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The Bank of Japan as a Real Estate Tycoon: Large-Scale REIT Purchases

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Abstract

This is the first study analyzing the Bank of Japan's purchases of real estate investment trusts (REITs) that started in 2010 as part of enhanced unconventional monetary policy. The Bank purchases REIT shares after observing a significantly negative return over the previous night and during the morning market. The Bank continues purchases daily until the overnight and morning REIT returns become positive. This counter-cyclical behavior is consistent with the objective of decreasing risk premia and stimulating spending. Our study sheds light on the unique program of a central bank's equity purchases.

JEL codes: E52, E58, G12, R33

Keywords: large-scale asset purchases (LSAP), quantitative easing (QE), central banking, real estate investment trust, unconventional monetary policy

1. Introduction

The Bank of Japan (BOJ) enhanced its unconventional monetary policy in October 2010 by purchasing equity exchange-traded funds (ETFs) and public real estate investment trusts (REITs) in addition to the open market operations of Japanese Government Bonds (JGBs). These equity purchase programs are unprecedented in the history of central banking.[1] In April 2013, the BOJ started the new policy regime called Quantitative and Qualitative Monetary Easing (QQE), in which the Bank further increased the asset purchase amount and started new fixed-price JGB purchase operations (Hattori and Yoshida, 2019). After ten years of continued REIT purchases, the bank has become one of the largest owners of public REITs. The Bank has issued the Report of Possession of Large Volume to 21 REITs by February 6, 2020, because it owns more than 5% of the outstanding shares.

Our study is the first to analyze the BOJ's behavior of purchasing REIT shares. We use both the BOJ's daily purchase report and intra-day REIT return data. Using the linear probability model and the Cox hazard model with time-varying covariates, we find that the BOJ tends to start purchasing REIT shares when it observes a significantly negative return over the previous night and during the morning market on the Tokyo Stock Exchange. However, an afternoon return does not impact the BOJ's behavior. In particular, the BOJ strongly responds to a REIT return below the 30th percentile of historical overnight and morning returns. The BOJ continues purchasing REIT shares daily, while returns are negative. The Bank stops purchasing REITs when either overnight or morning returns become positive. Thus, we speculate that the BOJ applies a counter-cyclical intervention rule based on the overnight and morning returns. However, general stock

[1] For more information, see https://www.boj.or.jp/en/announcements/release_2013/k130404a.pdf and https://www.boj.or.jp/en/announcements/press/koen_2013/data/ko130412a1.pdf.

market returns do not impact the BOJ's REIT purchase decisions.

The Bank of Japan's program to purchase REITs and ETFs is unique among central banks' large-scale asset purchase (LSAP) programs. Most LSAPs—first deployed by the BOJ in 2001—are targeted to long-maturity bonds such as government bonds and mortgage-backed securities (MBSs). These Bond-LSAPs are used to lower long-term interest rates and stimulate spending when the short-term policy rate is near the zero lower bound (ZLB). However, both REIT shares and ETFs are risky equity securities traded on a stock exchange. The principal objective of REIT/ETF purchases is to decrease various risk premia by attracting more funds into the financial markets and stabilizing the economy (Shirakawa, 2010). Thus, this program can be understood as an extension of Bond-LSAPs that aim to decrease risk premia.[2]

Extant studies identify several channels through which Bond-LSAPs can impact long-term interest rates. In particular, Government-Bond LSAPs can take effect through (1) the expectations/signaling channel, (2) the scarcity channel, and (3) the duration-risk channel (D′ Amico et al., 2012; Krishnamurthy and Vissing-Jorgensen, 2011, 2013). The expectations/signaling channel is based on the expectations hypothesis, in which the expected path of short-term rates determines the long-term interest rate. A central bank's bond purchases impact long-term rates through the bank's signaling of future short-term rate policies and the state of the economy. In contrast, the scarcity channel is based on the preferred-habitat approach, in which investors with unique preferences for certain maturities create segmented bond markets (e.g., Modigliani and Sutch, 1966; Wallace, 1981; Vayanos and Vila, 2009; Greenwood and Vayanos 2014). A central bank's demand for long-term bonds increases bond prices in that maturity segment

[2] A major difference is that the BOJ has been making advance announcements of the exact date of JGB auctions since March 2017, whereas the Bank purchases REITs and ETFs without announcements.

(equivalently, a central bank's purchases make long-term bonds scarcer for investors). Last, the duration risk channel is based on the change in risk-averse arbitrageurs' aggregate exposure to risky longer-term bonds. As a central bank purchases long-term bonds, arbitrageurs' aggregate exposure to longer-term bonds decreases, and thus duration-risk premia also decrease for the entire duration spectrum.

In addition to these channels, MBS-LSAPs can take effect through (4) the prepayment-risk channel and (5) the capital-constraint channel (Krishnamurthy and Vissing-Jorgensen, 2013). A central bank's purchases of MBSs decrease marginal investors' exposure to mortgage prepayment risk and thus, decrease prepayment-risk premia. When MBS investors are capital-constrained, MBS yields include premia corresponding to under-diversification. When a central bank purchases MBSs, these capital-constraint premia will decrease.

The BOJ's ETF purchases can increase stock price indexes (Harada and Okimoto, 2019; Charoenwong et al., 2019) through the scarcity channel (Barbon and Gianinazzi, 2019). Although there is no study about REIT purchases, the BOJ may be able to decrease REIT risk premia more than ETF risk premia through an additional capital-constraints channel if the marginal REIT investor is less diversified than the marginal ETF investor. Also, REIT/ETF share purchases can decrease long-term interest rates through the expectation/signaling channel (by demonstrating a strong commitment to monetary easing) and the default risk channel (through the reduction of REIT and corporate credit risk). However, a higher share price may increase borrowing rates through the scarcity and duration channels if REITs and corporations issue more debt.

Our finding that the BOJ purchases REIT shares after observing a significant negative return suggests that the Bank aims to mitigate large decreases in REIT prices. This behavior is

consistent with the Bank's key objective to decrease various risk premia because a higher REIT price is associated with a lower expected REIT equity premium. The program can also stimulate spending (or mitigate a decrease in spending) through wealth effects for REIT investors. However, the program may create a side-effect on the price discovery function of the financial market. If REIT market prices do not incorporate negative information fully, investors' assessment of the economic condition may be biased.

The remainder of this paper is organized as follows. Section 2 describes the BOJ's unconventional monetary policy, and Section 3 explains the Japanese REIT market. After Section 4 describes the data, Section 5 details our empirical strategy. Section 6 presents our empirical results. Section 7 concludes.

2. Bank of Japan's unconventional monetary policy

The BOJ pioneered in adopting an unconventional monetary policy. It was the first central bank to use forward guidance in 1999 when it adopted the zero-interest-rate policy. After the global financial crisis, the BOJ set up in October 2010 the fund to purchase REITs and ETFs. In April 2013, the Bank started the Quantitative and Qualitative Monetary Easing to achieve a two-percent inflation rate measured by the consumer price index. The "Quantitative" component corresponds to the change in the BOJ's target from the uncollateralized overnight call rate (i.e., price) to the monetary base (i.e., quantity). The BOJ targeted to increase the monetary base by approximately 60–70 trillion JPY each year.[3] Two years after starting QQE, the BOJ almost doubled the monetary base by holding more JGBs on its balance sheet. Subsequently, the BOJ further accelerated the

[3] This description is based on the release in April 2013.

monetary-base growth from October 2014.

The "Qualitative" component corresponds to open-market operations for longer-maturity government bonds, ETFs, and REITs. Under QQE starting in 2013, the Bank applied negative ten bps to private banks' current accounts at the BOJ (January 2016) and bought JGBs by an unlimited amount at a fixed price to control the yield curve (September 2016).

The BOJ started purchasing REITs in October 2010 up to a limit of 50 billion JPY, which was increased later by 10 billion JPY in April 2012.[4] Under QQE starting in 2013, the Bank changed the limit to an annual purchase amount of 30 billion JPY. From October 2014, the BOJ tripled the annual purchase amount to 90 billion JPY under QQE2. The BOJ's REIT holdings and ownership ratio increased significantly during QQE2 (Figure 1). In 2019, the BOJ's ownership ratio became approximately 3.5% of the 16-trillion yen market capitalization of REITs. The maximum ownership proportion for each REIT is 10%, which was increased in December 2015 from 5%.

The BOJ sets several conditions for the REIT to be purchased. It must trade for more than 200 days with an annual trading value of 20 billion JPY or larger. The Bank also applies the collateral standards set forth in the Guidelines on Eligible Collateral (Policy Board Decision on October 13, 2000):[5] (1) Publicly-offered bonds issued by a firm must be rated AA or higher by an eligible rating agency, and (2) principal investment objects of a firm should be real estate (including leaseholds, superficies, and asset-backed securities).

The BOJ does not make an advance notice about the specific date of a REIT purchase operation, although it announces the annual budget and the daily ex-post purchase record. The BOJ

[4] The BOJ sets up a trust and purchases REIT shares as the trust property.
[5] See https://www.boj.or.jp/en/mopo/measures/term_cond/yoryo18.htm/

submits a REIT purchase order through the designated trust banks without public notice. This operation method contrasts with the BOJ's regular JGB auctions, for which the Bank makes each month the announcement of the purchase amount and frequency for the following month.[6]

3. The Japanese REIT market

Japanese REITs were established in 2000 by the amendment to the Act on Investment Trusts and Investment Corporations. The first two REITs—Nippon Building Fund and Japan Real Estate—were listed on the Tokyo Stock Exchange (TSE) in September 2001. Figure 2 depicts the growth of the Japanese public REIT market in terms of the number of listed REITs and their market capitalization. The initial growth period until 2007 was followed by a contraction period between 2010 and 2012 due to the global financial crisis starting in 2007 and the Great East Japan Earthquake in 2011. However, there has been another period of steady market growth since 2012. As of January 31, 2020, 64 REITs were listed with the total market capitalization of 17 trillion JPY, which accounts for approximately 3% of the market capitalization of TOPIX. The Japanese REIT market is now the second-largest REIT market in the world after the US REIT market. Of the 19.2 trillion-yen asset under management, office properties are 41.6%, retail properties are 17.6%, industrial properties are 16.0%, residential properties are 14.4%, and hotel properties are 8.4%.

Figure 3 depicts the TOPIX and the TSE-REIT Index (ex-dividends) between 2003 and 2020. After a sharp decrease between 2007 and 2008, the REIT Index generally exhibits an upward trend until 2019. Two indexes generally moved in tandem, but they started to diverge since around 2014.

[6] See Hattori (2020) for the detail of the BOJ's bond purchases.

Figure 4 depicts the net purchase amount by investor type between 2013 and 2019. Throughout this period, individuals have been net sellers, whereas foreign investors have been net buyers since 2016. Other institutions have been increasing the net purchase amount since 2015. In 2019, sellers were individuals (338 billion JPY) and financial institutions (47 billion JPY), whereas buyers were mutual funds (81 billion JPY), foreign firms (69 billion JPY), and others (208 billion JPY). The BOJ's annual net purchase amount of 90 billion JPY is sizable in the market.

4. Data

We obtain the date and amount of the BOJ's REIT purchase operations from the Bank's website. Figure 5 depicts the size of daily operation (Panel A) and the number of operations for each month (Panel B). Before QQE2 (i.e., until September 2014), the size of each operation varied significantly, and the operations were irregular. Under QQE2, the size of each operation became almost constant at 1.2 billion JPY, and more than one operation took place almost every month. The average number of operations is 2.5 before QQE2 and 5.3 under QQE2.

We use TSE-REIT Index to compute REIT returns from April 2013 to December 2019. We divide each trading day into four subperiods: the overnight period (from 15:00 on the previous trading day to 09:00), the morning market (from 09:00 to 11:30), the lunchtime (from 11:30 to 12:30), and the afternoon market (from 12:30 to 15:00). Table 1 shows the descriptive statistics of the TSE-REIT Index ex-dividend returns. The mean daily return is 2.1 bps, with a standard deviation of 95.7 bps. Periodic returns tend to be slightly lower and less volatile while the market is closed (overnight and lunchtime) than while the market is open.

Table 2 shows the deciles of TSE-REIT Index returns for each subperiod. For our

empirical analysis, we construct a dummy variable for each decile group: e.g., returns less than the 10th percentile, returns greater than or equal to the 10th percentile and less than the 20th percentile, etc.

5. Empirical strategy

5.1 Linear probability model (LPM)

We first estimate the following linear probability model (LPM) to analyze the BOJ's REIT purchase decisions by using the daily data.

$$\mathbb{I}_t = \alpha_1 + \sum_{i=\{N,A,L,P\}} \beta_1^i \ r_t^i + \varepsilon_{1,t}, \qquad (1)$$

where $\mathbb{I}_t$ denotes the dummy variable that takes a value of one if the BOJ purchases REIT shares at date t and takes zero otherwise. The explanatory variable r_t^i denotes TSE-REIT Index returns during subperiod i, as defined in Section 4. The subperiods consist of the overnight period (N), the morning market (A), the lunchtime (L), and the afternoon market (P). $\varepsilon_{1,t}$ denotes the error term. A negative coefficient β_1^i indicates that the BOJ is more likely to purchase REIT shares on date t if a REIT return is smaller (i.e., more negative) during subperiod i.

The second variation includes lagged REIT returns:

$$\mathbb{I}_t = \alpha_2 + \sum_{i=\{N,A,L,P\}} \beta_2^i \ r_t^i + \gamma_2^i \ r_{t-1}^i + \varepsilon_{2,t}. \qquad (2)$$

By testing the statistical significance of β_2^i and γ_2^i, we can identify whether the BOJ responds to returns on the same day or the previous day.

The third variation includes TOPIX returns to test whether the BOJ responds to REIT returns or stock returns:

$$\mathbb{I}_t = \alpha_3 + \sum_{i=\{N,A,L,P\}} \beta_3^i \; r_t^i + \delta_3^i \; s_t^i + \varepsilon_{3,t}. \qquad (3)$$

where s_t^i denotes TOPIX returns for subperiod i. A statistically significant coefficient β_3^i indicates that the BOJ responds to REIT returns after controlling for the response to TOPIX returns. The fourth variation includes lagged terms for both REIT and TOPIX returns.

$$\mathbb{I}_t = \alpha_4 + \sum_{i=\{N,A,L,P\}} \beta_4^i \; r_t^i + \gamma_4^i \; r_{t-1}^i + \delta_4^i \; s_t^i + \theta_4^i \; s_{t-1}^i + \varepsilon_{4,t}. \qquad (4)$$

In the previous specifications, the estimated coefficient β^i is a local linear approximation of the potentially non-linear effect of REIT returns. To estimate a non-linear effect, we use the return-decile dummy variables that we define in Section 4. By using the sixth-decile group (i.e., between the 50th and 60th percentiles) as the reference group, we estimate the following equation for each subperiod $i = \{N, A, L, P\}$:

$$\mathbb{I}_t = \alpha_5^i + \sum_{d=\{1,\ldots,5,7,\ldots,10\}} \beta_5^{i,d} \; \mathbb{r}_t^{i,d} + \varepsilon_{5,t}^i, \qquad (5)$$

where $\mathbb{r}_t^{i,d}$ denotes the dummy variable that takes a value of one if a subperiod-i return on date t is in decile-group d and takes zero otherwise. Thus, the coefficient $\beta_5^{i,d}$ represents the incremental probability of the BOJ's purchase when a return is in the dth-decile group as opposed to the sixth-decile group.

5.2 Cox hazard model with time-dependent covariates

An issue with a linear probability model is that it ignores the conditional nature of the BOJ's decision making. In other words, it does not distinguish consecutive daily purchases from a single purchase. To analyze the BOJ's decision conditional on a sequence of its past decisions,

we estimate the Cox hazard model (Cox, 1972). When T denotes the random failure time after a period of survival, the survival function of time t is defined as:

$$S(t) \equiv \Pr(T \geq t) = \int_t^{\infty} f(u)du,$$

where $f(u) \equiv \lim_{\Delta u \to 0} \frac{1}{\Delta u} \Pr(u \leq T < u + \Delta u)$ is the density function. Then, the hazard function that represents an instantaneous rate of failure conditional on survival up to t is defined as:

$$\lambda(t) \equiv \lim_{\Delta t \to 0} \frac{1}{\Delta t} \Pr(t \leq T < t + \Delta t | T \geq t) = \frac{f(t)}{S(t)}.$$

When covariates impact the failure time, most studies assume a Cox proportional hazard model with time-invariant covariate vector $\boldsymbol{X}$:

$$\lambda(t|\boldsymbol{X}) = \lambda_0(t) e^{\boldsymbol{X}\boldsymbol{\beta}},$$

where $\lambda_0(t)$ denotes the baseline hazard function. We allow for a time-dependent covariate vector $\boldsymbol{X}(t)$ (e.g., Fisher and Lin, 1999; Zhang et al., 2018; Dirick et al., 2019):

$$\lambda\big(t\big|\boldsymbol{X}(t)\big) = \lambda_0(t) e^{\boldsymbol{X}(t)\boldsymbol{\beta_6}}. \qquad (6)$$

For covariates, we use contemporaneous and lagged TSE-REIT subperiod returns as in Equation (2): $\boldsymbol{X}(t)\boldsymbol{\beta_6} = \sum_{i=\{N,A,L,P\}} \beta_6^i \ r_t^i + \gamma_6^i \ r_{t-1}^i$.

We analyze both starting and stopping decisions by defining two different failure events. To analyze the BOJ's starting decision, we treat a consecutive period of BOJ inaction as survival and the first day of REIT purchases as a failure. In this specification, a negative coefficient β_6^i indicates that a lower (i.e., more negative) return is associated with a larger hazard rate of starting purchases conditional on no-purchases up to the previous day. In the second specification to analyze stopping decision, we reverse survival and failure; we treat a consecutive period of BOJ purchases as survival and the first day of inaction as a failure. In this specification, a positive

coefficient β_6^i indicates that a higher (i.e., more positive) return is associated with a larger hazard rate of stopping purchases conditional on a series of purchases up to the previous day.

6. Empirical result

6.1 Linear probability model

Table 3 shows the estimation results of Equations (1), (2), (3), and (4). Column (1) shows that the probability of BOJ purchases is strongly negatively associated with overnight and morning returns. These associations do not change when we include lagged REIT returns (Column (2)), TOPIX returns (Column (3)), and lagged REIT and TOPIX returns (Column (4)). Lagged returns largely have insignificant coefficients.

As returns are measured in percentage points, a 0.1 percentage-point lower return during the overnight period and the morning market is associated with 3.9 and 3.0 percentage-points larger probability of purchases, respectively. This negative coefficient for overnight returns should indicate a causal relationship because an overnight return is determined at the beginning of the morning market. A comparable magnitude of the coefficient on morning returns seems to suggest that the BOJ also observes returns during the morning market before making a purchase decision.

In contrast, the coefficient on lunchtime returns is positive and statistically significant. A 0.1 percentage-point larger return is associated with a 3.4 percentage-point larger probability of purchases. This positive association may be due to reverse causality; i.e., the BOJ's purchase order submitted after the morning market may be increasing REIT share prices at the opening of the afternoon market. Afternoon returns are not significantly associated with BOJ purchases. Although the BOJ does not disclose the exact time of submitting a purchase order, it seems plausible that the

Bank usually submit an order during lunchtime.

Table 4 shows the estimation results of Equation (4) by three subperiods. Before QQE (from October 2010 to March 2013), the negative coefficients on overnight and morning returns were smaller in magnitude than those for the entire sample period. The magnitude of these coefficients significantly became larger under QQE (from April 2013 and September 2016), and even larger under the Yield Curve Control regime (from October 2016 and December 2019). TOPIX and lagged returns are not associated with the BOJ's purchase decision in any subperiod. The BOJ seems to have established and strengthened its purchase rule overtime.

Table 5 and Figure 6 show the estimation result of Equation (5) regarding the nonlinear effect of returns on the BOJ's behavior. For overnight returns, the estimated coefficients are positive and statistically significant for the first, second, and third decile groups. When an overnight return is significantly negative and below the first decile, the BOJ is 52.6 percentage points more likely to purchase REITs. In the second and third decile groups, the coefficients monotonically decrease to 0.287 and 0.166, respectively. In contrast, the coefficients for the seventh through tenth decile groups are negative and statistically significant. Thus, when an overnight return is significantly positive, the BOJ is less likely to purchase REITs.

A similar result is obtained for morning returns. The coefficients are positive and monotonically decreasing for the first (0.560) through fourth (0.081) decile groups, whereas they are negative and decreasing for the seventh (-0.063) through tenth (-0.143) decile groups. For lunchtime returns, the coefficient is still positive for the first decile group. Thus, the BOJ tends to respond to a significantly large negative return even during lunchtime. However, the coefficients for the eighth through tenth decile groups are positive and increasing. If the BOJ submits its buy-

orders during the lunchtime, this result suggests that the BOJ's purchase tends to increase REIT share prices significantly. The coefficients for afternoon returns are largely insignificant, suggesting that the BOJ neither responds to afternoon returns nor submit buy-orders during the afternoon market.

6.2 Cox hazard model

Table 6 shows the estimated coefficient vector $\boldsymbol{\beta_6}$ in Equation (6) for the Cox hazard model of starting decisions (i.e., when a failure is defined as the start of the BOJ's REIT purchases). The reported coefficients are the natural logarithm of the hazard ratio for a one basis-point higher return. Consistent with the results from the LPMs, overnight returns and morning returns have negative coefficients that are statistically significant at the one percent level. Thus, after a period of inaction, the BOJ is more likely to start purchasing REIT shares when overnight and morning returns are negative. For a one-basis-point lower return during the overnight period and the morning market, the hazard function is 1.8 and 1.1 percent larger, respectively (i.e., the log hazard ratio is 0.018 and 0.011, respectively). The coefficient on lunchtime returns is positive as for the LPM. Thus, the start of REIT purchases is associated with larger lunchtime returns. Our interpretation by reverse causality does not change when we take into account the conditional nature of decision making. No lagged return is statistically significant.

Table 7 shows the estimated coefficient vector $\boldsymbol{\beta_6}$ in Equation (6) for the Cox hazard model of stopping decisions (i.e., when a failure is defined as the end of consecutive REIT purchases). The coefficients on overnight and morning returns are positive and statistically significant at the one percent level. Thus, after consecutive daily purchases, the BOJ is more likely

to stop operations when overnight and morning returns are positive. For a one-basis-point higher return, the hazard function is 0.4 percent larger (i.e., the log hazard ratio is 0.004). The coefficient is statistically insignificant for lunchtime and afternoon returns, as well as lagged returns.

7. Conclusion

Our study is the first to analyze the BOJ's REIT purchase program. Because it is an unprecedented program even in large-scale asset purchase programs around the world, this study makes a unique contribution to the literature. Our main finding is that the BOJ purchases REIT shares in a highly discretionary way rather than on a regular schedule. Using a linear probability model and Cox proportional hazard model with time-varying covariates, we find that the BOJ tends to start purchasing REIT shares when it observes a significantly negative return over the previous night and during the morning market on the Tokyo Stock Exchange. However, an afternoon market return does not impact the BOJ's behavior. The Bank stops purchasing REITs when either overnight or morning returns become positive. However, general stock market returns do not impact the BOJ's REIT purchase decisions. This study is limited by data availability. We cannot analyze a more detailed market microstructure because the BOJ releases only a daily purchase summary rather than the time of purchase. Nevertheless, we find the BOJ's counter-cyclical purchase behavior to decrease equity risk premia and generate wealth effects on investor spending.

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Table 1
Tokyo Stock Exchange REIT Index returns

Periods	Obs	Mean	Std. Dev.	Min	Max
Daily	1,654	0.00021	0.00957	-0.07340	0.05713
Overnight (15:00–9:00)	1,654	-0.00027	0.00423	-0.02002	0.02028
Morning Market (9:00–11:30)	1,654	0.00016	0.00567	-0.03282	0.05087
Lunchtime (11:30–12:30)	1,654	-0.00018	0.00116	-0.01029	0.00642
Afternoon Market (12:30–15:00)	1,654	0.00049	0.00585	-0.04671	0.05772

Note: This table shows the descriptive statistics of the TSE-REIT Index returns from April 2013 to December 2019. Source: Bloomberg

Table 2
Percentiles of Tokyo Stock Exchange REIT Index returns

Percentiles	Daily	Overnight (15:00–9:00)	Morning Market (9:00–11:30)	Lunchtime (11:30–12:30)	Afternoon Market (12:30–15:00)
10th	-0.00909	-0.00457	-0.00555	-0.00139	-0.00514
20th	-0.00547	-0.00249	-0.00315	-0.00092	-0.00318
30th	-0.00329	-0.00158	-0.00180	-0.00061	-0.00185
40th	-0.00162	-0.00080	-0.00081	-0.00037	-0.00071
50th	0.00017	-0.00012	0.00014	-0.00016	0.00036
60th	0.00172	0.00057	0.00104	0.00006	0.00144
70th	0.00341	0.00129	0.00218	0.00028	0.00261
80th	0.00596	0.00225	0.00346	0.00058	0.00395
90th	0.00946	0.00386	0.00556	0.00103	0.00631

Note: This table shows TSE-REIT Index return deciles for each of the four subperiods. The sample period is from April 2013 to December 2019. Source: Bloomberg

Table 3
Linear probability model for the entire sample period

	(1)	(2)	(3)	(4)
TSE REIT Index				
Overnight	-39.118 ***	-38.180 ***	-40.066 ***	-38.734 ***
	(-11.549)	(-11.937)	(-9.957)	(-10.487)
Mornig	-30.372 ***	-30.258 ***	-30.251 ***	-30.419 ***
	(-8.560)	(-8.539)	(-8.986)	(-9.241)
Lunchtime	33.814 ***	34.318 ***	37.120 ***	37.825 ***
	(3.424)	(3.510)	(3.889)	(4.071)
Afternoon	0.948	1.225	1.115	1.227
	(0.657)	(0.855)	(0.689)	(0.769)
Lagged Overnight		-5.696 ***		-3.921
		(-2.569)		(-1.447)
Lagged Morning		-2.464		-1.700
		(-1.369)		(-0.924)
Lagged Lunchtime		-12.949		-15.712
		(-1.445)		(-1.664) *
Lagged Afternnon		3.622		3.452
		(1.319)		(1.327)
TOPIX				
Overnight			1.006	0.530
			(0.592)	(0.311)
Mornig			-0.015	-0.016
			(-0.009)	(-0.010)
Lunchtime			-5.325	-5.993
			(-0.977)	(-1.085)
Afternoon			-0.156	0.247
			(-0.089)	(0.147)
Lagged Overnight				-1.229
				(-0.833)
Lagged Morning				-2.997 *
				(-1.951)
Lagged Lunchtime				5.151
				(1.054)
Lagged Afternnon				0.434
				(0.201)
N	1654	1654	1654	1654
Adjusted R-squared	0.336	0.341	0.335	0.341

Note: This table shows the estimation results of Equations (1) through (4). The dependent variable is the dummy variable for the BOJ's REIT purchases. The covariates are TSE-REIT Index and TOPIX returns during the overnight period (from 15:00 on the previous trading day to 09:00), the morning market (from 09:00 to 11:30), the lunchtime (from 11:30 to 12:30), and the afternoon market (from 12:30 to 15:00). Lagged returns are for the previous trading day. The sample period is from April 2013 to December 2019. The t-statistics are in parentheses based on Newey-West (1987) standard errors. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 4
Linear probability model by sub-period

	Before QQE Oct. 2010-Mar. 2013	QQE before YCC Apr. 2013-Sep. 2016	QQE under YCC Oct. 2016-Dec. 2019
TSE REIT Index			
Overnight	-26.676 ***	-33.194 ***	-55.492 ***
	(-5.820)	(-9.038)	(-7.983)
Mornig	-6.664 *	-24.426 ***	-55.162 ***
	(-1.783)	(-9.256)	(-12.014)
Lunchtime	-3.742	34.285 ***	34.306 ***
	(-0.560)	(3.079)	(2.414)
Afternoon	9.331	0.618	3.496
	(1.629)	(0.351)	(0.935)
Lagged Overnight	2.089	-4.405	-3.489
	(0.530)	(-1.497)	(-0.740)
Lagged Morning	2.043	-0.434	-5.242
	(1.079)	(-0.214)	(-1.466)
Lagged Lunchtime	1.860	-19.957 *	1.278
	(0.374)	(-1.916)	(0.072)
Lagged Afternnon	4.770	3.714	-2.625
	(1.061)	(1.389)	(-0.793)
TOPIX			
Overnight	-4.498 *	-2.086	3.368
	(-1.929)	(-0.986)	(1.468)
Mornig	-4.597	0.380	-0.617
	(-1.610)	(0.211)	(-0.221)
Lunchtime	-5.200	-7.560	2.084
	(-0.740)	(-0.999)	(0.285)
Afternoon	3.631	0.685	-3.768
	(0.989)	(0.377)	(-0.862)
Lagged Overnight	-2.459	-2.141	0.534
	(-1.255)	(-1.162)	(0.269)
Lagged Morning	-1.192	-2.503	-2.319
	(-0.442)	(-1.334)	(-0.813)
Lagged Lunchtime	2.932	2.832	6.094
	(0.344)	(0.485)	(0.768)
Lagged Afternnon	-1.841	0.577	-1.656
	(-0.529)	(0.257)	(-0.410)
N	560	859	793
Adjusted R-squared	0.266	0.354	0.395

Note: This table shows the estimation results of Equation (4) by three subperiods. The dependent variable is the dummy variable for the BOJ's REIT purchases. The covariates are TSE-REIT Index and TOPIX returns during the overnight period (from 15:00 on the previous trading day to 09:00), the morning market (from 09:00 to 11:30), the lunchtime (from 11:30 to 12:30), and the afternoon market (from 12:30 to 15:00). Lagged returns are for the previous trading day. The sample period is from April 2013 to December 2019. The t-statistics are in parentheses based on Newey-West (1987) standard errors. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 5
Linear probability model based on return decile dummies

Return Decile Groups	Overnight	Morning	Lunchtime	Afternoon
< 10th	0.526 ***	0.560 ***	0.152 ***	0.031
	(10.92)	(10.08)	(2.17)	(0.57)
10th-20th	0.287 ***	0.503 ***	0.015	-0.044
	(5.98)	(10.21)	(0.35)	(-0.91)
20th-30th	0.166 ***	0.256 ***	0.013	0.003
	(3.60)	(5.14)	(0.33)	(0.06)
30th-40th	0.026	0.081 **	0.035	-0.051
	(0.63)	(2.14)	(0.90)	(-1.08)
40th-50th	0.032	-0.002	0.075	-0.091 *
	(0.65)	(-0.06)	(1.77)	(-1.91)
50th-60th	Reference	Reference	Reference	Reference
	(omitted)	(omitted)	(omitted)	(omitted)
60th-70th	-0.123 ***	-0.063 **	0.069	0.006
	(-3.13)	(-2.16)	(1.62)	(0.12)
70th-80th	-0.133 ***	-0.109 ***	0.163 ***	0.004
	(-3.46)	(-3.73)	(4.00)	(0.08)
80th-90th	-0.126 ***	-0.119 ***	0.235 ***	0.049
	(-3.30)	(-3.79)	(4.92)	(0.96)
> 90th	-0.161 ***	-0.143 ***	0.303 ***	0.098 *
	(-3.82)	(-4.44)	(3.99)	(1.90)
N	1654	1654	1654	1654
Adjusted R-squared	0.210	0.272	0.032	0.008

Note: This table shows the estimation result of Equation (5). The dependent variable is the dummy for REIT purchases, and the independent variables are dummy variables for return decile groups. Return decile groups are calculated for each of the overnight period (from 15:00 on the previous trading day to 09:00), the morning market (from 09:00 to 11:30), the lunchtime (from 11:30 to 12:30), and the afternoon market (from 12:30 to 15:00). The sample period is from April 2013 to December 2019. The t-statistics are in parentheses based on Newey-West (1987) standard errors.

Table 6
Cox Hazard Model of Starting Decisions

	(1)	(2)
Overnight	-0.018 ***	-0.018 ***
	(-12.93)	(-12.13)
Morning	-0.011 ***	-0.011 ***
	(-11.51)	(-11.03)
Lunchtime	0.014 ***	0.014 ***
	(2.48)	(2.39)
Afternoon	-0.001	-0.001
	(-0.83)	(-0.79)
Lagged Overnight		-0.002
		(-1.34)
Lagged Morning		0.000
		(-0.37)
Lagged Lunchtime		0.001
		(0.36)
Lagged Afternoon		-0.001
		(-1.01)
N	1,222	1,222

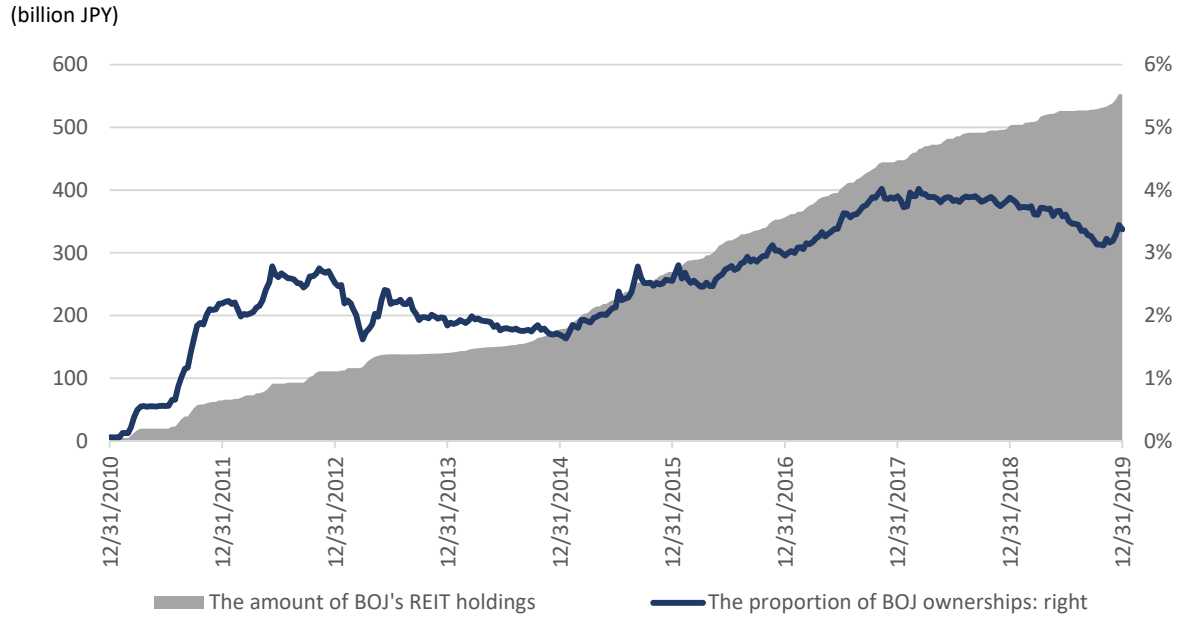
Note: This table shows the estimation result of Equation (6) for the Cox hazard model of starting decisions. A failure is defined as the start of the BOJ's REIT purchases after a period of inaction. REIT returns are measured in basis points. The sample period is from April 2013 to December 2019. The z-statistics are in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 7
Cox Hazard Model of Stopping Decisions

	(1)	(2)
Overnight	0.004 ***	0.005 ***
	(3.47)	(3.81)
Morning	0.004 ***	0.004 ***
	(4.81)	(5.00)
Lunchtime	-0.001	-0.002
	(-0.12)	(-0.28)
Afternoon	0.000	0.000
	(-0.07)	(-0.38)
Lagged Overnight		0.003 **
		(1.97)
Lagged Morning		0.002
		(1.25)
Lagged Lunchtime		0.006
		(1.27)
Lagged Afternoon		-0.001
		(-1.50)
N	431	431

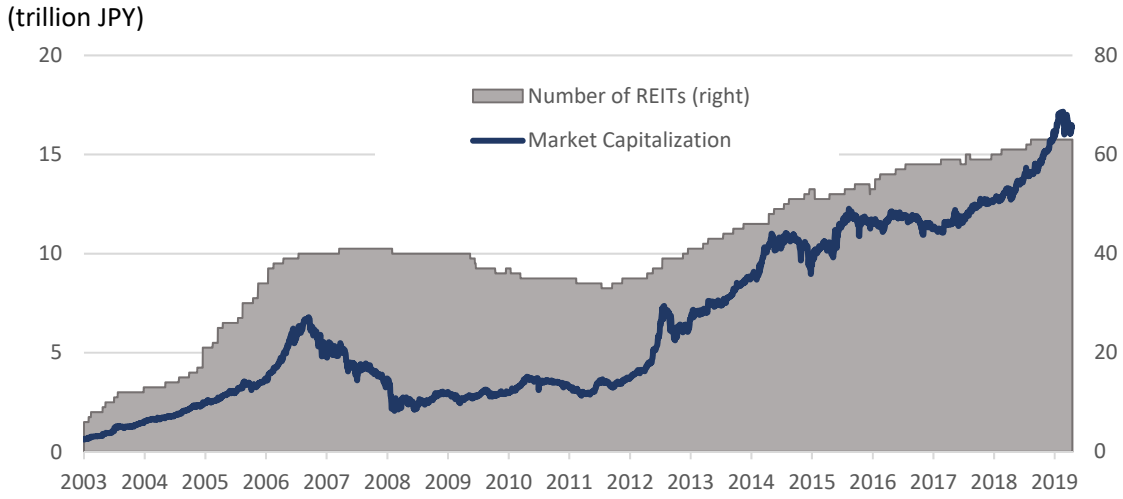
Note: This table shows the estimation result of Equation (6) for the Cox hazard model of stopping decisions. A failure is defined by the end of the BOJ's REIT purchases after consecutive daily purchases. REIT returns are measured in basis points. The sample period is from April 2013 to December 2019. The z-statistics are in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Figure 1
The BOJ's REIT holdings



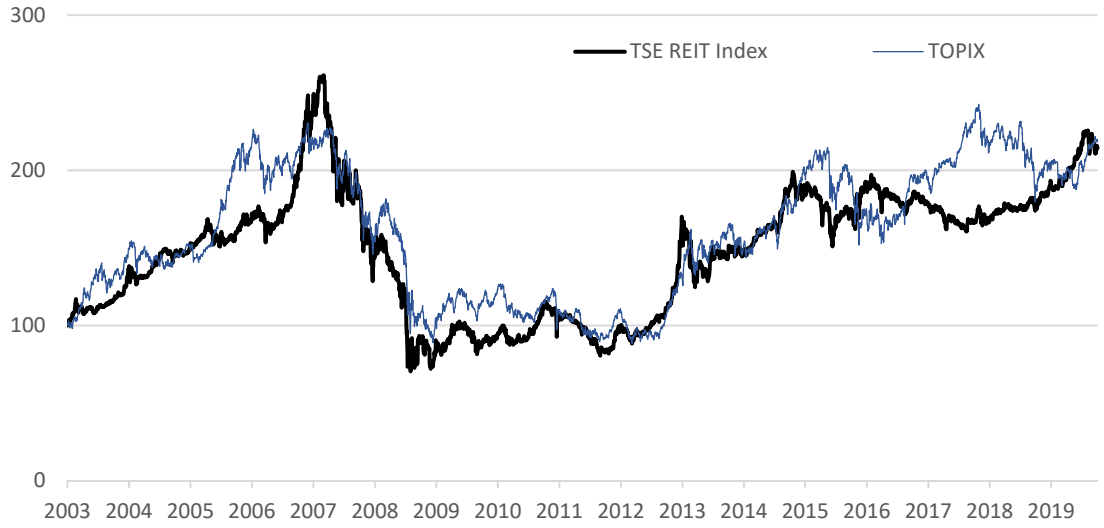
Source: Bloomberg

Figure 2
Number and Market Capitalization of REITs



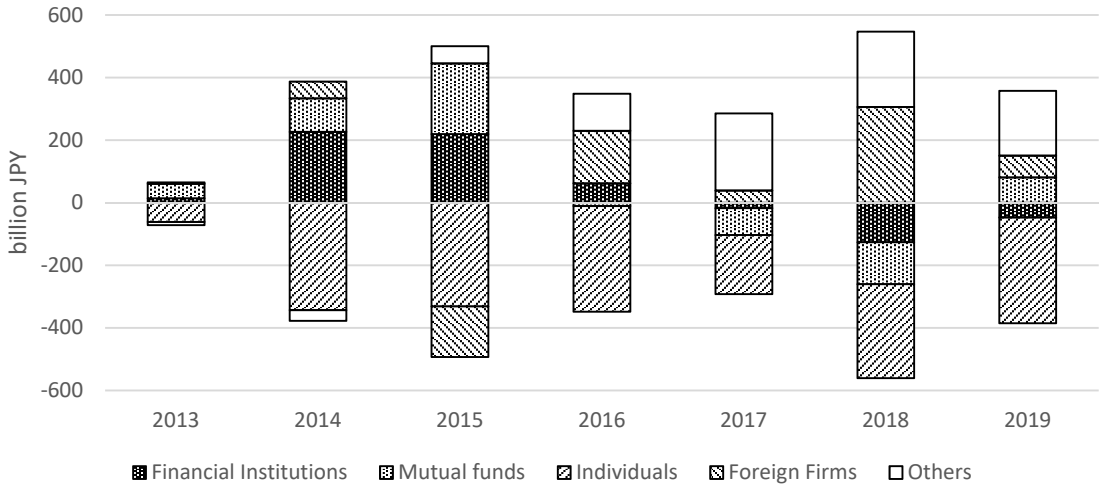
Source: Bloomberg

Figure 3
TOPIX and REIT price returns



Source: Bloomberg

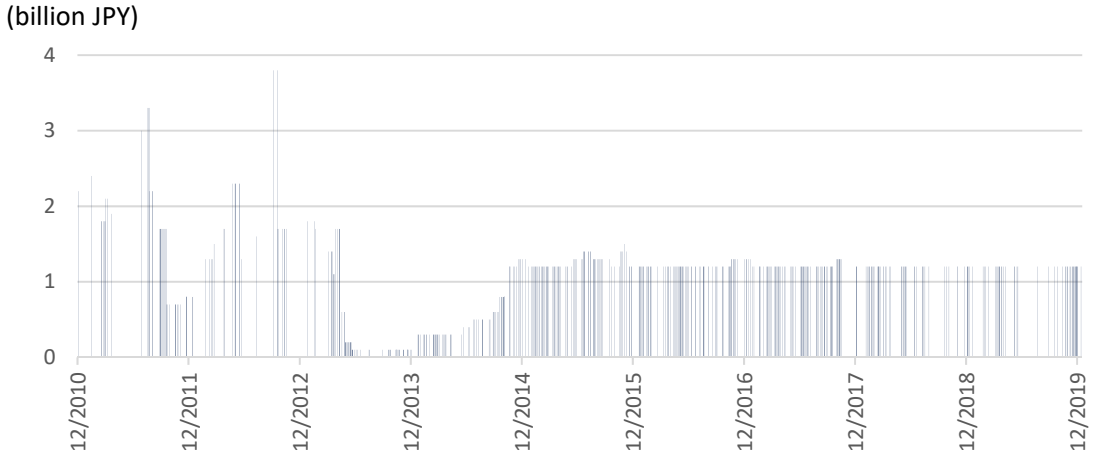
Figure 4
Net purchase amount by investor type



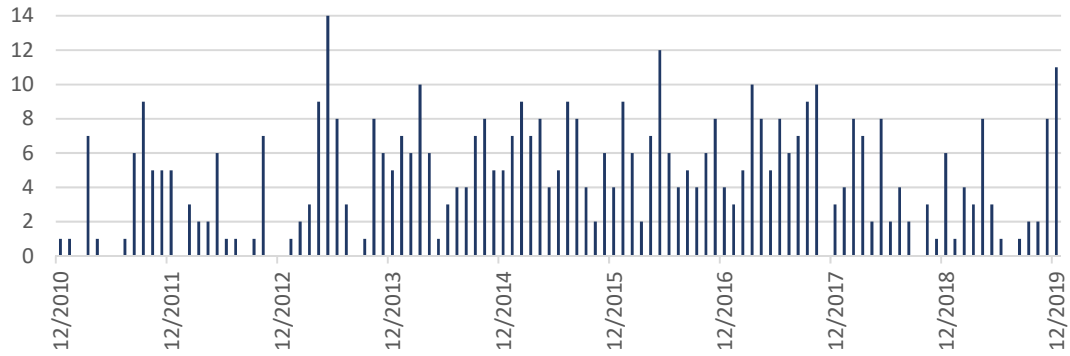
Source: Bloomberg

Figure 5
BOJ's REIT purchase operations

A. The size of daily operation



B. The number of operations for each month

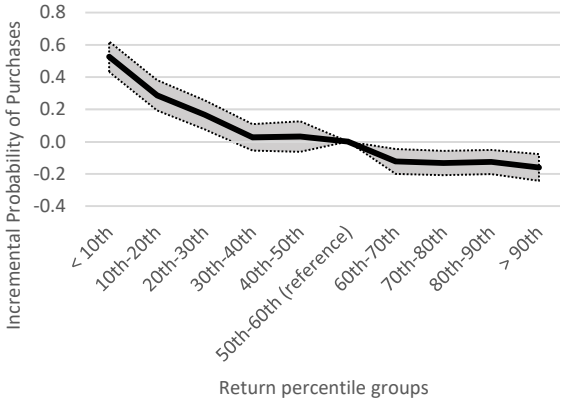


Source: BOJ

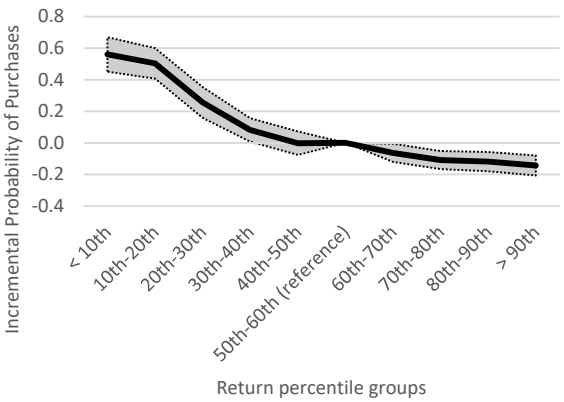
Figure 6

Incremental probability of purchases by return decile groups

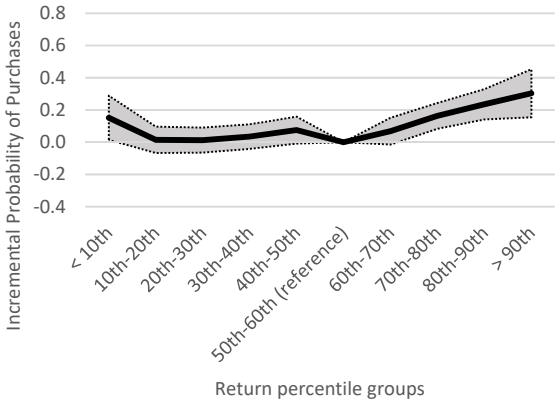
A. Overnight returns



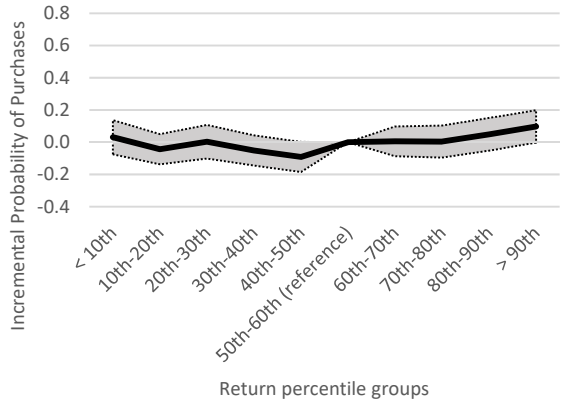
B. Morning returns



C. Lunchtime returns



D. Afternoon returns



Note: This figure depicts the estimated coefficients from Table 5. The vertical axis shows the incremental probability of BOJ's purchase relative to the baseline probability for the sixth decile group. Return decile groups are calculated for each of the overnight period (from 15:00 on the previous trading day to 09:00), the morning market (from 09:00 to 11:30), the lunchtime (from 11:30 to 12:30), and the afternoon market (from 12:30 to 15:00). The sample period is from April 2013 to December 2019.

Appendix

We estimate Equation (2) by using REIT spreads over TOPIX returns instead of controlling for TOPIX returns directly as in Equations (3) and (4). The result is consistent with that for Equations (4) shown in Table 3.

Linear Probability Model Based on REIT spreads over TOPIX returns

	Coefficient	Coefficient
overnight (spread)	-2.319	-1.983
	(-1.081)	(-0.938)
morning (spread)	-12.290 ***	-12.257 ***
	(-6.654)	(-6.339)
lunch (spread)	13.363 *	14.195 **
	(1.95)	(2.046)
afternoon (spread)	3.96 **	4.089 **
	(2.19)	(2.255)
L.overnight (spread)		1.784
		(1.033)
L.morning (spread)		-1.282
		(-0.817)
L.lunch (spread)		-0.799
		(-0.133)
L.afternoon (spread)		3.924 **
		(2.373)
N	1654	1654
Adjusted R-squared	0.046	0.048

Note: This table shows the estimation results of Equations (1) and (2) by replacing REIT returns with REIT spread over TOPIX returns. The dependent variable is the dummy variable for the BOJ's REIT purchases. Returns are measured during the overnight period (from 15:00 on the previous trading day to 09:00), the morning market (from 09:00 to 11:30), lunchtime (from 11:30 to 12:30), and the afternoon market (from 12:30 to 15:00). Lagged returns are for the previous trading day. The sample period is from April 2013 to December 2019. The t-statistics are in parentheses based on Newey-West (1987) standard errors. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.