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Article

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FINANCIAL ECONOMICS | RESEARCH ARTICLE

The Bank of Japan's equity exchange-traded funds purchasing operation and its impact on equity returns

Kentaro Koyama^{1*}

Abstract: The Bank of Japan (BoJ) conducts an unconventional monetary policy that includes exchange-traded fund (ETF) purchases, which can be expected to affect aggregate equity indices. As equity ETF purchases represent a unique and exceptional monetary policy framework, there are few studies on how such purchases have affected the stock markets or the real economy. The motivation of this paper is therefore to reveal the effectiveness of the BoJ's equity ETF purchases and contribute to the broad literature on unconventional monetary policy by providing new insights. Ordinary least squares regression analysis is conducted to examine the effects of the BoJ's ETF purchases and determine whether they are predictable, the effect of expected versus unexpected purchases on aggregate equity indexes differs, and price effects are long lasting. Since the October 2014 increase in the annual volume of ETF purchases by the BoJ, such purchases have become less predictable. Expected purchases do not affect prices, whereas unexpected purchases have a significant, positive price impact. However, this impact is found to be temporary in nature.

Subjects: Economics; Macroeconomics; Finance; Investment & Securities

Keywords: the Bank of Japan (BoJ); unconventional monetary policy; exchange-traded funds (ETFs); quantitative easing (QE); quantitative and qualitative easing (QQE)

JEL Classification: E58; G12; G14.

1. Introduction

After the global financial crisis (GFC) in 2007–2008, major central banks rapidly lowered their policy rates and hit the zero lower bound (ZLB). Consequently, they introduced so-called unconventional monetary policy (Fischer, 2016). According to Borio and Zabai (2018), two types of unconventional monetary policies exist: interest rate policy and balance sheet policy. Interest rate policy includes forward guidance on interest rates and a negative interest rate policy. Balance sheet policy includes exchange rate policy, quasi-debt management policy, credit policy, bank reserve policy, and forward guidance on the balance sheet. Each major central bank deploys a mix of unconventional monetary policy measures suitable for each country and region.

The most popular policy tool within unconventional monetary policy is quantitative easing (QE) policy, which is equivalent to domestic balance sheet policy. For example, the US Federal Reserve (Fed) aggressively reduced rates following the GFC, lowering its policy rate target to 0%–0.25% in December 2008.¹ This reduction brought the rate to the brink of the ZLB. Still, the poor domestic inflation and employment outlook spurred the Fed to launch a large-scale asset-purchasing

scheme the same month and begin purchasing US Treasuries (USTs) and mortgage-backed securities (MBS). In Europe, the European Central Bank (ECB) gradually lowered its policy rates following the GFC and the 2010 European debt crisis, ultimately dropping its deposit facility rate to 0% in July 2012.² The ECB then shifted to an unconventional monetary policy, introducing forward guidance on policy rates in July 2013³ and a negative interest rate policy in June 2014.⁴ The subsequent slowdown in consumer price index inflation raised the specter of deflation, causing the bank to announce a public sector purchase program in March 2015⁵ and a corporate sector purchase program in June 2016.⁶

Among the major central banks, the Bank of Japan (BoJ) has been a front-runner in unconventional monetary policy. In 2001, the BoJ introduced a QE policy targeting the current account balances at the BoJ (bank reserves) held by financial institutions.⁷ After the GFC, the BoJ adopted comprehensive monetary easing at its monetary policy meeting (MPM) in October 2010 by establishing a temporary asset-purchasing program to buy Japanese government bonds (JGBs), commercial paper, corporate bonds, equity ETFs, and Japanese Real Estate Investment Trusts (J-REIT).⁸ After the inauguration of Governor Haruhiko Kuroda in April 2013, the BoJ started a quantitative and qualitative easing (QQE) policy to pave the way for more aggressive asset purchases.⁹

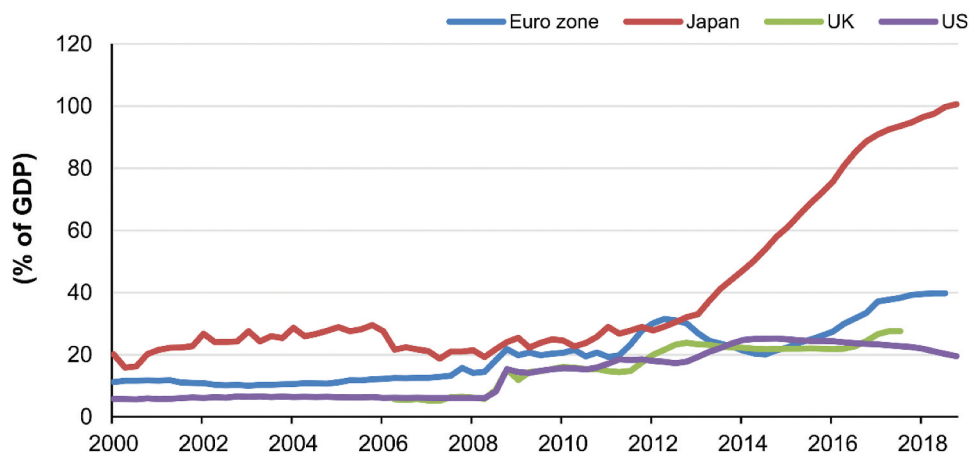
The BoJ's QE policy was strikingly greater in scale than that of either the Fed or the ECB. As of December 2018, the BoJ's balance sheet stood at 100.6% of nominal gross domestic product (GDP; see, [Figure 1](#)). Its QE policy was also distinguished in terms of the breadth of the assets purchased. Its purchase of equity ETFs, which may be considered a type of credit policy as defined by Borio and Zabai (2018), was particularly unusual. However, the policy differs markedly from the credit policy practiced by the Fed and the ECB. While those policies involved corporate bonds and MBS, the assets acquired were fixed-income products. The BoJ is the only major central bank to acquire stocks with no maturity dates.

The purchase of stocks is a risk for the BoJ. Share prices are naturally more volatile than bond prices are, and the BoJ faces the potential for substantial losses. In addition, because stocks do not expire, the bank will be forced to sell them at some point to reduce its balance sheet. It cannot passively shrink its balance sheet, as the Fed did, simply by halting reinvestments.

As previously discussed, the BoJ's equity ETF purchases represent a unique and exceptional monetary policy framework among central banks in developed nations even from a historical perspective. Therefore, there are few studies on how the BoJ's equity ETF purchases have affected stock markets or the real economy. Ueda (2013) did not explicitly measure the impact of the BoJ's equity purchases but reported that the comprehensive monetary easing that occurred in 2010 (including the ETF purchasing scheme) and the enhancement of this policy

Figure 1. Central bank assets as a percentage of nominal gross domestic product.

Source: Haver Analytics.



in 2011 had no statistically significant effect on the Topix. Barbon and Gianinazzi (2019) observed the impact of the BoJ's purchasing operations on stock price returns starting the day policy changes were implemented (31 October 2014 and 29 July 2016). They concluded that every ¥1 trillion in purchasing generated an increase of approximately 20 basis points. However, this increase may also include the effects of changes in the BoJ's commitment to a more accommodative policy and may not be purely the result of ETF purchases. Harada and Okimoto (2019) examined the impacts of the BoJ's ETF purchasing program on the Nikkei 225 and found that Nikkei 225 component stocks returns are significantly greater than those of non-Nikkei 225 stocks are when the BoJ purchases ETFs. However, they did not investigate the impact on the Topix, which has been purchased by BoJ mainly since September 2016.

Apart from the BoJ's equity ETF purchases, Shogbuyi and Steeley (2017) observed how QE policy affected the covariance structure of the equity markets. They concluded that although QE policy reduced the overall volatility of the equity markets, daily operations increased volatility.

Regarding the BoJ's monetary policy, most existing studies examine the BoJ's JGB purchasing program after its first QE policy was implemented in 2001. Oda and Ueda (2007) analyzed the yield curve impact of the BoJ's first QE using a macro-finance model. Kimura and Small (2006) estimated the effect of the BoJ's initial QE on risky assets, such as corporate bonds. Nakano et al. (2017) investigated how announcements by the BoJ since QQE2 of 2014 and actual supply and demand (i.e., the existing amount of JGB less BoJ holdings) affected JGB yields. Fukunaga et al. (2015) examined the effect of increases in the BoJ's JGB holdings and the lengthening of its purchasing maturity from the start of the QQE policy in April 2013 through September 2014. Bowman et al. (2015) investigated the impact of the BoJ's QE on bank lending.

The BoJ has not investigated the effect of its equity ETF purchases. The BoJ conducted a broad analysis of the impact of its JGB purchases in its comprehensive policy assessment of September 2016 but did not extend this analysis to equity ETFs. Therefore, several questions remain open regarding the effectiveness of the BoJ's equity ETF purchases, such as that of whether these purchases have a meaningful impact on equity prices, and if so, what underlying mechanism influences them. The existing literature does not answer this relatively primitive question. Therefore, the motivation of this research study is to reveal the effectiveness of the BoJ's unique unconventional monetary policy and contribute to the existing broad literature on QE by providing new insights.

The main contributions of this research study are as follows. First, providing new insight is a reactionary function of central banks. This paper finds that the BoJ determines whether to purchase ETFs on the basis of the equity price returns in the morning session and makes the purchase during the afternoon session, suggesting that equity prices affect the BoJ's timing of purchases. This paper applies this finding to estimate the reaction function of the BoJ's equity ETF purchases. Eser and Schwaab (2016) reported that the ECB often decides to buy government bonds given changes in yields that day (i.e., the ECB buys bonds because yields are rising), demonstrating the importance of endogeneity and impact identification. However, they did not estimate the reaction function of the ECB.

This study also divides purchases into anticipated and unanticipated purchases on the basis of the reaction function and determines that only unanticipated purchases have a significant impact on the stock price index. This finding is consistent with those of existing studies on conventional monetary policy. Kuttner (2001) observed, "Interest rates' response to anticipated target rate changes is small, while their response to unanticipated changes is large and highly significant" (p. 523). This statement is consistent with the financial and economics literature that has determined that unexpected fund flows have a significant impact on equity index returns (Edelen & Warner, 2001; Warther, 1995). These arguments indicate that anticipated and unanticipated sovereign bond purchasing operations may have dissimilar effects, but existing studies¹⁰ have not investigated this possibility.

Furthermore, the BoJ's equity ETF purchasing operations have larger return reversals than the sovereign bond purchasing operations reported in existing studies. In the words of D'Amico and King (2013), this finding indicates that stock effects are minimal relative to flow effects and that the impact of the BoJ's equity ETF purchasing on equity prices is short-lived. This short horizon could stem from the difference in the BoJ's market dominance. The BoJ owned 43.2% of all outstanding JGBs as of March 2018, and its equity ETF holdings represented only 2.6% of the First Section of the Tokyo Stock Exchange's (TSE's) market value. This percentage also suggests that the signaling effects (or information revelation effects) of equity ETF purchases are weak. These effects are reportedly persistent in sovereign bond purchasing operations (Bauer & Rudebusch, 2014; Christensen & Rudebusch, 2012; Krishnamurthy & Vissing-Jorgensen, 2011). In contrast, because the volume of the BoJ's ETF purchasing operations is decided in advance annually, daily operations are not indicative of future policy. The signaling effect could also be poor, given the lower correlation between equity ETF purchases and future policy rates than that between sovereign bond purchases and future policy rates.

The remainder of this study is organized as follows. Section 2 explains the details of the BoJ's equity ETF purchasing operations. Section 3 provides an empirical analysis of the effectiveness of the BoJ's ETF purchases, including conducting estimations of the reaction function for the BoJ's operation and identification strategy. Section 4 proposes a theoretical explanation of the empirical results. Section 5 concludes.

2. Details of the BoJ's ETF purchasing operation

2.1. Scale and timing

On its website, the BoJ provides daily updates of the results of its ETF purchases. The trend and statistics are depicted in Figure 2 and listed in Table 1. The frequency of the BoJ's purchases increased after the introduction of the QQE in April 2013, and the purchasing volume per offering increased with the launch of the QQE2 in October 2014 and supplementary easing measures implemented in July 2016. The average purchasing volume per offer from the start of their equity 2010 until the ETF purchases at the start of QQE was ¥22.87 billion, and the frequency of their offers was 0.6 times per week. Following the launch of QQE in April 2013, average purchases per offer declined to ¥15.74 billion, but offer frequency increased to 1.4 times per week. After the QQE2 in October 2014, when ETF purchases were raised to an annual level of ¥3 trillion, the volume per

Figure 2. The BoJ's exchange-traded fund (ETF) purchasing volume over time, 2010–2018.

Note. The BoJ started ETF purchases on 15 December 2010. Before the BoJ introduced the quantitative and qualitative easing (QQE) on 4 April 2013, no annual purchasing targets existed. The annual purchasing target was ¥1 trillion between 4 April 2013 and 30 October 2014; ¥3 trillion between 31 October 2014 and 28 July 2016; and ¥6 trillion after 29 July 2016.

Source: The Bank of Japan.

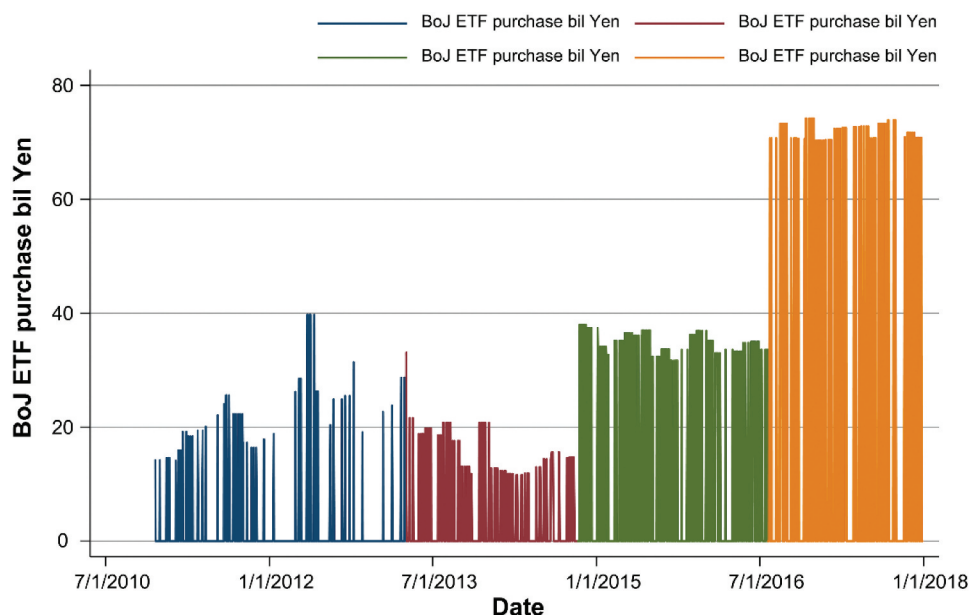


Table 1. Summary statistics for the BoJ's ETF purchases

	Annual purchasing volume (in trillions of JPY)	Purchasing volume over time (in billions of JPY)	Number of purchases per week
Pre-QQE: 15 December 2010– 3 April 2013	No annual target	22.87	0.6
QQE: 4 April 2013– 30 October 2014	1	15.74	1.4
QQE2: 31 October 2014– 28 July 2016	3	34.85	1.7
Post-QQE2: 29 July 2016– December 31, 2017	6	71.43	1.5

Source: The Bank of Japan.

offer jumped to ¥34.85 billion, whereas the frequency changed little, at 1.7 times per week. After annual ETF purchases were further increased to ¥6 trillion in July 2016, the volume per offer reached ¥71.43 billion, which reveals that the BoJ responded to the increased annual ETF purchasing volume under QQE2 mainly by increasing its purchasing volume per offer.

2.2. Types of ETFs

The BoJ's ETF purchases were initially linked to both the Nikkei225 and the Topix. Subsequent links were established on 31 October 2014, to the JPX400 ETF, and on 18 December 2015, to support firms proactively investing in physical and human capital expenditure (capex)-related ETFs (¥0.3 trillion in purchases per year). The amount of each ETF purchase, other than the capex ETFs, was proportional to the total market capitalization of each ETF. The BoJ altered this amount on 21 September 2016, such that ¥3 trillion of its annual ¥5.7 trillion (¥6.0–¥0.3 trillion) in purchases was used for tracking the three indices in proportion to the ETFs' market capitalization, whereas the remaining ¥2.7 trillion was reserved for Topix-linked ETFs. Figure 3 shows my estimation of the composition of the BoJ's ETF purchases based on their market capitalization data. Before September 2016, approximately half of the BoJ's ETF purchases were linked to the Topix; however, after October 2016, the weight of the ETFs linked to the Topix was approximately 70%.

3. Research methods and empirical analysis

3.1. Simple OLS regression analysis

First, this paper uses OLS regressions to analyze whether the BoJ's ETF purchases had any impact on equity price indices. This setting is similar to those in Krishnamurthy and Vissing-Jorgensen (2012) and D'Amico and King (2013), who analyzed the impact of government bond purchases on bond prices as follows:

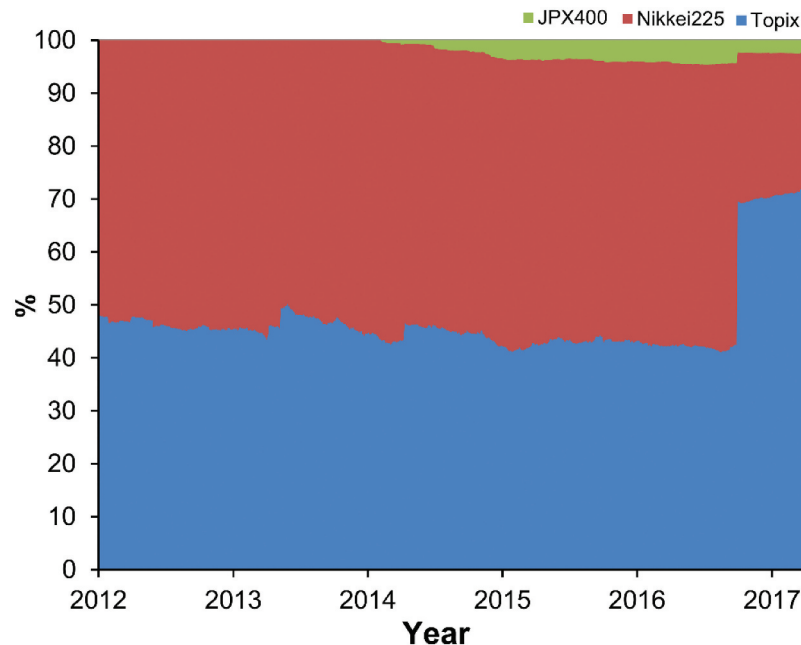
$$\Delta s_t = \alpha_0 + \alpha_1 \Delta sp_{t-1} + \alpha_2 \Delta fx_t + \alpha_3 boj_t + \varepsilon_t \quad (1)$$

where Δs represents the daily return on the Nikkei225 or the Topix, and Δsp represents the daily return on the S&P500. S&P500 returns are necessary to control the linkage between Japan and US stock markets. Δfx represents the return on the exchange rate of US dollar (USD)/Japanese yen (JPY) from 3:00 p.m. the previous day to 3:00 p.m. the current day. The foreign exchange (FX) rate is important information, particularly for determining stock prices for exporters, typically large manufacturing companies, and 3:00 p.m. is the time that trading on the TSE ends. In addition, the USD/JPY captures the degree of uncertainty of the financial markets. Fatum and Yamamoto (2016) found that the JPY is the safest among the safe-haven currencies and that the JPY appreciates as

Figure 3. Composition of the BoJ's ETF purchases, 2012–2017.

Note. The BoJ's ETF purchases were initially linked to both the Nikkei225 and the Topix and were subsequently expanded on 31 October 2014, to influence the JPX400 ETFs. The amount of each ETF purchase was proportional to the total market capitalization of each ETF. This figure indicates my estimation of the composition of the BoJ's ETF purchases based on market capitalization data.

Sources: Bloomberg Finance LP, the Bank of Japan.



market uncertainty increases because of higher geopolitical risk and economic policy uncertainty. Therefore, the USD/JPY is an important determinant for the Japanese equity markets. *boj* represents the BoJ's ETF purchasing volume (in billions of yen). Descriptive statistics on asset price returns are available in Table 2. Figure 4 shows the historical charts for the USD/JPY, the Nikkei225, the Topix, and the S&P500 and their daily returns. The hypothesis here is that BoJ's equity ETF purchasing has a positive impact on equity prices.

Table 3 provides the estimation results. An unexpected finding is that the BoJ's ETF purchases have a statistically significant negative effect on equity returns. However, such an effect is natural, given the timing of the bank's ETF purchases. Financial market participants broadly understand that the BoJ checks the movement of equity prices during the morning session and conducts ETF purchases in the afternoon session when equity indices fall to a certain extent (Lewis, 2017). Therefore, the BoJ's ETF purchasing activity is a signal that equity prices declined that day. Consequently, the results in Table 3 are consistent with the view of market participants, which is also consistent with Eser and Schwaab's (2016) findings that the ECB's bond purchases sometimes corresponded to a rise in bond yields (i.e., a decline in prices). They attributed this relationship to the impact identification problem, wherein the ECB tends to purchase bonds when yields rise. Therefore, to estimate the impact of asset purchases by central banks, we must identify the causality between asset prices and asset purchases. The daily frequency is too low; at least a twice per day frequency is necessary to identify the impact of the BoJ's ETF purchases.

3.2. Reaction function for the BoJ's ETF purchases

The literature on estimating the reaction function for a central bank's market operations is rather abundant in foreign exchange interventions. This study follows Dominguez (1998) and Kim and Sheen (2002) and constructs a probit model that explains a binary variable for the BoJ's purchases (i.e., a variable that takes the value of 1 for a day with purchases and the value of 0 for a day without purchases) in terms of equity price index returns during the morning session.

$$Pr(\text{BoJ purchases ETF}) = \Phi(\alpha_0 + \alpha_1 * \Delta s_{am,t}) + \epsilon_t \quad (2)$$

Table 2. Descriptive statistics based on the BoJ's ETF purchases

		N	mean	sd	Min	max
Day without BoJ purchases						
<i>fx_day</i>	USD/JPY daily return	1,369	0.136	0.557	−2.377	4.601
<i>sp</i>	S&P500 daily return	1,333	0.086	0.844	−4.782	4.332
<i>tpx</i>	Topix daily return	1,277	0.434	1.041	−3.256	8.021
<i>nky</i>	Nikkei225 daily return	1,386	0.42	1.081	−3.959	7.709
<i>fx_am</i>	USD/JPY half-day return (AM)	1,367	0.14	0.514	−2.135	4.417
<i>tpx_am</i>	Topix half-day return (AM)	1,276	0.441	0.795	−1.528	5.967
<i>nky_am</i>	Nikkei225 half-day return (AM)	1,277	0.46	0.856	−1.595	5.706
<i>fx_pm</i>	USD/JPY half-day return (PM)	1,374	−0.004	0.196	−2.695	1.762
<i>tpx_pm</i>	Topix half-day return (PM)	1,277	−0.007	0.572	−4.651	3.056
<i>nky_pm</i>	Nikkei225 half-day return (PM)	1,277	−0.005	0.605	−5.005	3.334
Day with BoJ purchases						
<i>fx_day</i>	USD/JPY daily return	451	−0.334	0.573	−2.742	2.335
<i>sp</i>	S&P500 daily return	439	−0.069	1.016	−6.663	4.741
<i>tpx</i>	Topix daily return	452	−1.04	1.272	−9.473	2.711
<i>nky</i>	Nikkei225 daily return	452	−1.078	1.343	−10.554	2.203
<i>fx_am</i>	USD/JPY half-day return (AM)	451	−0.323	0.516	−2.645	1.715
<i>tpx_am</i>	Topix half-day return (AM)	452	−1.057	0.897	−6.973	0.037
<i>nky_am</i>	Nikkei225 half-day return (AM)	452	−1.051	0.921	−6.452	0.45
<i>fx_pm</i>	USD/JPY half-day return (PM)	452	−0.012	0.25	−1.483	2.635
<i>tpx_pm</i>	Topix half-day return (PM)	452	0.015	0.738	−5.853	3.969
<i>nky_pm</i>	Nikkei225 half-day return (PM)	452	−0.029	0.833	−7.527	3.995
Total						

(Continued)

Table 2. (Continued)

		N	mean	sd	Min	max
Day with BoJ purchases						
<i>fx_day</i>	USD/JPY daily return	1,820	0.02	0.597	−2.742	4.601
<i>sp</i>	S&P500 daily return	1,772	0.047	0.892	−6.663	4.741
<i>tpx</i>	Topix daily return	1,729	0.049	1.281	−9.473	8.021
<i>nky</i>	Nikkei225 daily return	1,838	0.052	1.319	−10.554	7.709
<i>fx_am</i>	USD/JPY half-day return (AM)	1,818	0.025	0.552	−2.645	4.417
<i>tpx_am</i>	Topix half-day return (AM)	1,728	0.05	1.053	−6.973	5.967
<i>nky_am</i>	Nikkei225 half-day return (AM)	1,729	0.065	1.097	−6.452	5.706
<i>fx_pm</i>	USD/JPY half-day return (PM)	1,826	−0.006	0.211	−2.695	2.635
<i>tpx_pm</i>	Topix half-day return (PM)	1,729	−0.002	0.62	−5.853	3.969
<i>nky_pm</i>	Nikkei225 half-day return (PM)	1,729	−0.011	0.672	−7.527	3.995

Source: Bloomberg Finance LP.

where Δs_{am} represents the returns in the morning session for the Nikkei225 or the Topix, and Φ represents a cumulative standard normal distribution. The parameter α_1 is expected to be negative.

Table 4 reveals that the parameters for Topix and Nikkei225 morning returns are statistically significant and negative, indicating that the greater the drop in the indices during the morning session the greater the likelihood of an ETF purchasing operation being conducted by the BoJ. Interestingly, the R^2 value for the Topix is higher, suggesting that the BoJ gives greater weight to the Topix in deciding whether to proceed with ETF purchases. The R^2 value for the subsample from 15 December 2010 to 3 April 2013, is also higher, suggesting that the rule for ETF purchasing became complicated after the launch of the QQE in April 2013. Additionally, the QQE period from 4 April 2013 to 29 December 2017, had smaller coefficients for the Topix and the Nikkei225. This finding suggests that the bank carried out ETF purchases under the QQE even after less significant market drops, which is consistent with the rise in their actual purchasing frequency. The required decline in the equity indices for a 50% probability for the BoJ making a purchase is—1.0% for the Topix during the December 2010 to April 2013 sample period (before the QQE) and—0.3% during the April 2013 to December 2017 sample period (after the QQE; see, Figure 5).

Table 5 indicates the predictive power of my probit model with the Topix during the estimation period from December 2010 to April 2013 and from April 2013 to December 2017, respectively. The model's predictive power is significantly higher before the QQE; its percentage of correct classifications (i.e., the model predicts a purchase and the BoJ subsequently makes one, as well as the reverse) is 99.65%. This percentage was lower after the QQE, at 90.89%.

Figure 4. Historical charts for the Nikkei225, Topix, S&P500, and USD/JPY, 2010–2019.

Sources: Bloomberg Finance LP and the Bank of Japan.

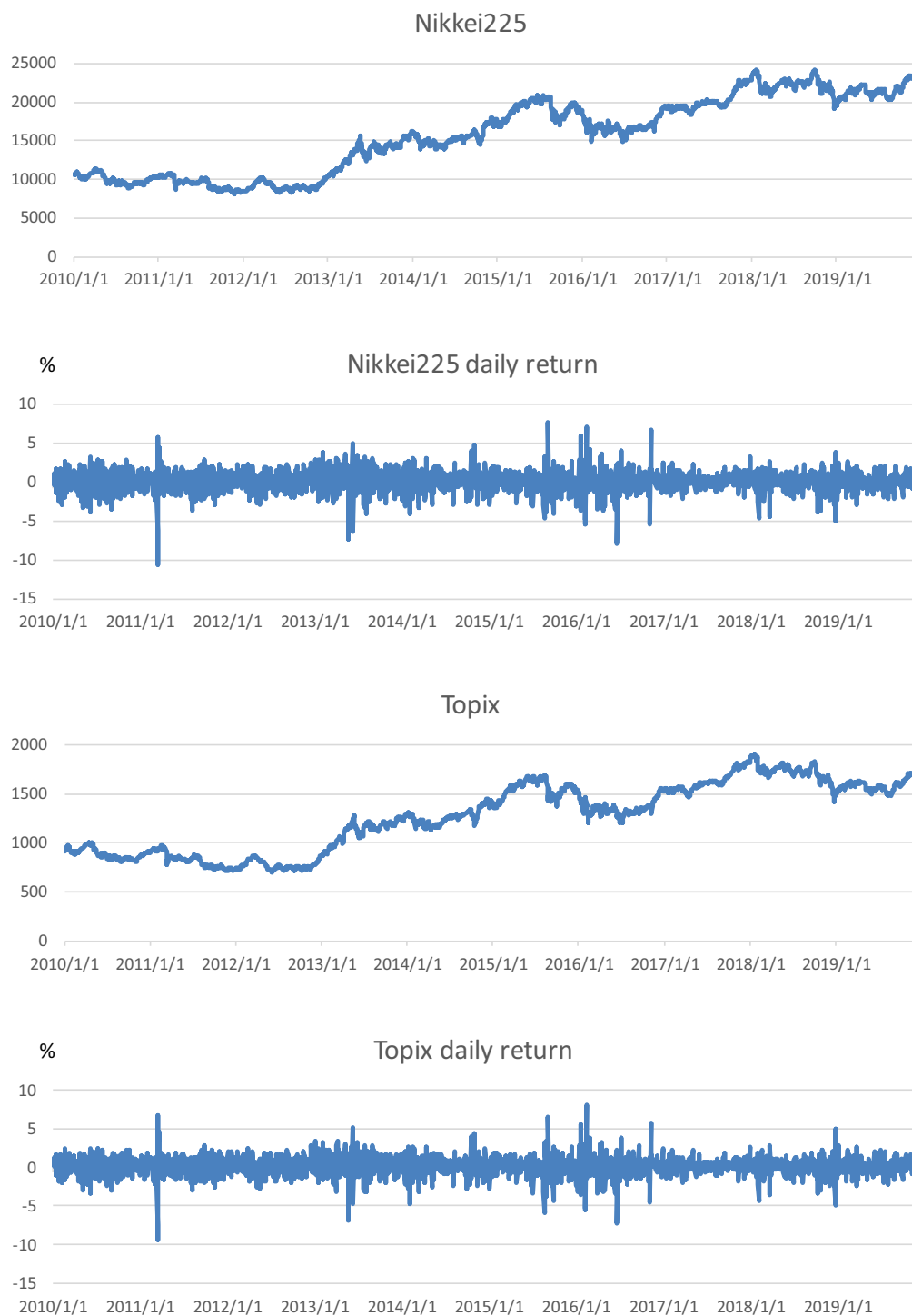


Figure 4. Continued.

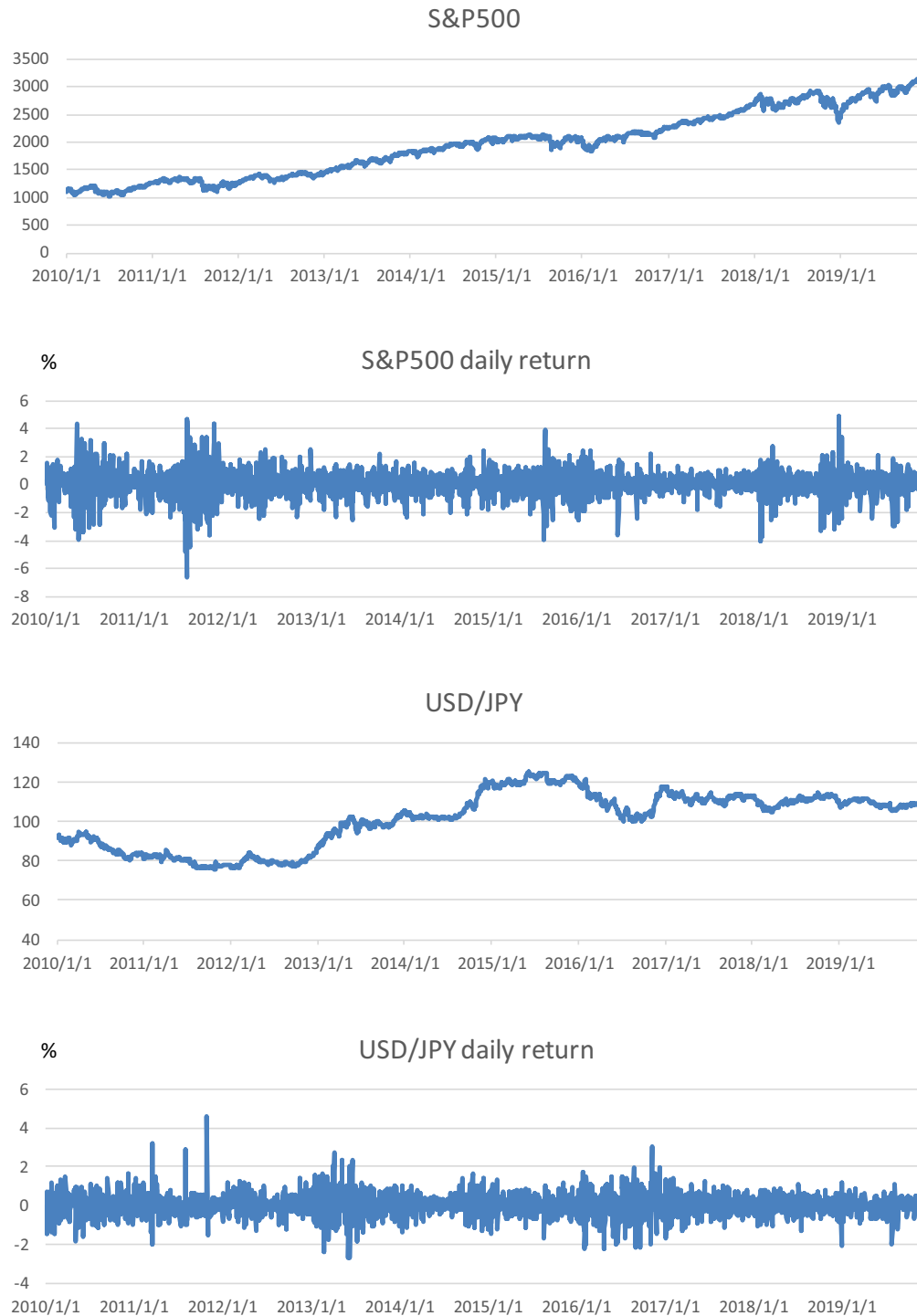


Table 3. Estimation results of simple OLS regression Equation (1)

	nky			tpx		
	Full sample	Before QQE	After QQE	Full sample	Before QQE	After QQE
sp [-1]	0.464*** (0.0377)	0.360*** (0.0475)	0.480*** (0.0595)	0.459*** (0.0371)	0.339*** (0.0448)	0.510*** (0.0570)
Fx	0.982*** (0.0760)	0.580*** (0.127)	1.141*** (0.0801)	0.958*** (0.0784)	0.751*** (0.115)	1.137*** (0.0740)
boj	-0.00916*** (0.00122)	-0.0484*** (0.00703)	-0.00687*** (0.00123)	-0.00823*** (0.00125)	-0.0489*** (0.00610)	-0.00555*** (0.00124)
Constant	0.0948*** (0.0261)	0.134** (0.0421)	0.102** (0.0328)	0.0783** (0.0266)	0.166*** (0.0396)	0.0750* (0.0322)
N	1756	563	1193	1657	770	1125
R-sq	0.428	0.395	0.478	0.433	0.427	0.506
adj. R-sq	0.427	0.391	0.476	0.432	0.425	0.504
Sample period	12/15/2010–12/29/2017	12/15/2010–4/3/2013	4/4/2013–12/29/2017	12/15/2010–12/29/2017	12/15/2010–4/3/2013	4/4/2013–12/29/2017

Standard errors appear in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Note. This table reports the results of OLS regressions of daily equity index returns. The dependent variable is the Nikkei 225 daily return (*nky*) or Topix daily return (*tpx*). “sp[-1]” denotes the previous day’s S&P 500 returns, “fx” is the USD/JPY returns from 3:00 p.m. the previous day to 3:00 p.m. the current day, and “boj” is the BoJ’s ETF purchasing volume (in billions of yen).

Table 4. Estimation probit model results Equation (2)

	1 if BoJ purchases ETF, zero if not					
	Full sample	Before QQE	After QQE	Full sample	Before QQE	After QQE
nky_am	-1.752*** (0.0887)	-2.943*** (0.339)	-2.340*** (0.143)			
tpx_am				-2.263*** (0.117)	-4.675*** (0.621)	-3.499*** (0.219)
Constant	-1.092*** (0.0544)	-3.395*** (0.365)	-0.826*** (0.0640)	-1.244*** (0.0633)	-4.810*** (0.601)	-1.046*** (0.0806)
N	1729	565	1164	1729	565	1164
pseudo R-sq	0.473	0.708	0.542	0.541	0.806	0.651
Sample period	12/15/2010–12/29/2017	12/15/2010–4/3/2013	4/4/2013–12/29/2017	12/15/2010–12/29/2017	12/15/2010–4/3/2013	4/4/2013–12/29/2017

Standard errors appear in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Note. This table reports the results of the probit model for estimating the BoJ’s ETF purchases. The dependent variable is a binary variable that takes the value of one if the BoJ purchases ETFs and zero otherwise. “nky_am”, and “tpx_am” denote the Nikkei 225 and Topix returns in the morning session, respectively.

Based on this finding, the anticipated timeframe for the BoJ’s ETF purchases can be observed in Figure 6.

3.3. OLS regression with half-day data

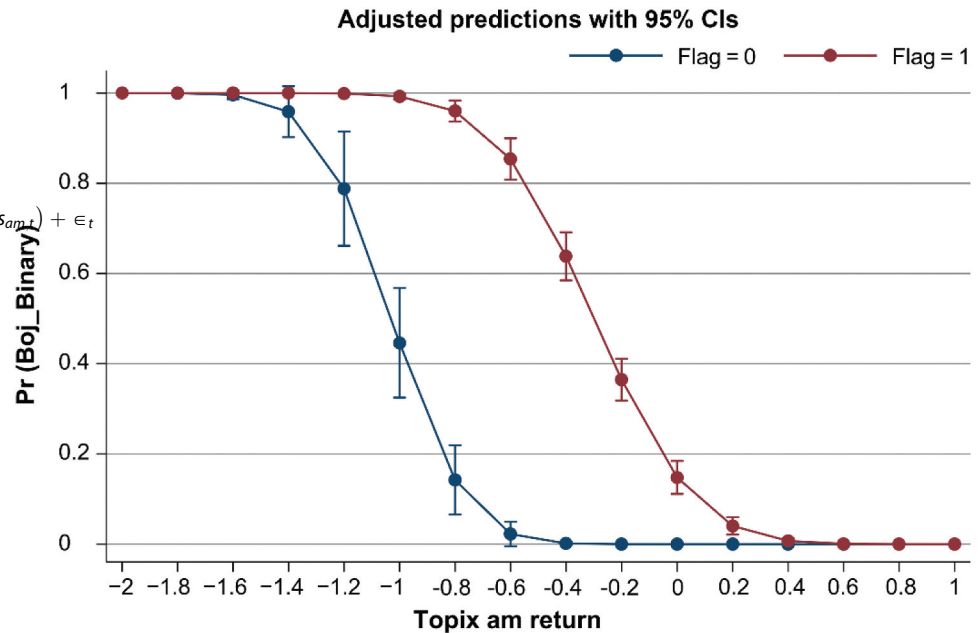
For an accurate estimation of the effects of the BoJ’s ETF purchases, the stock returns in the afternoon session (12:30 p.m.–3:00 p.m.) must be regressed by the BoJ’s ETF purchasing volume. This identification strategy follows Edelen and Warner (2001). The explanatory variables include the morning returns for equity price indices and afternoon returns for the USD/JPY.

Figure 5. Estimated probability of the BoJ's ETF purchases using the probit model.

Estimated by using the following probit model:-

$$Pr(BoJpurchasesETF) = (\alpha_0 + \alpha_1 * \Delta s_{am,t}) + \epsilon_t$$

where $\Delta s_{am,t}$ are returns in the morning session of the Topix, and Φ is a cumulative standard normal distribution. "Before QQE" is from 15 December 2010 to 3 April 2013, and "After QQE" is from April 4 to 29 December 2017.



$$\Delta s_{pm,t} = \alpha_0 + \alpha_1 * \Delta s_{am,t} + \alpha_2 * \Delta f_{x_{pm,t}} + \alpha_3 * boj_t + \epsilon_t \quad (3)$$

where Δs_{pm} and Δs_{am} represent returns in the afternoon and morning sessions for the Nikkei225 and the Topix, respectively, $\Delta f_{x_{pm}}$ represents the returns on the USD/JPY from 11:30 a.m. to 3:00 p.m., and boj represents the BoJ's ETF purchasing volume (in billions of yen). The duration of the USD/JPY is from 11:30 a.m. and not 12:30 p.m. because stock prices in the afternoon session should reflect the information available after the morning session, which ends at 11:30 a.m. S&P500 returns are excluded because the information is already discounted in the morning session. The parameter α_3 is expected to be positive (i.e., the BoJ's equity ETF purchasing is expected to increase equity prices).

Given these adjustments, the BoJ's ETF purchasing coefficient is a statistically significant positive figure (Table 6). In addition, parameters on the BoJ's ETF purchases are greater before the QQE, indicating the diminishing marginal impact of the BoJ's ETF purchases. Before the QQE, ¥70 billion in purchases led to a 0.81% rise in the Nikkei225 in the afternoon session and a 0.22% increase after the QQE.

3.4. Expected and unexpected purchases

Using the results of the probit model in Section 3.2, this study now explores how the BoJ's expected and unexpected JGB purchasing operations influence equity prices. Before the QQE, the timing of the BoJ's ETF purchases was almost predictable. However, because the rule for ETF purchases became complicated after the QQE, the timing of the BoJ's ETF purchases should feature some surprises.

This study defines purchasing operations in the probit model with a probability higher than 95% as expected and those with a probability lower than 95% as unexpected.¹¹ Therefore, Equation (3) is modified as follows:

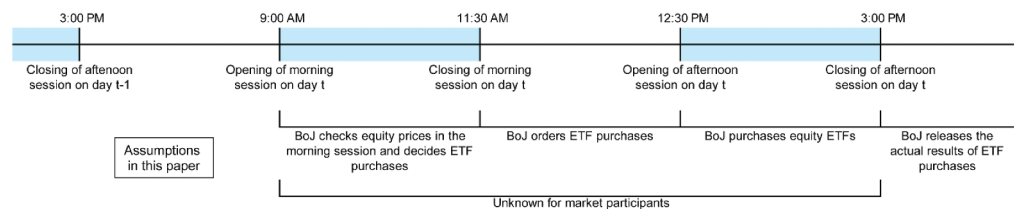
$$\Delta s_{pm,t} = \alpha_0 + \alpha_1 * \Delta s_{am,t} + \alpha_2 * \Delta f_{x_{pm,t}} + \alpha_3 * boj_{exp,t} + \alpha_4 * boj_{unexp,t} + \epsilon_t \quad (4)$$

Table 5. Predictive power of the probit model

Sample period: 15 December 2010–3 April 2013 (before QQE)				Sample period: 4 April 2013–29 December 2017 (after QQE)			
	TRUE				TRUE		
Classified	D	~D	Total	Classified	D	~D	Total
+	68	0	68	+	309	33	342
–	2	495	497	–	73	748	821
Total	70	495	565	Total	382	781	1163
Classified + if predicted $\Pr(D) \geq 0.5$				Classified + if predicted $\Pr(D) \geq .5$			
True D defined as if BoJ purchases ETF				True D defined as if BoJ purchases ETF			
Sensitivity	$\Pr(+ D)$	97.14%		Sensitivity	$\Pr(+ D)$	80.89%	
Specificity	$\Pr(- \sim D)$	100.00%		Specificity	$\Pr(- \sim D)$	95.77%	
Positive predictive value	$\Pr(D +)$	100.00%		Positive predictive value	$\Pr(D +)$	90.35%	
Negative predictive value	$\Pr(\sim D -)$	99.60%		Negative predictive value	$\Pr(\sim D -)$	91.11%	
False + rate for true ~D	$\Pr(+ \sim D)$	0.00%		False + rate for true ~D	$\Pr(+ \sim D)$	4.23%	
False – rate for true D	$\Pr(- D)$	2.86%		False – rate for true D	$\Pr(- D)$	19.11%	
False + rate for classified +	$\Pr(\sim D +)$	0.00%		False + rate for classified +	$\Pr(\sim D +)$	9.65%	
False – rate for classified –	$\Pr(D -)$	0.40%		False – rate for classified –	$\Pr(D -)$	8.89%	
Correctly classified		99.65%		Correctly classified		90.89%	

Note. TRUE D: The BoJ purchases ETFs, True ~D: The BoJ does not purchase ETFs, Classified +: The model predicts the BoJ's ETF purchases, Classified -: The model does not predict the BoJ's ETF purchases.

Figure 6. Assumed timeframe for the BoJ's ETF purchasing operation.



where Δs_{pm} and Δs_{am} represent returns in the afternoon and morning sessions for the Nikkei225 and Topix, respectively; $\Delta f_{x_{pm}}$ represents the returns on the USD/JPY from 11:30 a.m. to 3:00 p.m.; and boj_{exp} and boj_{unexp} denote expected and unexpected purchases, respectively, in billions of yen. The estimation results in Table 7 indicate that the coefficient for unexpected purchases is statistically significant for either the Topix or the Nikkei225, whereas the coefficient for expected purchases is not significant for the Nikkei 225. In addition, the coefficient for expected purchases is less than that for unexpected purchases. These findings are consistent with those of Warther (1995), who examined the effect of aggregate-level fund flows on equity indices and found that unexpected fund flows have a significant impact on equity index returns.

Table 6. OLS regression results for afternoon returns Equation (3)

	nky_pm			tpx_pm		
	Full sample	Before QQE	After QQE	Full sample	Before QQE	After QQE
nky_am	0.0967*** (0.0254)	0.164*** (0.0586)	0.0839*** (0.0253)			
tpx_am				0.0882*** (0.0240)	0.130*** (0.0494)	0.0885*** (0.0264)
fx_pm	1.775*** (0.147)	1.048*** (0.190)	1.927*** (0.173)	1.587*** (0.124)	1.028*** (0.168)	1.707*** (0.144)
boj	0.00317*** (0.000668)	0.0106*** (0.00381)	0.00311*** (0.000624)	0.00377*** (0.000610)	0.0116*** (0.00348)	0.00386*** (0.000612)
Constant	-0.0378** (0.0164)	-0.0262 (0.0283)	-0.0585*** (0.0200)	-0.0337** (0.0151)	-0.0220 (0.0253)	-0.0558*** (0.0191)
N	1723	559	1164	1722	559	1163
R-sq	0.349	0.16	0.423	0.331	0.137	0.406
adj. R-sq	0.348	0.156	0.421	0.330	0.132	0.404
Sample period	12/15/2010–12/29/2017	12/15/2010–4/3/2013	4/4/2013–12/29/2017	12/15/2010–12/29/2017	12/15/2010–4/3/2013	4/4/2013–12/29/2017

Standard errors appear in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Note. This table reports the results of OLS regressions of equity index returns for the afternoon session. The dependent variable is afternoon session returns for the Nikkei 225 (*nky_pm*) or Topix (*tpx_pm*). “*nky_am*” and “*tpx_am*” are morning session returns for Nikkei 225 and Topix. “*fx_pm*” is USD/JPY returns from 11:30 a.m. to 3:00 p.m. “*boj*” is the BoJ’s ETF purchasing volume (in billions of yen).

For expected purchases, the BoJ’s acquisition of ETFs is discounted in advance by the markets (perhaps during the morning session), limiting the impact on returns in the afternoon session. However, in the case of unexpected purchases, limited prior discounting occurs, which leads to a statistically significant impact on equity prices in the afternoon session. Another possible explanation for the results in Table 7 is that expected purchases by the BoJ are absorbed by arbitrageurs in the afternoon session, but unexpected purchases are not. This explanation is discussed in detail in Section 4.

These findings are consistent with existing monetary policy studies that indicate that policy changes require the element of surprise to have a significant influence on asset prices (Kuttner, 2001).

3.5. Return reversal

If unexpected purchases affect equity prices through the price pressure hypothesis (Warther, 1995), that is, if the BoJ’s ETF purchases affect equity prices through changes in supply and demand conditions in the market, they lead to a temporary divergence in equity prices from their fundamental values, subsequently prompting reversal of returns to their fundamental values. To examine this effect, this study estimates a regression model using the OLS method that explains stock returns in the morning session in terms of the previous day’s unexpected purchases.

$$\Delta s_{am,t} = \alpha_0 + \alpha_1 * \Delta s_{pm,t-1} + \alpha_2 * \Delta fx_{am,t} + \alpha_3 * \Delta sp_{t-1} + \alpha_4 * boj_{unexp,t-1} + \epsilon_t \quad (5)$$

where Δs_{am} and Δs_{pm} represent returns in the morning and afternoon sessions for the Nikkei225 and the Topix, respectively; Δfx_{am} represents returns on the USD/JPY from 3:00 p.m. the previous day to 11:30 a.m. the current day; Δsp represents daily returns on the S&P500; and boj_{unexp} represents the BoJ’s unexpected ETF purchasing volume (in billions of yen). The duration of the USD/JPY is from 3:00 p.m. the previous day because stock prices in the morning session

Table 7. Impact of expected and unexpected ETF purchases by the BoJ Equation (4)

	nky_pm	tpx_pm
nky_am	0.0761*** (0.0257)	
tpx_am		0.0784*** (0.0271)
fx_pm	1.926*** (0.172)	1.705*** (0.144)
boj_exp	0.00181 (0.00144)	0.00232* (0.00121)
boj_unexp	0.00341*** (0.000616)	0.00420*** (0.000626)
Constant	0.0538*** (0.0197)	0.0502*** (0.0189)
N	1164	1163
# of expected purchases	176	176
# of unexpected purchases	206	206
R-sq	0.423	0.407
adj. R-sq	0.421	0.405
Sample period	4/4/2013- 12/29/2017	4/4/2013- 12/29/2017

Standard errors appear in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Note. This table reports the results of OLS regressions of equity index returns for the afternoon session. The dependent variable is Nikkei 225 returns (*nky_pm*) or Topix returns (*tpx_pm*). “*nky_am*” and “*tpx_am*” are morning session returns for the Nikkei 225 and the Topix. “*fx_pm*” is USD/JPY returns from 11:30 a.m. to 3:00 p.m. “*boj_exp*” and “*boj_unexp*” represent expected and unexpected ETF purchasing volume, respectively, by the BoJ (in billions of yen).

should reflect the information available after the previous day’s afternoon session, which ends at 3:00 p.m.

The estimation results are shown in Table 8. The coefficients for the previous day’s unexpected purchases for both the Nikkei225 and the Topix are significantly negative, which confirms that a return reversal indeed occurred, supporting the notion that the price pressure hypothesis took effect. This finding is consistent with that of Edelen and Warner (2001), who investigated large institutional fund flows and determined that such flows led to significant return reversals.

Thus, the BoJ’s ETF purchases have a significant effect on daily equity prices; however, given the return reversal the following day, a long-term persistent impact on equity prices is unlikely. These results challenge the objective of the BoJ’s ETF purchases—to influence the equity risk premium.¹²

4. Theoretical and practical underpinnings of the estimated outputs

The results in Table 7 and Table 8 can be summarized in Figure 7. When the BoJ conducts expected ETF purchases, the morning session’s Topix return is deeply negative, which is why market participants can expect afternoon purchases by the BoJ. The expected purchases lead to negative Topix returns in the afternoon session and approximately zero returns in the next day’s morning session. In contrast, when the BoJ engages in unexpected purchases, the morning session’s Topix returns are higher than that of unexpected returns, which makes it difficult to correctly forecast the BoJ’s future purchases. The Topix return is positive in the afternoon session and negative in the morning session the next day. What are the possible theoretical and practical underpinnings of this phenomenon?

Table 8. OLS regression results for returns reversals Equation (5)

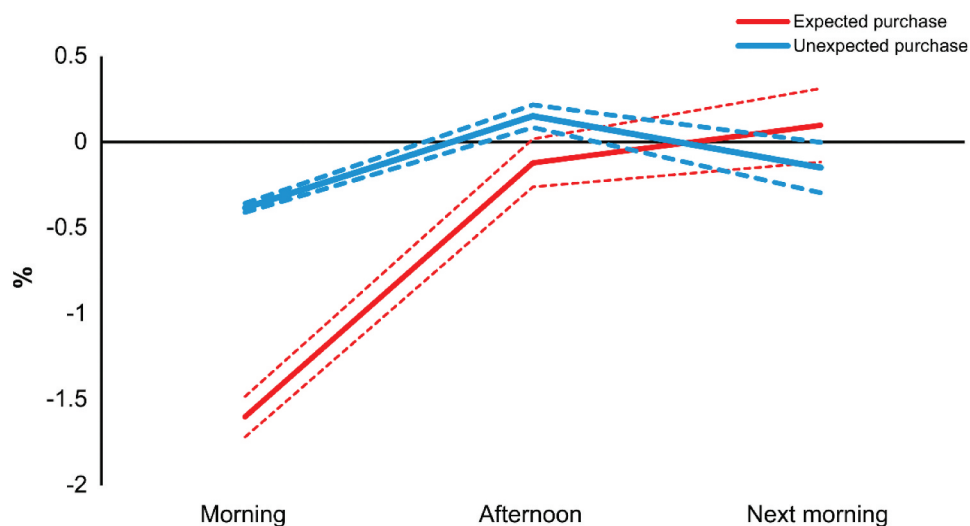
	nky_am	tpx_am
nky_pm[−1]	−0.266***	
	(0.0463)	
tpx_pm[−1]		−0.222***
		(0.0535)
fx_am	1.085***	1.023***
	(0.0524)	(0.0509)
sp[−1]	0.558***	0.545***
	(0.0458)	(0.0434)
boj_unexp[−1]	−0.00228**	−0.00244***
	(0.000897)	(0.000875)
Constant	0.0415*	0.0305
	(0.0235)	(0.0224)
N	1070	1069
R-sq	0.599	0.594
adj. R-sq	0.597	0.592
Sample period	4/4/2013–12/29/2017	4/4/2013–12/29/2017

Standard errors appear in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Note. This table reports the results of OLS regressions of equity index returns for the morning session. The dependent variable is the morning session returns for the Nikkei 225 (*nky_am*) or the Topix (*tpx_am*). “*nky_pm[−1]*” and “*tpx_pm[−1]*” are afternoon session returns for the Nikkei 225 and the Topix the previous day. “*fx_am*” is USD/JPY returns from 3:00 p.m. the previous day to 11:30 a.m. the current day. “*sp[−1]*” is S&P500 returns the previous day. “*boj_unexp[−1]*” is the unexpected ETF purchasing volume (in billions of yen) the previous day.

Figure 7. Topix returns when the BoJ purchases ETFs.

Note. The dotted lines represent 95% confidence intervals. This paper defines ETF purchases with a probability higher than 95% in the probit model, as expected, and those with a probability lower than 95%, as unexpected. When the BoJ conducts expected ETF purchases, Topix returns are negative in the afternoon session and approximately zero in the next day's morning session. In contrast, when the BoJ conducts unexpected



Warther (1995) suggested that fund flows affect asset prices via two channels—information revelation and price pressure. Applying this hypothesis to a central bank's asset-purchasing program enables information revelation to be regarded as the signaling effect (Oda & Ueda, 2007). Through its bond purchases, a central bank signals the market that it will continue to guide yields in the future to low levels, thus affecting long-term interest rates (Bernanke et al., 2004). The same thing could happen with equity ETF purchases. For example, when equity prices declined significantly in the morning session and the BoJ subsequently skipped making equity ETF purchases, some market participants began expecting a scaling back of the policy (Lewis, 2020).

That said, the BoJ announces its annual equity purchases in advance, making its daily buying activity unlikely to include information on future policies. Therefore, asset prices are affected through the price pressure channel. In fact, the occurrence of return reversals the day after an unexpected ETF purchase helps support the price pressure hypothesis. Because the BoJ announces only its annual equity purchasing volume, the pace of purchases during the year is uncertain. Therefore, the BoJ's purchases could change the expectation of market participants regarding the pace of near-future purchases. For example, market participants might expect a slower pace of purchasing going forward if the BoJ made significant purchases in the past.

Furthermore, the finding that unexpected ETF purchases have a significant impact on equity prices should be consistent with the "Limits of Arbitrage" in Gromb and Vayanos (2010) and "Slow-Moving Capital" in Duffie (2010). The BoJ's unexpected purchases can be regarded as a demand shock accompanying the uncertainty arising from the lack of prior BoJ announcements regarding the timing of its ETF purchases. If arbitrageurs (i.e., frequent investors) are unable to supply liquidity immediately in the case of a demand shock, given constraints, such as leverage regulation or capital shortages, the positive demand shock cannot be quickly absorbed, causing stock prices to increase. Meanwhile, for expected purchases, price concessions are sought in advance, causing prices to change prior to the actual purchase. Still, the argument holds that price pressures last one-half of a day at most and that price changes are not as sustainable as indicated by Duffie (2010). However, the duration is much shorter than the duration found in existing studies because equity-index-linked ETFs have high liquidity and are only one of several derivative products available on the market.

5. Conclusion

The BoJ introduced comprehensive monetary easing at its MPM on 5 October 2010, which established an asset-purchasing program to buy equity ETFs. The BoJ's equity ETF purchases are exceptional among central banks in developed nations even from a historical perspective. However, scant research exists on how this policy has affected stock markets or the real economy. This study seeks to answer the following questions: Have the BoJ's ETF purchases had a meaningful impact on equity price indices? If so, what is the mechanism underlying the impact?

First, by estimating a probit model for BoJ purchasing decisions, this paper determined that the BoJ conducts ETF purchasing operations in the afternoon sessions when equity indices decline to a certain extent during the morning session, making the operations highly predictable. This strategy is consistent with market participants' sense of practicality.

Second, expected and unexpected operations have entirely different effects on stock prices. This study found a statistically significant impact on stock prices only in the latter case. The existing literature on monetary policy has demonstrated that policy changes need an element of surprise to have a significant influence on asset prices—this study reached the same conclusion regarding the BoJ's ETF purchasing operations.

Third, this paper confirmed a reversal effect, with stock prices suffering a statistically significant decline on the morning of the day after unexpected purchasing operations occur. In other words, the BoJ's ETF purchases have only a temporary effect on stock prices. These results challenge the objective of the BoJ's ETF purchases—to influence the equity risk premium.

This paper highlights possible future research avenues on a central bank's QE program. First, distinguishing between expected and unexpected purchases is important for both equity ETF purchases as well as sovereign bond purchases. For example, the BoJ started to announce a schedule of JGB purchasing operations in March 2017, which made the timing of the purchases perfectly predictable. This predictability could change the impact of the JGB purchasing operation. Second, this paper investigated the impact of equity ETF purchases on stock prices. However, conducting an analysis of the risk premium might be more plausible as the BoJ's objective is the

equity risk premium and not stock prices. In the future, an analysis of the influence of the BoJ's equity ETF purchasing operations on the risk premium should be conducted.

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Notes

1. See <https://www.federalreserve.gov/newsevents/pressreleases/monetary20081216b.htm>.
2. See <https://www.ecb.europa.eu/press/pr/date/2012/html/pr120705.en.html>.
3. See <https://www.ecb.europa.eu/press/pressconf/2013/html/is130704.en.html>.
4. See <https://www.ecb.europa.eu/press/pr/date/2014/html/pr140605.en.html>.
5. See <https://www.ecb.europa.eu/press/pressconf/2015/html/is150305.en.html>.
6. See <https://www.ecb.europa.eu/press/pressconf/2016/html/is160602.en.html>.
7. See http://www.boj.or.jp/en/announcements/release_2001/k1010319a.html.
8. See http://www.boj.or.jp/en/announcements/release_2010/k101005.pdf.
9. See http://www.boj.or.jp/en/announcements/release_2013/k130404a.pdf.
10. See, for example, Gagnon et al. (2011), Joyce et al. (2011), Hancock and Passmore (2011), Hamilton and Wu (2012), Krishnamurthy and Vissing-Jorgensen (2012), D'Amico and King (2013), and Neely (2015).
11. The standard threshold is 50%; however, given the high predictability of my probit model, 50% tilts the sample size.
12. See http://www.boj.or.jp/en/announcements/release_2010/mok1011b.pdf.

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