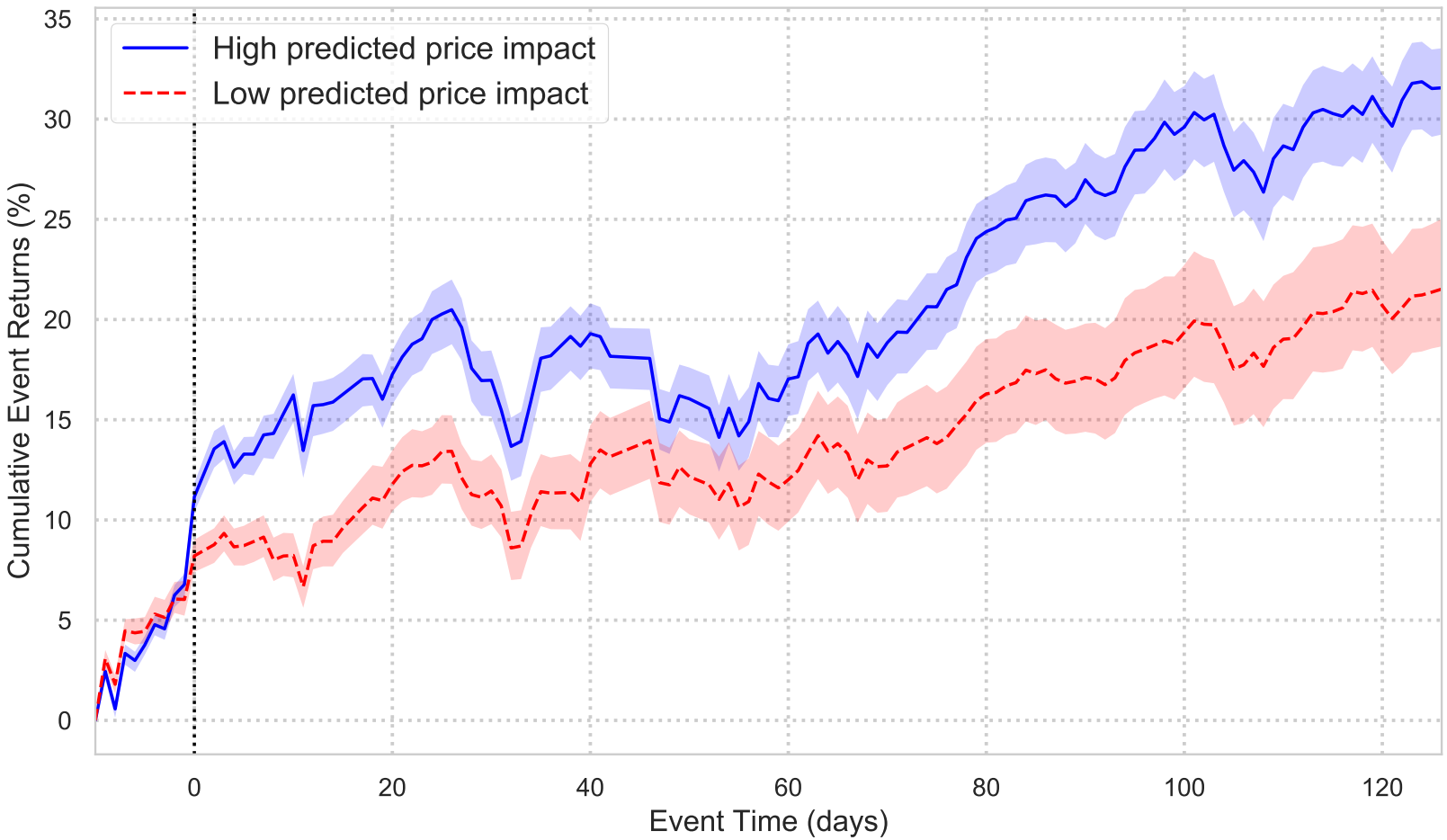
Motivation

- QE by many central banks to push up prices
- Prices need to react to changes in supply
- Portfolio Balance Channel
- Purschases of equity ETFs by the Bank of Japan
- **H0: Demand curves for stocks slope down because of the portfolio rebalancing mechanism**

Preview of the Results

- Simple model of portfolio balance channel
- Test on unique setting of ETF program of the BOJ
- Positive, sizeable net supply effect on prices
- Persistent effect: no reversal over a 1-year window
- CS and TS of returns is consistent with the model
- Punchline: demand curves for stocks do slope down

Preview of the Results



Related Literature

- Empirical literature

  Portfolio Balance Eser and Schwaab (2016), Miles and Schanz (2014), D'Amico and King (2013), Krishnamurthy and Jorgensen (2011, 2013), Joyce et al (2012), Gagnon et al (2011)

  Signalling Bauer and Rudebusch (2014), Christensen and Rudebusch (2012)

  Bank Funding Miles (2011, 2012)

- Theoretical literature

  Eggerston and Woodford (2003), Sargent and Smith (1987), Chamley and Polemarchakis (1984), Wallace (1981)

  Greenwood and Vayanos (2014), Vayanos and Vila (2009)

Related Literature

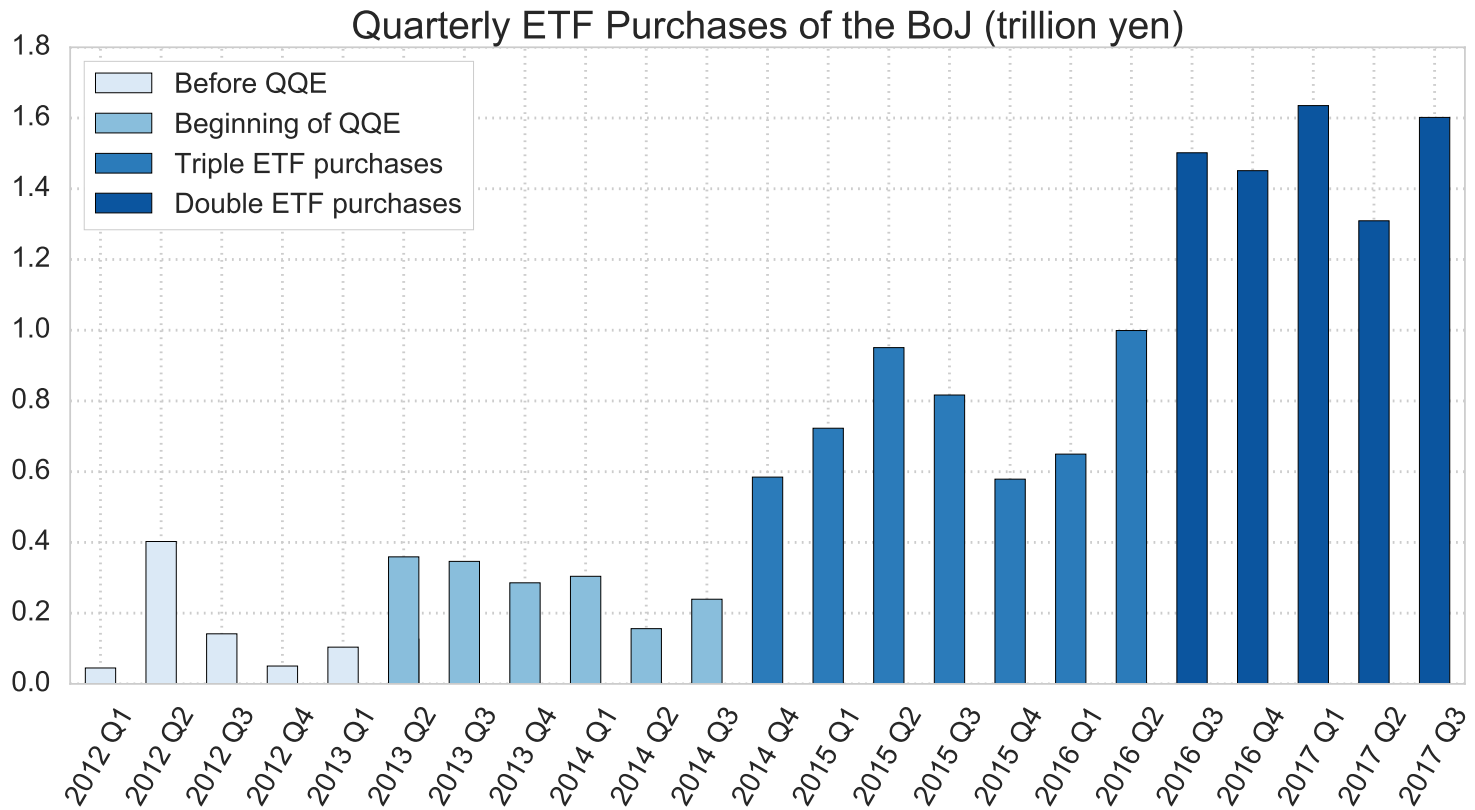
- Empirical literature

  Index Redefinitions Chen (2006), Greenwood (2005), Kaul et al. (2000), Lynch and Mendenhall (1997), Shleifer (1986), Harris and Gurel (1986), Garry and Goetzmann (1986)

  Fire Sales Coval and Stafford (2007)

- Limits to arbitrage can justify temporary price pressure
- Short-term demand curves slope down
- but long-term demand curves are flat
- Different explanation... but also different type of shock!

The ETF Purchase Program of the BoJ



- Support asset prices and reduce the cost of capital
- Oct 31st, 2014: ¥1 tn $\rightarrow$ ¥3 tn
- July 29th, 2016: ¥3 tn $\rightarrow$ ¥6 tn

details

ETFs

Index	ETF Name	Management Company	Fund AUM (bn JPY)
Topix	TOPIX ETF	Nomura AM	3'885
	Daiwa ETF-TOPIX	Daiwa AM	1'811
	Listed Index Fund TOPIX	Nikko AM	1'718
	MAXIS TOPIX ETF	Mitsubishi UFJ Kokusai AM	495
	DIAM ETF TOPIX	Asset Management One	56
	iShares TOPIX ETF	BlackRock Japan	49
			8'013
Nikkei 225	Nikkei 225 ETF	Nomura AM	4'051
	Daiwa ETF - Nikkei 225	Daiwa AM	1'881
	Listed Index Fund 225	Nikko AM	1'982
	MAXIS NIKKEI225 ETF	Mitsubishi UFJ Kokusai AM	895
	iShares Nikkei 225 ETF	BlackRock Japan	363
	DIAM ETF Nikkei225	Asset Management One	265
			9'476

(AUM as of 1.1.2017)

- "The maximum amount of each ETF to be purchased [...] shall be set so that the Bank's purchase would roughly be proportionate to the total market value of that ETF issued."

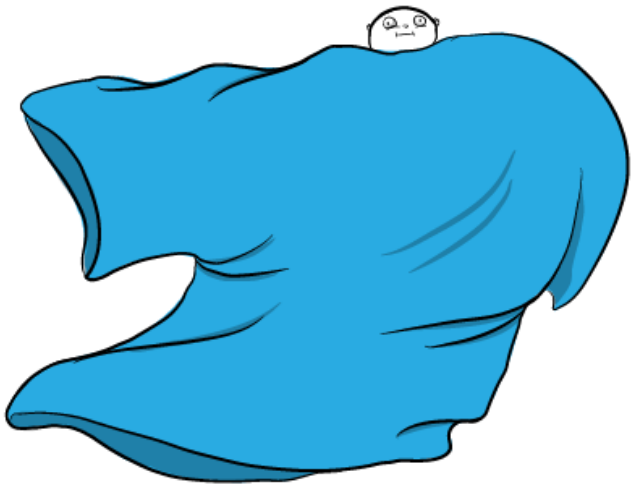
Stock-level implications

- Stock-level demand shock proportional to a stock's weight in the BOJ vector of purchases
- Allocation rule

$$u(¥) \cong \frac{w_{\mathsf{T}} + w_{\mathsf{N}}}{2} \times 1¥$$

- The Topix is a value weighted index of the stocks in the TSE 1st section
- The Nikkei is a price weighted index of 225 companies representative of the Japanese economy

Nikkei Distortion



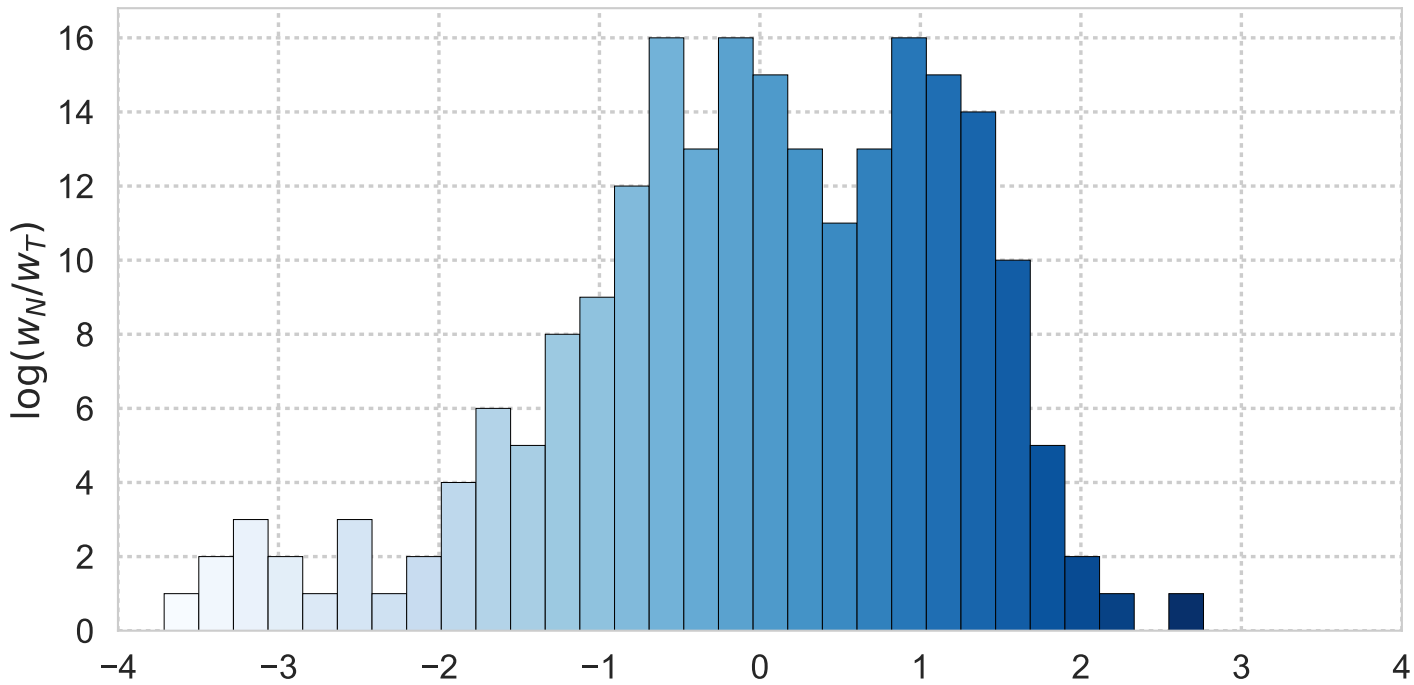
- Non-Nikkei
- Low Nikkei weight

Nikkei

High Nikkei weight

Nikkei Distortion

- Nikkei 225 is price-weighted, Topix is value-weighted



- Nikkei weights induce exogenous cross-sectional variation in the BoJ purchase schedule, relative to market capitalization

A Natural Experiment

1. **Exogenous** demand shock

2. The BOJ buys ETFs tracking the **Topix** and the **Nikkei** 225 according to a **well defined rule** mitigating endogeneity concerns

3. Purchase schedule u is **not** proportional to market caps

   $\Longrightarrow$ Crucial for our identification strategy

Model Overview

- Partial equilibrium model with risk-averse RA
- The CB is exogenous and its balance sheet evolves deterministically
- QE affects the equilibrium price via market clearing
- Constant shares outstanding but CB reduces the free float
- Reduced-form model consistent with financial frictions:
  - Investors discriminate btw their holdings and those of the CB
  - Limited participation $\rightarrow$ risk sharing

Model Details

- Multiple assets with stochastic dividends

$$D_{i,t} = D_{i,0} + \sum_{s=1}^{t} \varepsilon_{i,s}, \qquad \forall i \in 1, \ldots, n$$

  with stationary covariance matrix Σ

- Representative agent with CARA utility (risk-averse)

$$\max_{N} \; \mathrm{E}_t \left(-\exp(-\gamma W_{t+1}) \right) \qquad \text{s.t.}$$

$$W_{t+1} = W_t(1 + r_f) + N_t'(p_{t+1} + D_{t+1} - p_t(1 + r_f))$$

The Model – Solution

- The FOC determines the optimal demand schedule

$$N_t = \frac{1}{\gamma} Var_t[p_{t+1} + D_{t+1}]^{-1} (\mathrm{E}_t[p_{t+1} + D_{t+1} - p_t])$$

- Market clearing $N_t = Q_t$ leads to the pricing equation

$$p_t = \frac{1}{r_f} (D_t - \gamma \Sigma \Omega_t)$$

- Here Ω_t is the expected discounted future asset supply

$$\Omega_t = \frac{r_f}{1 + r_f} \sum_{i=0}^{\infty} \frac{\mathrm{E}_t[Q_{t+i}]}{(1 + r_f)^i}$$

Testable Predictions

1. **Announcement returns**: The vector of event returns is positively related in the cross-section to

$$\pi \equiv \Sigma u$$

(the price adjustment is proportional to the expected reduction in risk)

2. **Momentum effect**: The vectors of post-event returns are positively related in the cross-section to

$$\pi \equiv \Sigma u$$

(the actual quantity available keeps reducing as the central bank carries over its purchases)

Identification of the Net Supply Effect

- Purchases proportional to market caps (i.e. $u = kQ$):

$$\pi \qquad \propto \qquad \beta$$

...the net supply effect would be indistinguishable from aggregate market movements!

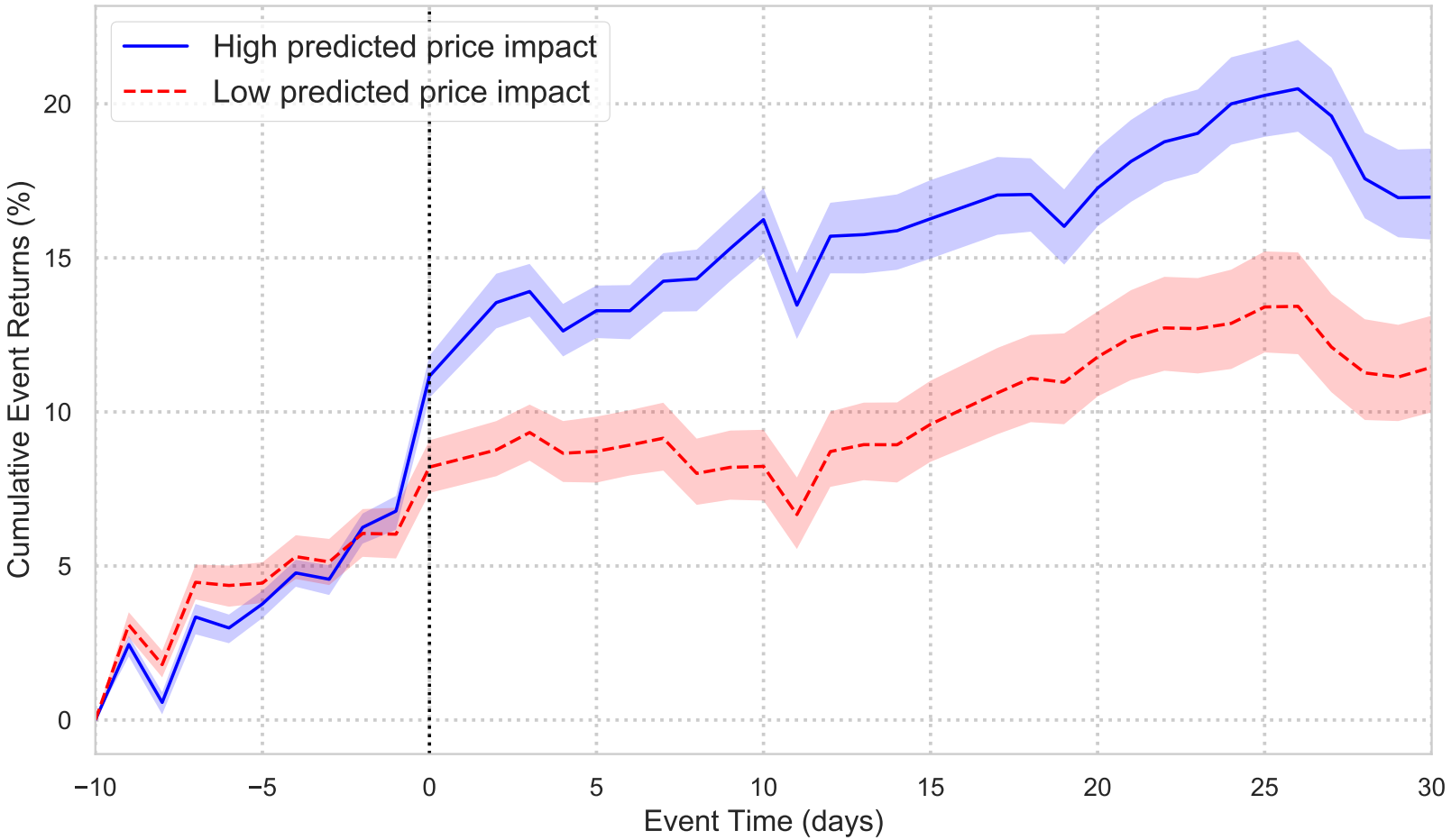
- Purchases tilted away from market caps (i.e. $u \neq kQ \ \forall k$):

$$\pi \qquad \not\propto \qquad \beta$$

...the net supply effect leaves a **characteristic footprint** in the CS of stocks returns!

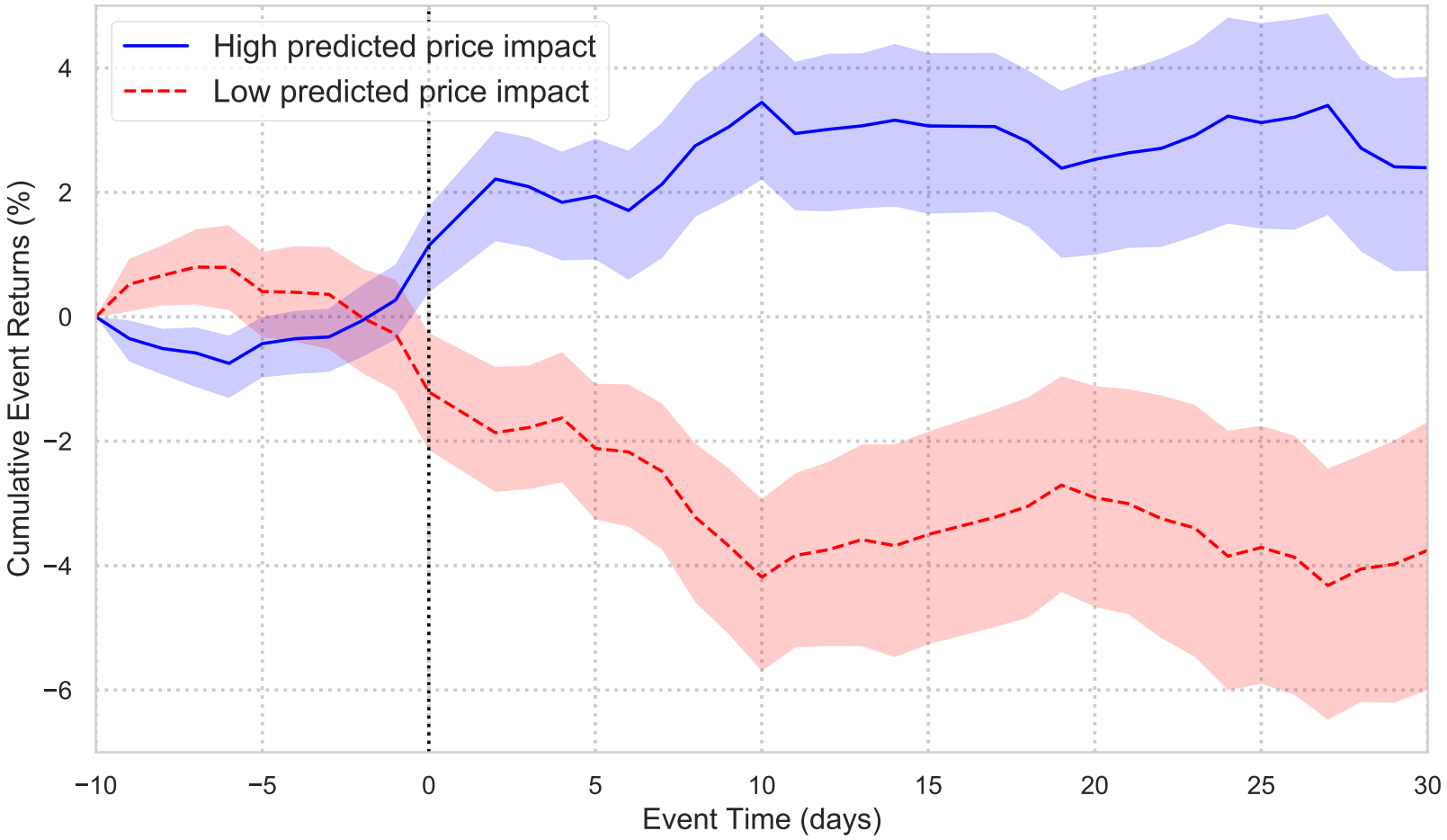
Event Returns – 2014

- We sorts stocks based on the predicted price impact $\pi = \Sigma u$
- We plot event returns for the top and the bottom quartiles



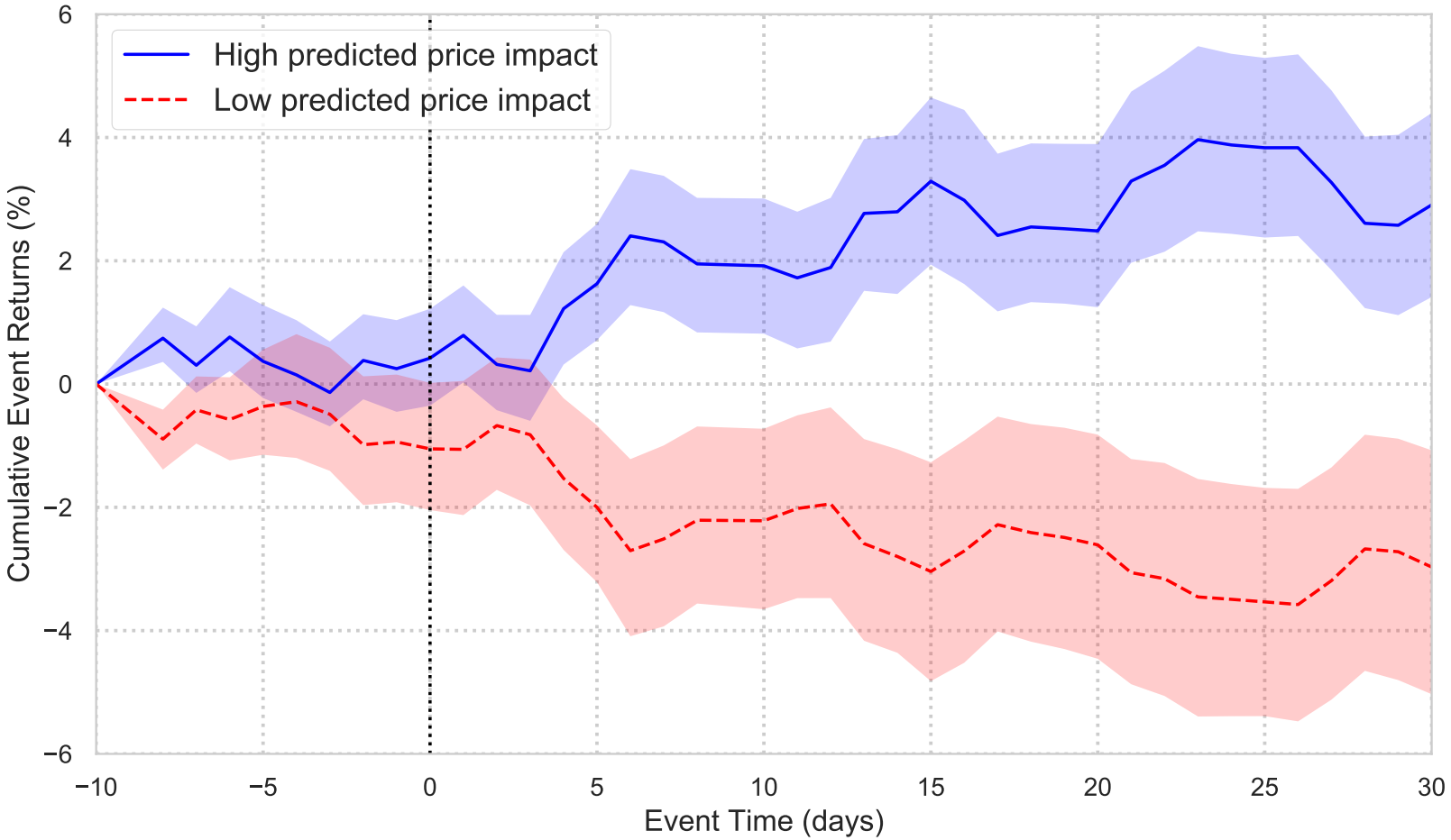
Abnormal Event Returns – 2014

- The spread is more pronounced looking at abnormal returns



Abnormal Event Returns – 2016

- Similar pattern for the 2016 announcement



Summary Statistics by Π

	Market Cap (bn JPY)			Market beta			Forex beta			Market Leverage (%)			Market to Book		
	mean	std	p50	mean	std	p50	mean	std	p50	mean	std	p50	mean	std	p50
As of 2013:															
High Pi	808.4	1643.5	297.8	1.04	0.24	1.03	0.00	0.12	-0.01	26.4	22.4	21.6	1.2	0.5	1.1
Medium-high Pi	118.3	195.4	53.2	0.79	0.27	0.78	-0.03	0.11	-0.04	24.1	22.8	17.2	1.2	2.0	1.0
Medium-low Pi	46.3	69.7	25.4	0.75	0.31	0.72	-0.06	0.14	-0.07	25.9	23.3	20.0	1.1	0.8	1.0
Low Pi	30.8	55.7	17.7	0.90	0.32	0.90	-0.07	0.16	-0.06	25.7	22.6	21.1	1.4	1.3	1.0
As of 2015:															
High Pi	943.1	1822.3	391.3	1.00	0.18	1.01	0.00	0.13	-0.01	23.9	22.7	18.1	1.4	0.9	1.1
Medium-high Pi	134.8	219.2	53.7	0.84	0.22	0.85	-0.04	0.12	-0.05	23.3	22.6	17.9	1.2	0.8	1.0
Medium-low Pi	66.2	110.1	30.0	0.81	0.23	0.82	-0.05	0.14	-0.06	24.5	22.6	18.2	1.2	0.9	1.0
Low Pi	44.6	58.9	22.7	0.89	0.22	0.89	-0.05	0.17	-0.05	24.1	22.0	18.2	1.5	1.3	1.1

- π is positively related to size and forex beta
- π is not related to leverage and growth opportunities
- π does not seem to capture financial constraints

Cross-sectional Regressions – 2014

- We run a cross-sectional regression of realized 10-days event returns on the predicted price impact π

	Raw Returns				Abnormal Returns			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
π	**57.86*** **	**59.15*** **	**31.92*** **	**23.27*** **	**36.06*** **	**37.75*** **	**39.95*** **	**30.60*** **
	(8.59)	(8.00)	(4.40)	(3.49)	(4.94)	(4.81)	(5.54)	(4.62)
u		-0.00	-0.02***	-0.02***		-0.00	-0.02***	-0.02***
		(-0.95)	(-3.83)	(-3.43)		(-1.34)	(-3.62)	(-3.20)
Market Beta			0.040	0.025			-0.05	-0.07*
			(0.75)	(0.51)			(-1.48)	(-1.97)
Forex Beta			0.040*	0.043**			0.040*	0.041**
			(1.87)	(2.32)			(1.96)	(2.32)
log(Market Cap)			0.007	0.007			0.005	0.006
			(1.17)	(1.36)			(0.97)	(1.16)
Amihud			0.000	0.000			0.000	4.618
			(0.53)	(0.49)			(0.22)	(0.03)
Observations	1,851	1,851	1,807	1,701	1,851	1,851	1,807	1,701
R-squared	0.106	0.106	0.162	0.203	0.046	0.047	0.108	0.160
Industry FE	NO	NO	NO	YES	NO	NO	NO	YES

t-statistics are computed from placebo regressions around non-event days

Cross-sectional Regressions – 2016

- The pattern is similar for the 2016 announcement

	Raw Returns				Abnormal Returns			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
π	**14.07***	**14.30***	**12.17***	**11.88**	**15.33***	**16.33***	**17.49****	**16.69****
	(2.09)	(1.93)	(1.68)	(1.78)	(2.10)	(2.08)	(2.43)	(2.52)
u		-0.00	0.001	0.002		-0.00	0.004	0.004
		(-0.29)	(0.19)	(0.38)		(-1.33)	(0.56)	(0.67)
Market Beta			0.006	-0.00			0.002	-0.01
			(0.12)	(-0.06)			(0.06)	(-0.26)
Forex Beta			0.016	0.012			0.019	0.014
			(0.78)	(0.66)			(0.94)	(0.80)
log(Market Cap)			-0.00	-0.00			-0.00	-0.00
			(-0.10)	(-0.05)			(-0.58)	(-0.49)
Amihud			0.000	0.000			0.000	0.000
			(0.43)	(0.18)			(0.41)	(0.11)
Observations	1,905	1,905	1,839	1,734	1,905	1,905	1,839	1,734
R-squared	0.017	0.017	0.021	0.043	0.019	0.019	0.028	0.050
Industry FE	NO	NO	NO	YES	NO	NO	NO	YES

t-statistics are computed from placebo regressions around non-event days

Momentum Effect – 2014

- The effect is increasing in the returns horizon

	Abnormal Returns 2014					
Horizon (days)	5	10	21	63	126	252
π	**17.78****	**39.95*****	**28.31*****	**72.21*****	**171.9*****	**305.5*****
	(3.09)	(5.54)	(2.89)	(4.52)	(8.97)	(11.91)
u	-0.00	-0.02***	-0.01	-0.03***	-0.03**	-0.07***
	(-0.30)	(-3.62)	(-1.21)	(-3.20)	(-2.46)	(-3.43)
Market Beta	-0.02	-0.05	-0.07	-0.16*	-0.29**	-0.40***
	(-0.84)	(-1.48)	(-1.36)	(-2.02)	(-2.04)	(-2.51)
Forex Beta	0.036**	0.040*	0.101***	0.097**	0.043	-0.13
	(2.17)	(1.96)	(3.83)	(2.29)	(0.61)	(-0.02)
log(Market Cap)	0.001	0.005	0.001	0.001	0.005	-0.00
	(0.32)	(0.97)	(0.17)	(0.06)	(0.25)	(-0.27)
Amihud	0.001	0.000	-1.02	0.001	0.016***	0.018***
	(0.78)	(0.22)	(-0.01)	(0.70)	(6.27)	(7.17)
Observations	1,807	1,807	1,807	1,807	1,807	1,807
R-squared	0.055	0.108	0.073	0.098	0.153	0.119

t-statistics are computed from placebo regressions around non-event days

Momentum Effect – 2016

- The effect is increasing in the returns horizon

	Abnormal Returns 2016					
Horizon (days)	5	10	21	63	126	252
π	**17.43****	**17.49****	**33.70*****	**40.86****	**93.52*****	**120.2*****
	(3.03)	(2.43)	(3.44)	(2.56)	(4.88)	(4.69)
u	0.011**	0.004	0.026**	0.016	0.052***	0.118***
	(2.22)	(0.56)	(2.76)	(1.48)	(3.31)	(5.13)
Market Beta	0.026	0.002	0.025	0.025	0.041	0.068
	(0.86)	(0.06)	(0.47)	(0.32)	(0.28)	(0.43)
Forex Beta	-0.00	0.019	0.061*	0.070*	0.220***	0.216
	(-0.23)	(0.94)	(2.30)	(1.67)	(3.10)	(0.04)
log(Market Cap)	-0.00*	-0.00	-0.01*	-0.02	-0.07***	-0.11***
	(-1.60)	(-0.58)	(-1.81)	(-1.80)	(-3.52)	(-6.82)
Amihud	0.000	0.000	-0.00	-0.00	-0.00**	-0.00
	(0.47)	(0.41)	(-0.47)	(-0.92)	(-3.12)	(-2.16)
Observations	1,839	1,839	1,839	1,839	1,839	1,839
R-squared	0.051	0.028	0.079	0.077	0.178	0.140

t-statistics are computed from placebo regressions around non-event days

Control for Nikkei

- Results are not driven by Nikkei VS non-Nikkei stocks...

	Abnormal Returns 2014						Abnormal Returns 2016					
Horizon (days)	5	10	21	63	126	252	5	10	21	63	126	252
π	**19.04*** **	**42.17*** **	**28.77*** **	**72.38*** **	**172.5*** **	**300.7*** **	**17.61** **	**17.34***	**31.88*** **	**38.51** **	**87.69*** **	**112.9*** **
	(3.22)	(5.69)	(2.86)	(4.57)	(9.25)	(11.60)	(2.98)	(2.34)	(3.16)	(2.43)	(4.70)	(4.36)
u	0.008*	-0.00	-0.00	-0.03***	-0.03**	-0.11***	0.014***	0.001	-0.00	-0.02*	-0.04**	0.001
	(1.90)	(-1.32)	(-0.97)	(-3.44)	(-2.06)	(-4.64)	(3.28)	(0.27)	(-0.24)	(-2.15)	(-2.47)	(0.07)
Market Beta	-0.02	-0.05	-0.07	-0.16*	-0.29**	-0.40***	0.026	0.002	0.027	0.028	0.048	0.076
	(-0.84)	(-1.48)	(-1.37)	(-2.06)	(-2.05)	(-2.14)	(0.86)	(0.07)	(0.51)	(0.36)	(0.33)	(0.41)
Forex Beta	0.037**	0.042*	0.102***	0.097**	0.043	-0.13	-0.00	0.018	0.053*	0.060	0.196***	0.186***
	(2.20)	(2.02)	(3.81)	(2.28)	(0.61)	(-1.72)	(-0.18)	(0.90)	(2.00)	(1.43)	(2.73)	(2.33)
log(Market Cap)	0.001	0.006	0.001	0.001	0.005	-0.00	-0.00	-0.00	-0.01*	-0.03	-0.07***	-0.11***
	(0.33)	(0.94)	(0.16)	(0.06)	(0.24)	(-0.33)	(-1.48)	(-0.55)	(-1.80)	(-1.79)	(-3.58)	(-7.59)
Amihud	0.001	0.000	4.552	0.001	0.016***	0.018***	0.000	0.000	-0.00	-0.00	-0.00**	-0.00
	(0.79)	(0.25)	(0.00)	(0.67)	(6.13)	(7.14)	(0.48)	(0.39)	(-0.53)	(-0.96)	(-3.27)	(-2.45)
Nikkei	-0.01	-0.02*	-0.00	-0.00	-0.00	0.048*	-0.00	0.003	0.038*	0.049*	0.122***	0.153***
	(-1.26)	(-1.72)	(-0.27)	(-0.08)	(-0.18)	(1.54)	(-0.38)	(0.24)	(2.23)	(2.32)	(4.03)	(4.88)
Observations	1,807	1,807	1,807	1,807	1,807	1,807	1,839	1,839	1,839	1,839	1,839	1,839
R-squared	0.06	0.11	0.07	0.10	0.15	0.12	0.05	0.03	0.08	0.08	0.19	0.15
Industry FE	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

t-statistics are computed from placebo regressions around non-event days

Control for Nikkei

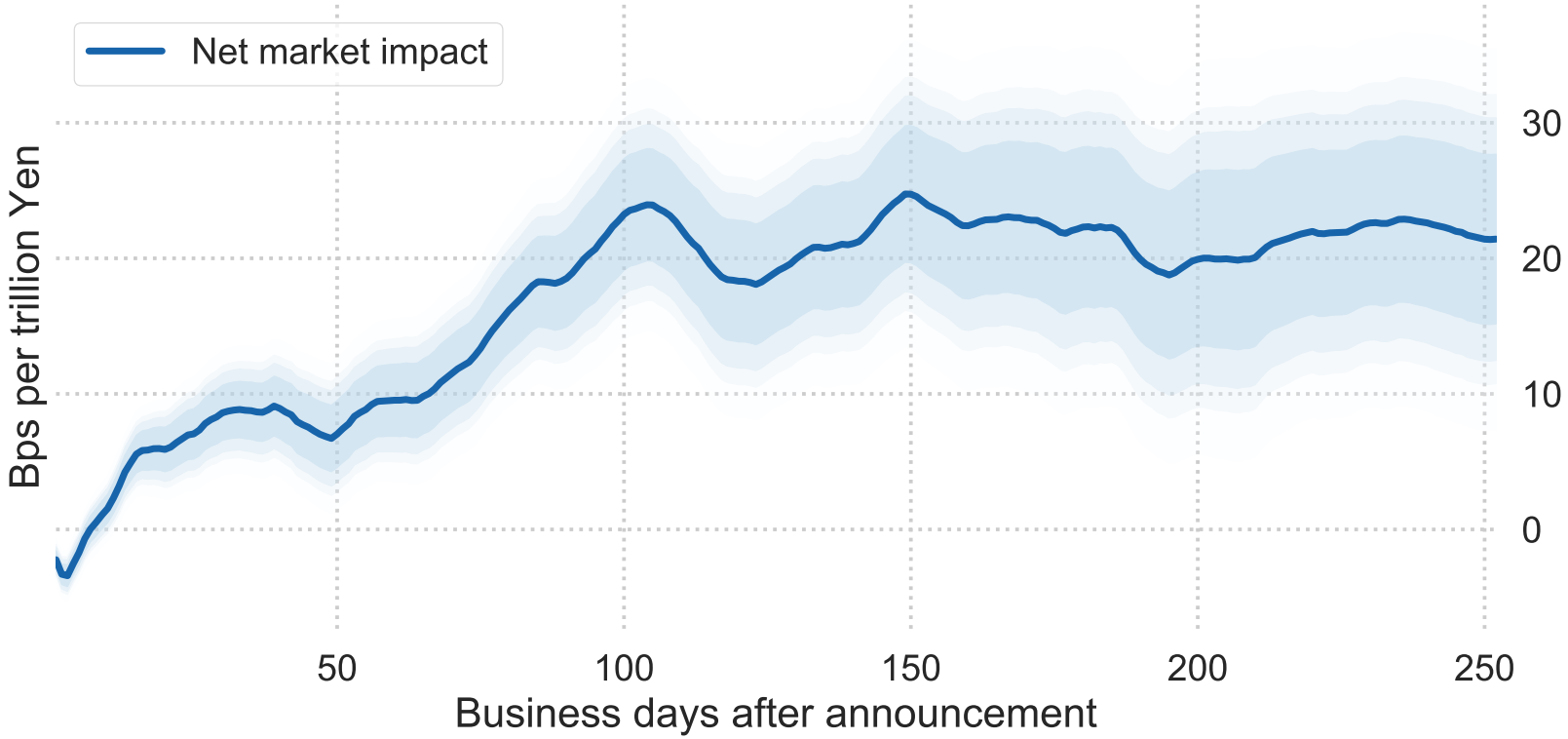
- ...nor by industries fixed effects

	Abnormal Returns 2014						Abnormal Returns 2016					
Horizon (days)	5	10	21	63	126	252	5	10	21	63	126	252
π	**12.21****	**32.64*****	**22.95****	**63.97*****	**150.7*****	**266.7*****	**15.62****	**16.37****	**28.39****	**31.48****	**75.75*****	**102.7*****
	(2.28)	(4.80)	(2.51)	(4.38)	(8.72)	(10.01)	(2.91)	(2.41)	(3.11)	(2.16)	(4.38)	(3.86)
u	0.006	-0.00	-0.00	-0.02***	-0.03**	-0.10***	0.012**	0.000	-0.00	-0.02*	-0.04**	-0.00
	(1.35)	(-1.41)	(-1.16)	(-2.89)	(-2.32)	(-4.28)	(2.72)	(0.05)	(-0.56)	(-2.42)	(-2.95)	(-0.21)
Market Beta	-0.04*	-0.07*	-0.08*	-0.17**	-0.33**	-0.46***	0.016	-0.00	0.011	0.015	0.014	0.050
	(-1.48)	(-1.98)	(-1.71)	(-2.38)	(-2.23)	(-2.28)	(0.59)	(-0.25)	(0.24)	(0.21)	(0.10)	(0.25)
Forex Beta	0.040**	0.043**	0.095***	0.087**	0.018	-0.12***	-0.00	0.012	0.044*	0.038	0.163**	0.134***
	(2.83)	(2.38)	(4.11)	(2.25)	(0.28)	(-1.93)	(-0.45)	(0.71)	(1.93)	(0.98)	(2.49)	(2.01)
log(Market Cap)	0.002	0.006	0.001	-0.00	0.004	-0.00	-0.00	-0.00	-0.01	-0.02	-0.06***	-0.10***
	(0.61)	(1.09)	(0.21)	(-0.07)	(0.24)	(-0.81)	(-1.29)	(-0.48)	(-1.61)	(-1.69)	(-3.43)	(-9.10)
Amihud	0.001	0.000	0.001	0.000	0.019***	0.005	0.000	0.000	-0.00	-0.00	-0.00**	-0.01***
	(0.67)	(0.06)	(0.70)	(0.34)	(6.97)	(1.52)	(0.18)	(0.09)	(-0.64)	(-1.32)	(-3.33)	(-3.15)
Nikkei	-0.01	-0.01	-0.00	-0.00	0.011	0.074***	-0.00	0.006	0.039*	0.050*	0.120***	0.143***
	(-1.04)	(-1.39)	(-0.22)	(-0.05)	(0.36)	(2.15)	(-0.17)	(0.46)	(2.24)	(2.29)	(3.62)	(4.17)
Observations	1,701	1,701	1,701	1,701	1,701	1,701	1,734	1,734	1,734	1,734	1,734	1,734
R-squared	0.12	0.16	0.10	0.12	0.18	0.14	0.07	0.05	0.11	0.12	0.21	0.20
Industry FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

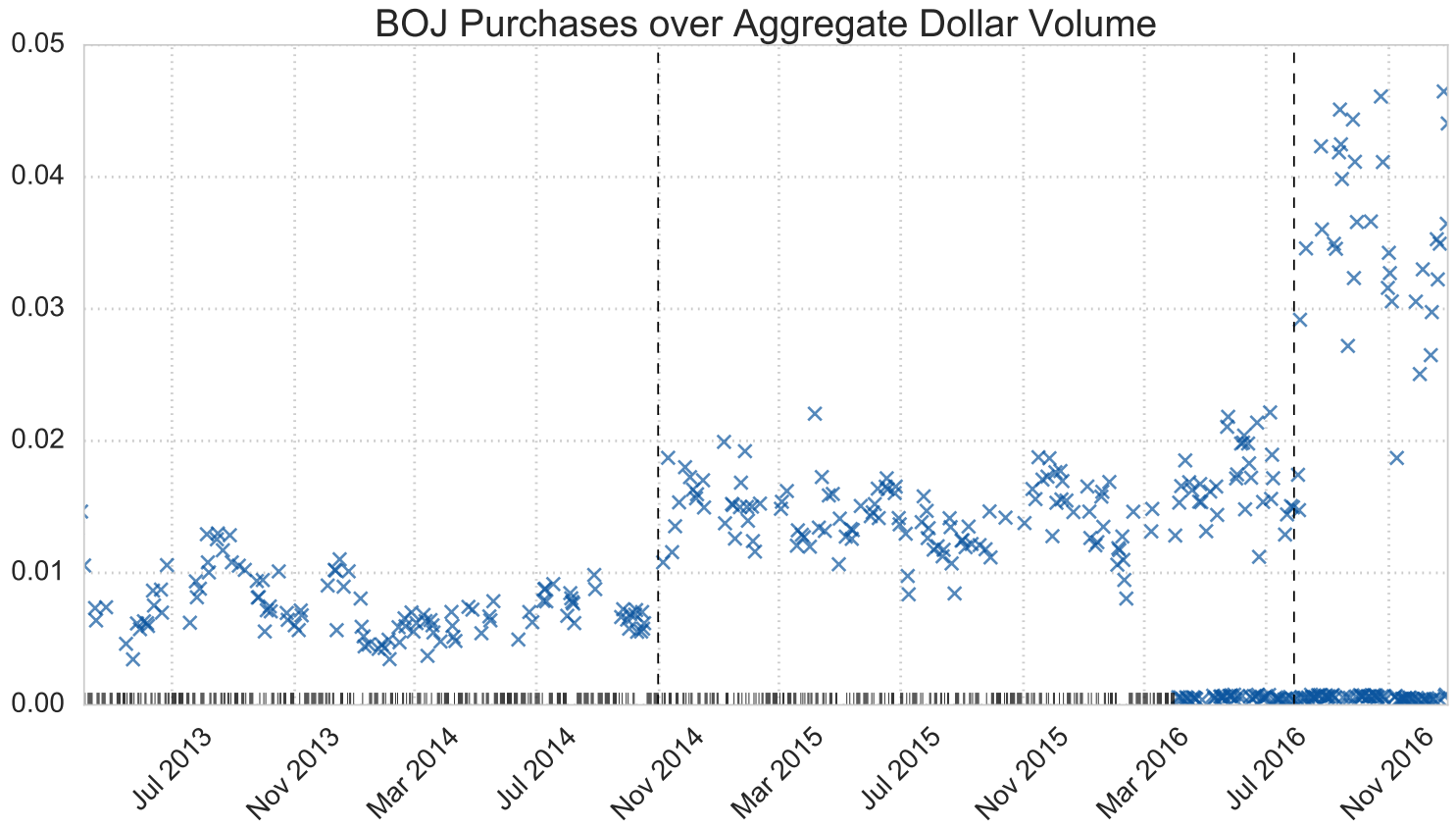
t-statistics are computed from placebo regressions around non-event days

Aggregate Net Supply Effect

$$\hat{R}^h = \hat{\beta}^h \left(\sum_i w_i \pi_{i,2014} + \sum_i w_i \pi_{i,2016} \right)$$



BOJ Purchases and Market Volume



- The BOJ does not buy every day
- It's trades are less than 5% of the market volume
- Flow effect?

details

Stock vs Flow Effects

$$AV_{i,t} = \frac{\text{Amount purchased by the BOJ}}{\text{Average volume over the previous semester}}$$

$$R_{i,t} = \beta_0 AV_{i,t} + \beta_1 AV_{i,t-1} + \gamma X_{i,t} + \delta \,\mathrm{FE}_t + \varepsilon_{i,t}$$

$$\tilde{R}_{i,t} = R_{i,t} - \hat{\beta}_0 AV_{i,t} - \hat{\beta}_1 AV_{i,t-1}$$

- Run our main regressions on π with the "purified" CAR:

Horizon (days)	**10**	**21**	**63**	**126**	**189**	**252**
Price pressure share (%)	13.31	17.85	36.17	29.54	23.29	24.29

Alternative Explanations

Evidence that the price effect is caused by the change in supply
Why do prices **stay** up?

1. We show that this is consistent with a demand and supply effect (discount rate effect)

2. But this could be due to a change in fundamentals (cash flow effect). Preliminary analysis shows no increase in stock issuance proportional to the impact of the policy.

Conclusions

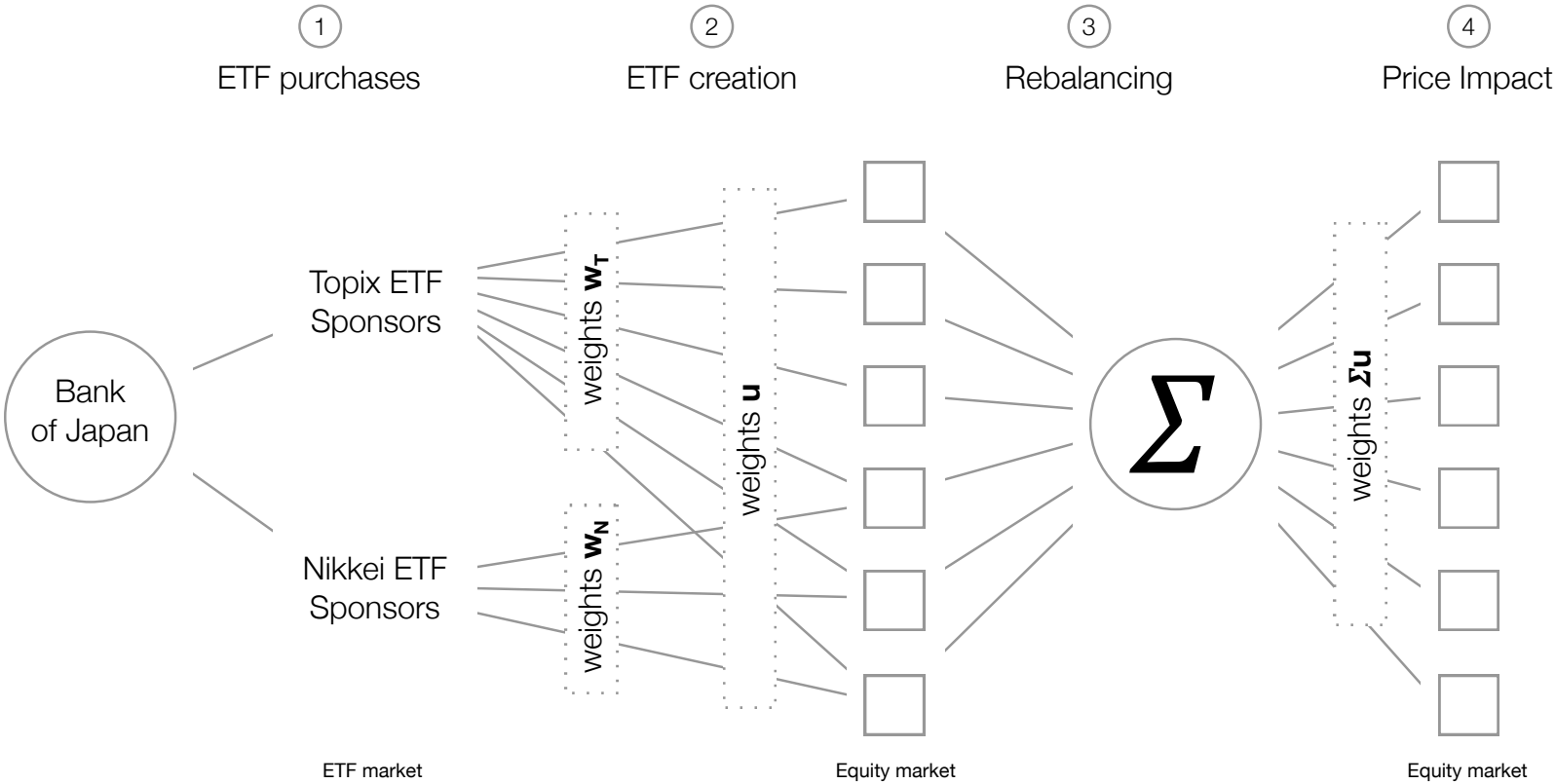
1. The LSAP has a positive and persistent effect on equity prices

2. The cross-sectional heterogeneity in returns is consistent with a portfolio rebalancing explanation

3. We estimate a market impact of 20 bps per trillion ¥ invested by the Central Bank in the program

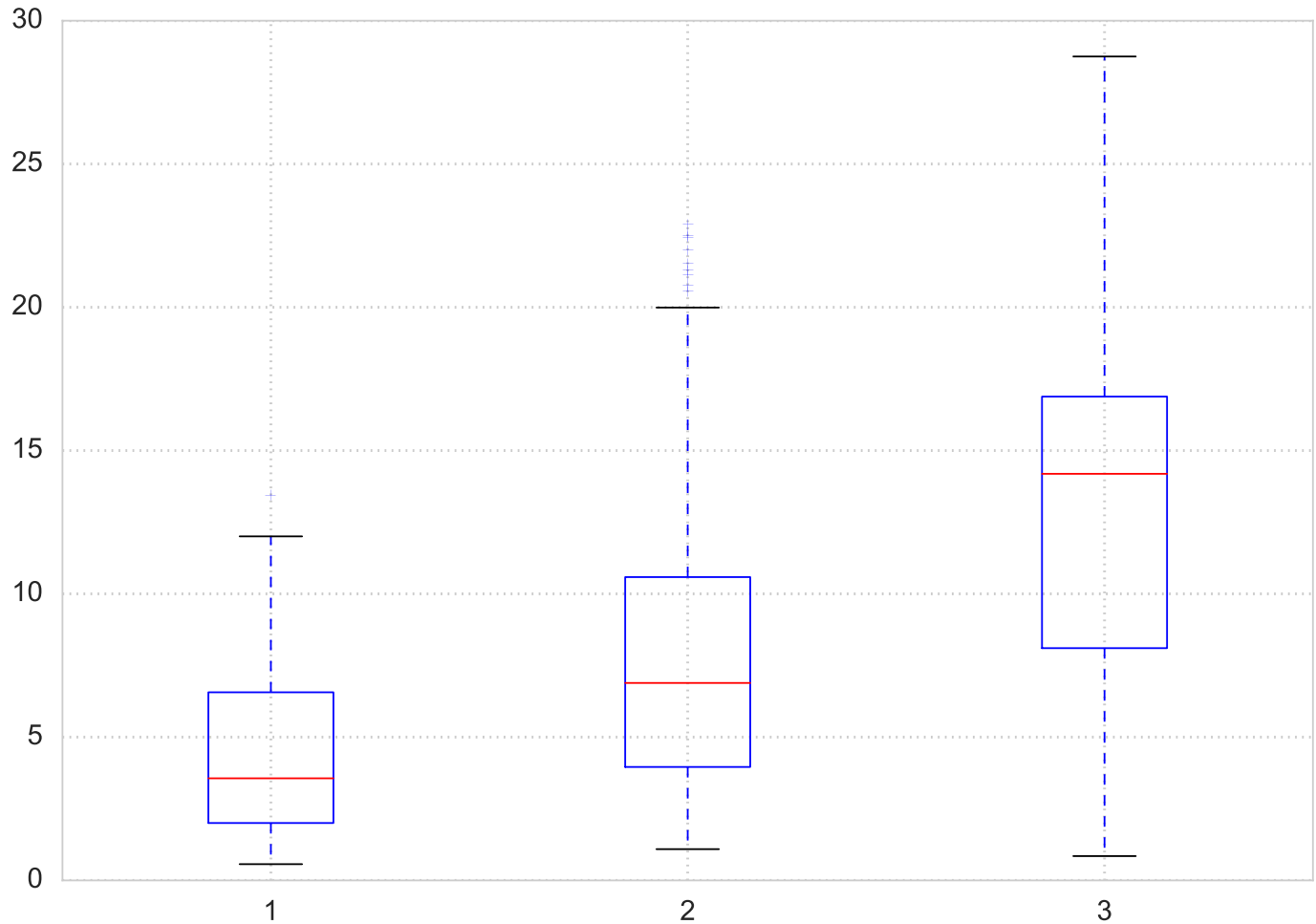
4. We provide empirical evidence suggesting that long-term demand curves for stocks slope down

ETF Transmission Channel

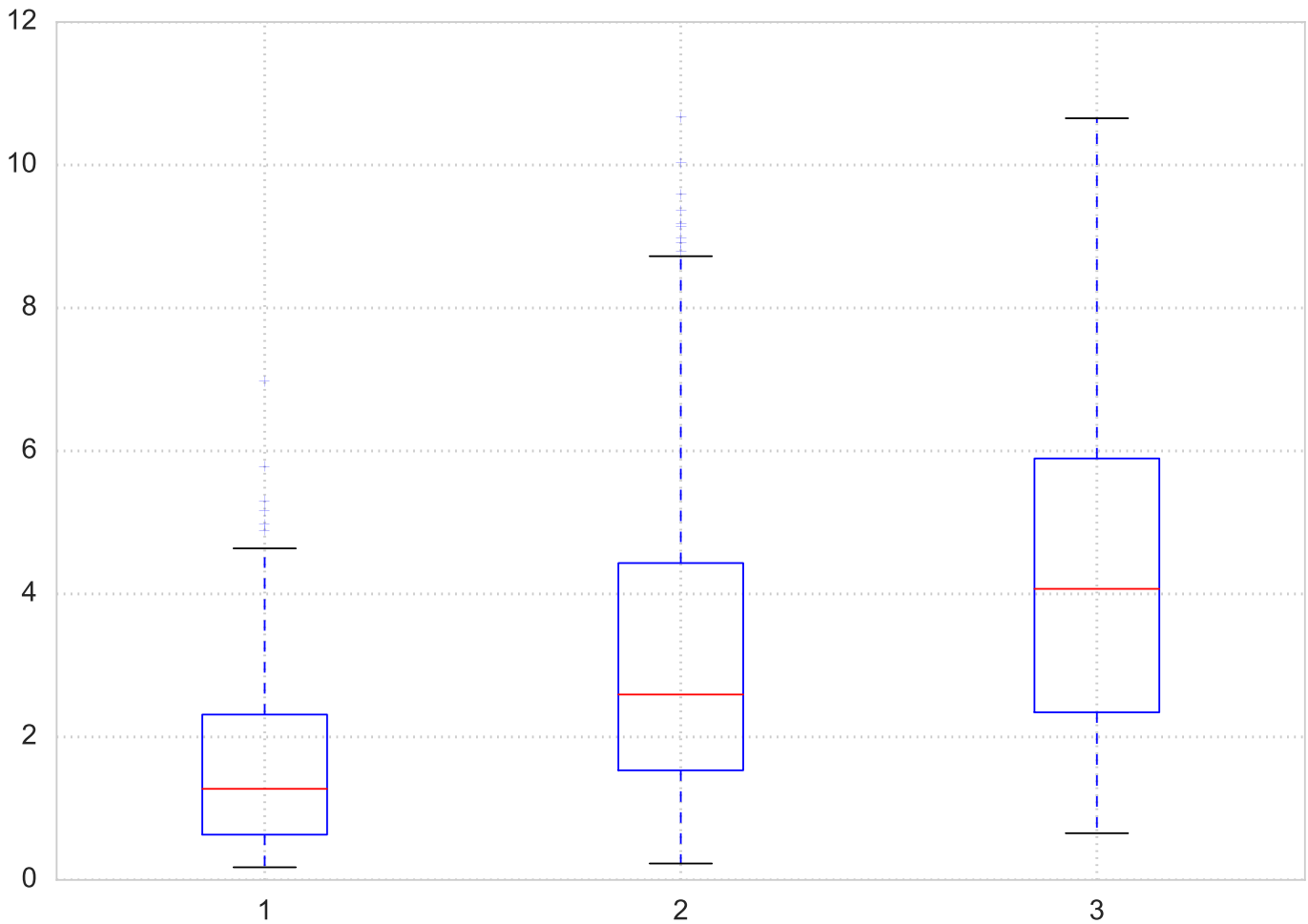


Back

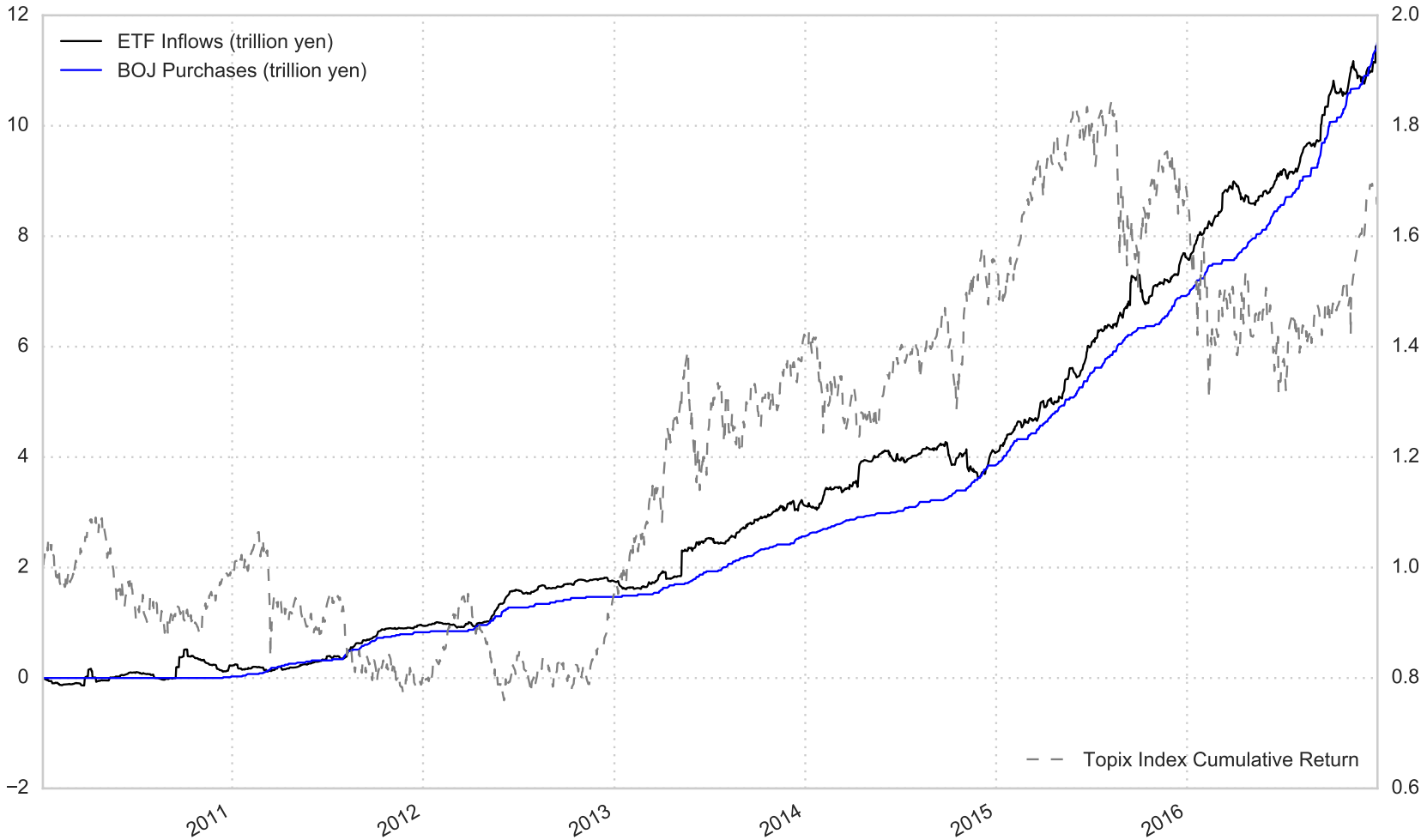
Stock-level Box Plots Daily



Stock-level Box Plots Weekly



ETF Flows


ETF Inflows (trillion yen)
BOJ Purchases (trillion yen)
Topix Index Cumulative Return
12
10
8
6
4
2
0
−2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
2011
2012
2013
2014
2015
2016

Price Pressure

BOJ ratio (%)

Pi-rank	**mean**	**[0.01**	**0.99]**
2014			
Q1	3.58	3.91	3.24
Q2	3.14	3.41	2.86
Q3	2.74	2.99	2.5
Q4	1.68	1.86	1.51
2016			
Q1	7.58	8.3	6.87
Q2	8.22	8.94	7.49
Q3	8.52	9.24	7.8
Q4	5.75	6.33	5.16

Stock Issuance and Repurchases

- Net stock issuance (NS) is the change in log split-adjusted shares outstanding over 1 year
- Issuers have $NS > 10\%$; Repurchasers have $NS < -0.5\%$