Stock Effects of the Bank of Japan's Equity Holdings[1]

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Abstract

The Bank of Japan (BoJ) purchased exchange-traded funds (ETFs) tracking the Nikkei 225 index from 2010 to 2021 and still holds large amounts. Primarily because the Nikkei index is price-weighted, the BoJ's indirect stock holdings are considerably distorted in the sense that certain stocks are overrepresented relative to their market capitalization. Examining cumulative returns using cross-sectional regressions suggests that the effect of BoJ holdings is large and persistent. A 1 percentage point higher BoJ share in a stock's market capitalization is associated with a roughly 5 to 8 percentage point higher return. The skewed BoJ holdings generated annualized return differences of more than 10 percentage points among individual stocks. There is little evidence of a return reversal in the 9 months after the termination of Nikkei 225 ETF purchases. A variety of analyses, including analysis on monthly returns, support these results. The large effect is likely attributable to the semipermanent nature of the BoJ's holdings.

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1. Introduction

A large number of empirical studies has found that a change in demand for stocks affects stock prices. The literature, however, has not yet reached a consensus on the magnitude and persistence of the impact. With the aim of contributing to this literature as well as the literature on unconventional monetary policy, this paper explores a unique natural experiment, the Bank of Japan's (BoJ's) purchases of equity index exchange-traded funds (ETFs).

The BoJ made the first announcement of ETF purchases on October 5, 2010. In the announcement, it stated that it would examine establishing a program to purchase financial assets, including ETFs, as part of its unconventional monetary policy. After completing preparations, it began purchasing ETFs in December 2010 and has continued to do so for more than a decade. At the end of March 2021, the market value of its holdings stood at 51.5 trillion yen. This is more than 7% of the market capitalization of issued stocks and more than 10% of the free float market capitalization of the First Section of the Tokyo Stock Exchange (TSE), Japan's major stock market.[3]

Most ETFs held by the BoJ are benchmarked to one of the two major indexes, the Tokyo Stock Price Index (TOPIX) and the Nikkei 225 index. The TOPIX is a free-float adjusted market capitalization-weighted index representing essentially all stocks listed on the First Section of the TSE. On the other hand, the Nikkei index is basically a simple average of the price per share of only 225 stocks. Therefore, the purchases of Nikkei 225 ETFs produce variation in the amount of individual stocks indirectly held by the BoJ via ETFs relative to their market capitalization. Meanwhile, the Nikkei 225 index more than tripled from the end of September 2010, just before the first announcement of ETF purchases, to the end of March 2021. Moreover, the Nikkei index rose more steeply than the TOPIX. Against this background, there has been concern that the BoJ's ETF purchases have a large distorting impact on stock prices. To address such concern, the BoJ terminated its purchases of Nikkei 225 ETFs at the

[3] The aggregate market capitalization of all listed stocks in Japan was 808 trillion yen on March 31, 2021, according to the Flow of Funds Accounts. Meanwhile, the market capitalization of issued stocks on the First Section of the TSE on that day was 723 trillion yen (89.4% of all listed stocks in Japan).

end of March 2021. The BoJ, however, has not sold any of the ETFs it has purchased and therefore still holds a large amount of Nikkei 225 ETFs.

While central bank equity purchases are rare, many central banks have engaged in large-scale bond purchases. The literature on central bank bond purchases distinguishes between flow and stock effects. This distinction can also be applied to equity purchases. Flow effects are defined as the response of prices to ongoing purchasing operations. On the one hand, flow effects may simply reflect short-run price pressures. On the other hand, flow effects may understate the overall effect of central bank asset purchases: for instance, if, as a result of the announcement of policy changes, market prices already incorporate the expected impact of such purchases, the market response to actual purchases may be weak. Since policymakers are interested in the long-run overall effects of central bank asset purchases, the literature often focuses on stock effects, which can be defined as persistent changes in asset prices that result from changes in actual and expected central bank holdings.

To identify the stock effects of the BoJ's ETF holdings, this paper exploits the cross-sectional variation in BoJ holdings as a percentage of market capitalization. Specifically, the baseline analysis runs cross-sectional regressions of stock-level raw or abnormal returns between September 30, 2010, and March 31, 2021, on the share of BoJ holdings in the market capitalization of that stock on March 31, 2021. To address potential endogeneity, the ratio of the Nikkei 225 weight to the TOPIX weight on September 30, 2010, is used to instrument the share of BoJ holdings in the market capitalization. Key to the analysis is the use of returns from the time before the first announcement of ETF purchases to the time after the BoJ ended its purchases of Nikkei 225 ETFs. While stock prices before the end of BoJ purchases of Nikkei 225 ETFs reflected market expectations of the BoJ's future purchases of such ETFs, there are no such expectations after the BoJ terminated Nikkei 225 ETF purchases. Furthermore, in March 2021, it was very unlikely that the BoJ would start selling ETFs in the near future, in part because the consumer price inflation rate continued to be far below the BoJ's 2% target. Therefore, the method used in this paper makes it possible to identify the effect of BoJ holdings on stock returns without being seriously contaminated by the effect of expectations of future purchases and sales.

The results show that the stock effects of BoJ holdings are large and persistent. The baseline model suggests that the price multiplier is around 5, that is, a stock's return is around 5 percentage points higher for each 1 percentage point increase in the BoJ share in the free float market capitalization. The multiplier is estimated to be around 7 to 8 when BoJ holdings are normalized by the market capitalization of shares outstanding. The estimated multiplier is higher than those estimated in the majority of studies on the impact of demand shocks on stock returns. In addition, a small number of stocks benefited much more than others, and the ETF holdings by the BoJ generated annualized return differences of more than 10 percentage points across Nikkei 225 member stocks. Moreover, there is little evidence of a return reversal in the 9 months since the BoJ terminated purchases of Nikkei 225 ETFs. A variety of analyses, including Fama-Macbeth (1973) regressions based on monthly returns, support the conclusion. The large and persistent effects of BoJ holdings are likely attributable to the semipermanent nature of BoJ holdings in line with finance theory, which suggests that more persistent demand shocks have larger and more persistent effects. Another possible explanation is that the effect of the BoJ holdings on returns was amplified by the uneven impact on firms' profitability through their capital costs. However, no evidence of such an effect is found.

Literature review The literature on central bank bond purchases distinguishes between flow and stock effects (D'Amico and King 2013). A majority of papers conduct event studies to estimate stock effects (Gagnon et al., 2011; Krishnamurthy and Vissing-Jorgensen 2011; Meaning and Zhu, 2011; Swanson 2011; and Joyce et al. 2012, among others). However, event studies may fail to capture the true effect, for example, if the announcements by the central bank are unclear, if market participants take time to digest the announcements, or if market participants expected the policy changes prior to the event windows.[4] To address this sort of critique, in particular with regard to timing, D'Amico and King (2013) employ cross-sectional regressions of security-level cumulative returns to estimate the stock effects of Treasury purchases by the Federal Reserve. This paper applies their method to the BoJ's ETF purchases.

[4] For critics and discussions of event studies, see Wright (2011), D'Amico and King (2013), Bernanke (2020), and Haddad et al. (2023).

Many studies on the BoJ's ETF purchases investigate the flow effects and find that the BoJ purchases have had a positive impact on stock prices (Matsuki et al., 2015; Shirota, 2018; Harada and Okimoto, 2021; Charoenwong et al., 2021; Fukuda and Tanaka, 2022; Fukui et al., 2022; Hattori and Yoshida 2023; among others). Some of these studies also support the widely held view that the BoJ has tended to purchase ETFs in the afternoon when stock prices fell sharply in the morning (Shirota 2018; Hattori and Yoshida 2023). On the other hand, only a few papers examine the stock effects of the BoJ's ETF purchases. Barbon and Gianinazzi (2019) conduct an event study, focusing on BoJ announcements in October 2014 and July 2016. Katagiri et al.'s (2022a) event study examines the effect of the March 2021 Monetary Policy Meeting (MPM). Studies that focus on limited events, however, cannot capture a large part of the effect of the ETF purchase policy, since the BoJ announced adjustments to its ETF purchases policy many times. Even covering all policy announcements is not necessarily promising, in part because the BoJ's announcements often did not contain sufficient information for market participants to accurately predict the future path of BoJ holdings, as will be outlined in Section 2. A unique approach is employed by Katagiri et al. (2022b), who find that capital asset pricing model (CAPM) beta has declined due to the countercyclical nature of purchases. They go on to argue that this decline in beta led to a decline in risk premia if the CAPM holds.

To identify the stock effects, the analysis employed in this paper exploits the fact that the BoJ's holdings are distorted in the sense that they do not fully reflect the market capitalization of firms but rather the weights of the Nikkei 225 index. The use of the resulting uneven demand shocks for individual shares for identification is not in itself new. For instance, Charoenwong et al. (2021) and Barbon and Gianinazzi (2019) take advantage of the skewed BoJ purchases to identify flow and stock effects, respectively. Similarly, Greenwood (2005, 2008) exploits the skewed weighting system of the Nikkei 225 index, for example, to identify the impact of a redefinition of the Nikkei index in April 2000.

Many studies, such as Shleifer (1986), Harris and Gurel (1986), and Wurgler and Zhuravskaya (2002), examine the impact of demand shocks on stock returns or estimate the price multiplier, mainly using U.S. data. Gabaix and Koijen (2022) survey the literature and

suggest that although there is a range of estimates, a typical price multiplier is about 1.[5] Several studies report higher multipliers, ranging between 2 and 5 (Chang et al. 2015; Greenwood et al. 2022). The multiplier obtained in this study, which is around 7 to 8 when, following many studies on U.S. data, the demand shock is normalized by the market capitalization of shares outstanding, is even higher than these previous estimates. To the best of the author's knowledge, only Barbon and Gianinazzi (2019) estimate the price multiplier of the stock effects of the BoJ's ETF purchases. The estimate, here again, is much higher than theirs of around 1. This comparison suggests that it may be difficult to capture the stock effects of the BoJ's policy using event studies.

Finally, Charoenwong et al. (2021) investigate the effects of the BoJ's ongoing purchases on firm behavior. They find, for instance, that, on average, firms' total assets increased as a result of increases in cash and short-term securities rather than capital investment, but in the case of firms with weak corporate governance, it was investment that increased. The current paper examines the effects of the BoJ's holdings, rather than purchases, on firm profitability, which is an important determinant of stock returns.

Outline The rest of this paper is organized as follows. Section 2 provides an overview of the BoJ's ETF purchases. Section 3 estimates BoJ holdings of individual stocks. Section 4 explains the baseline regression model. Section 5 presents the baseline result. Section 6 shows alternative regression results and discusses various issues, including the persistence of the effect of BoJ holdings. Section 7 concludes this paper. The online appendix contains details, discussions on other issues, and a number of robustness checks.

2. Background

The BoJ made the first announcement of ETF purchases on October 5, 2010. This announcement took market participants by surprise, in part because it is extremely unusual for

[5] As discussed by Gabaix and Koijen (2022), there are different concepts of the price multiplier. The current paper focuses on the micro multiplier, which is defined as the percentage change in the stock price when investors purchase a certain fraction of the market capitalization of a particular firm, while controlling for movements in the aggregate market.

central banks to purchase stocks – even indirectly through investment funds – to stimulate the economy. After completing preparations, the BoJ began purchasing ETFs in December 2010. Since then, the BoJ has adjusted its ETF purchase policy many times. The key announcements are summarized in Table A1 in the online appendix. The following is a brief overview.

The ETF purchases started as a temporary measure that was supposed to be terminated by around the end of 2011, with a maximum outstanding amount of ETFs of only around 0.45 trillion yen. The BoJ, however, has repeatedly increased the maximum amount and extended the termination date. In April 2013, before the completion of the previously announced policy and shortly after Governor Kuroda took office, the BoJ moved to open-ended purchases at an annual pace of increase in the amount outstanding of 1 trillion yen with the introduction of a new policy package called quantitative and qualitative easing (QQE). The BoJ subsequently increased the pace of purchases several times. Figure 1 shows the 4-quarter moving sums of flows from the BoJ into investment funds, which represent the BoJ's purchases of ETFs, and flows from investment funds into listed stocks. The figure shows that the BoJ accelerated the pace of ETF purchases until 2016 and then continued purchasing ETFs in the range of around 5 to 7 trillion yen per year, with its target of about 6 trillion yen at an annual pace of increase in the amount outstanding. In March 2021, however, it announced that, from April, it would purchase ETFs as necessary and eliminate the 6-trillion-yen target. As a result, it purchased only 0.28 trillion yen from April to December 2021. Figure 1 also indicates that the flows from the BoJ into investment funds largely match those from investment funds into listed stocks, although short-term deviations can often be observed. In fact, the total flows from 2010 to 2021 are very close (37.0 trillion yen and 36.2 trillion yen, respectively). This suggests that the BoJ has been the dominant end investor in equity funds, and other end investors trade on a relatively short-term basis.

As mentioned, the BoJ's announcements often did not provide sufficient information for market participants to accurately predict BoJ holdings. Therefore, market participants had to update their expectations of the future path of BoJ holdings, for instance by observing ongoing purchases. In particular after the purchase program became open-ended in 2013, it became more difficult to predict BoJ holdings. Further, how difficult it is to predict BoJ holdings is illustrated by the following example. In 2017, observing that the pace of BoJ purchases appeared to be slow relative to its target of about 6 trillion yen per year, many

discussed the possibility that the BoJ would increase the pace of purchases to meet the target by the end of the year. From the BoJ's perspective, this represented a misunderstanding of its policy, and Governor Kuroda was forced to clarify at his press conference on October 30, 2017, that the BoJ was not aiming to increase the amount outstanding by exactly 6 trillion yen of ETFs by the end of the year.

The BoJ initially purchased only ETFs that track the TOPIX or the Nikkei 225. In 2014, it added ETFs that track the JPX-Nikkei 400 index, a newly established index. Meanwhile, until September 2016, the BoJ allocated ETF purchases roughly in proportion to the total market value of individual ETFs. Since then, the BoJ has revised the ETF purchase program several times to increase the allocation weight to TOPIX ETFs, amid criticism that the purchases of Nikkei 225 ETFs distort the market. For instance, from October 2016 to early August 2018, while half of its investment was allocated to ETFs linked to any of the three indexes as before, most of the remaining investment was allocated to TOPIX ETFs only. From May 2020 to March 2021, as the BoJ became the dominant investor in the ETF market, it allocated about 25% of its investment to ETFs tracking either of the three indexes, taking the amount outstanding in circulation (i.e., the market value excluding BoJ holdings) into account, while about 75% was allocated to investment in TOPIX ETFs only. Moreover, in March 2021, the BoJ decided to purchase TOPIX ETFs only from April onward.

Meanwhile, in 2016, the BoJ additionally established a supplementary ETF purchase program to support firms proactively investing in physical and human capital. Under this program, the BoJ purchases eligible ETFs that track indexes composing such firms. However, the size of purchases has been only 0.3 trillion a year. Moreover, the BoJ has held less than 0.15 trillion yen of these ETFs and allocated most of the funds from the supplementary program to JPX-Nikkei 400 ETFs instead, in accordance with the special rules of the program (Samikawa and Nakano 2021). The reason is that there were very few ETFs meeting the criteria set by the BoJ, and furthermore, under the special rules, the BOJ can only purchase up to half of the total market value of such ETFs. In March 2021, the BoJ decided that from April it would not purchase JPX-Nikkei 400 ETFs under this program. This decision in effect has spelled the termination of the supplementary program.

The BoJ has also directly traded listed stocks under a different program. Specifically, from November 2002 to September 2004 and from February 2009 to April 2010, the BoJ, with the aim of promoting financial stability, purchased stocks from commercial banks to encourage them to reduce stock holdings. The BoJ has been exiting from these stock holdings by selling these stocks on stock exchanges very slowly so as not to significantly affect stock prices. Partly because no information about the composition of these direct trades is available, examining their impact is beyond the scope of this study. Given that total net sales from 2010 to 2021 were only 1.9 trillion yen, however, the direct trades likely had only a limited impact on stock prices during this period.

3. The BoJ's Indirect Stock Holdings

This section estimates the amount of individual stocks indirectly held by the BoJ. While the estimation method is essentially the same as that in previous studies, the approach differs in several respects, in part because the focus here is on the BoJ's holdings rather than its purchases. A list of the data used in this paper is provided in Table A2.

The estimation is carried out in three steps. In the first step, the BoJ's daily purchases of each ETF are estimated. The BoJ has published daily data on total ETF purchases for the main and the supplementary program. Using these data, the amount of daily purchases of each ETF is estimated based on several assumptions. For instance, when the BoJ purchased ETFs roughly in proportion to their total market value, it is assumed that the BoJ made purchases exactly in proportion to the ETFs' market value on the previous day. As for the supplementary program, it is assumed that the BoJ allocated all funds for the program to JPX-Nikkei 400 ETFs, since the allocation to ETFs tracking indexes consisting of firms that proactively invest in physical and human capital was limited, as mentioned in Section 2. In the second step, the BoJ's holdings of each ETF are estimated essentially by cumulating returns and flows.[6] Finally, in the third step, the BoJ's indirect holdings of individual stocks are estimated as follows using the index weights of individual stocks:

[6] For more details on the first two steps, see Appendix A.

$$BoJ_{n,t} = BoJ_t^{TPX} \cdot w_{n,t}^{TPX} + BoJ_t^{N225} \cdot w_{n,t}^{N225} + BoJ_t^{JN400} \cdot w_{n,t}^{JN400} \quad (1)$$

where $BoJ_{n,t}$ is the BoJ's holdings of stock n on day t. BoJ_t^{TPX}, BoJ_t^{N225}, and BoJ_t^{JN400} are the BoJ's holdings of ETFs that track the TOPIX, the Nikkei 225, and the JPX-Nikkei 400, respectively. These are calculated by aggregating the BoJ's holdings of individual ETFs estimated in the second step. w_n^{TPX} is the weight of stock n in the TOPIX, etc.

Figure 2 shows the estimates of BoJ holdings by index. The figure indicates that the BoJ's exposures to the TOPIX, the Nikkei 225, and the JPX-Nikkei 400 on March 31, 2021, were around 32 trillion yen, 17 trillion yen, and 3 trillion yen, respectively. The exposures have remained more or less flat since then, reflecting the limited BoJ purchases under the newly adjusted programs.

Due to data availability, the analysis in the remainder of this paper focuses on stocks listed on the First Section of the TSE. While the BoJ indirectly holds several stocks that are not in the First Section of the TSE, mainly because the JPX-Nikkei 400 includes these stocks, the amount of such holdings is very limited. For instance, on March 31, 2021, the BoJ held 51.5 trillion yen of ETFs in total, but holdings of stocks outside the First Section accounted for only 637 million yen of this.

Table 1 presents a list of the top 10 firms in terms of the ratio of the estimated BoJ holdings to the free float market capitalization on March 31, 2021. The free float market capitalization is calculated by multiplying the number of floating shares and the stock price. This free float market capitalization is essentially proportional to the TOPIX weight. This is because here the TSE-defined free float is employed, which is used to determine the TOPIX weights. As can be seen in column (1), the ratio is greater than 100% for Fast Retailing. This is likely because the TSE excludes the BoJ holdings from its definition of free float, as will be discussed in the next section. Meanwhile, Column (2) shows the ratio of a share's weight in the Nikkei 225 index to the weight in the TOPIX. For example, the weight of Fast Retailing in the Nikkei 225 (of more than 10% as of March 31, 2021) is 25.1 times greater than that in the TOPIX (0.43%). Looking at columns (1) and (2) together, a clear pattern emerges: the higher the ratio of BoJ holdings to the free float market capitalization, the higher the ratio of the Nikkei 225 weight to the TOPIX weight tends to be. Meanwhile, column (3) indicates that the

BoJ held 1.96 trillion yen of Fast Retailing shares, which was the second largest holding after SoftBank Group Corp. However, although the BoJ held 2.07 trillion yen of SoftBank Group shares, the firm is not listed in Table 1 since its free float market capitalization was much larger than that of Fast Retailing.

Figure 3 shows the contributions of the three indexes to the BoJ holdings-to-free float market capitalization ratio for firms ranked 11th through 500th. The horizontal axis represents the ranking. The figure only shows firms up to the 500th rank since no difference can be seen after the 447th rank. The decomposition results of the BoJ holdings-to-market capitalization ratio are based on the following equation, which is obtained using equation (1):

$$\frac{BoJ_{n,t}}{MC_{n,t}} = \frac{BoJ_t^{TPX} \cdot w_{n,t}^{TPX}}{MC_{n,t}} + \frac{BoJ_t^{N225} \cdot w_{n,t}^{N225}}{MC_{n,t}} + \frac{BoJ_t^{JN400} \cdot w_{n,t}^{JN400}}{MC_{n,t}} \quad (2)$$

where $MC_{n,t}$ is the free float market capitalization of stock n on day t, and Figure 3 shows the three terms on the right side of this equation. The figure clearly shows that the term for the Nikkei 225 index plays the dominant role in the variation of the ratio. On the other hand, since the TOPIX is a free-float adjusted weighted index, the contribution of the TOPIX to the BoJ holdings-to-free float market capitalization ratio is essentially flat across stocks. Inclusion in the JPX-Nikkei 400 somewhat increases the ratio for most firms up to the 447th rank. It plays a limited role in the variation, however, since the BoJ held only around 3 trillion yen of JPX-Nikkei 400 ETFs and weights in the JPX-Nikkei 400 index are essentially based on the free float, as in the TOPIX.

4. Baseline Regression Model

The regression model used in this paper is inspired by D'Amico and King (2013), who estimate the flow and stock effects of the Federal Reserve's Treasury purchases in 2009 using security-level data. To estimate the stock effects, they run a cross-sectional regression of cumulative total returns on Treasury securities between March 17 and October 30, 2009 (the day before the first announcement of the purchase program and the last day of purchases) on the amount of securities that was purchased by the Federal Reserve over the life of the program relative to

the amount outstanding. The key idea of their identification strategy is the use of the returns to the last day of purchases. Prior to the end of the program, it was uncertain which securities the Fed would purchase, so that security prices reflected market expectations about the Fed's future purchases. Expectations with regard to additional purchases do not matter, however, after the conclusion of the purchase program. Therefore, this method allows to identify the stock effect without any potential contamination by expectations with regard to future purchases.

In this paper, the cumulative returns of individual stocks between September 30, 2010, and March 31, 2021, are used. The former date is a few business days before the BoJ's first announcement of ETF purchases on October 5, 2010. One reason for selecting these dates is the superior availability of data at the end of a quarter. Meanwhile, March 31, 2021, is selected as this is the date on which the BoJ terminated its purchases of Nikkei 225 and JPX-Nikkei 400 ETFs and market participants did not expect additional purchases of these ETFs thereafter. Although the BoJ has continued to purchase TOPIX ETFs, the purchases of TOPIX ETFs are not expected to have a serious distorting impact on returns since the TOPIX weights are essentially proportional to the free float market capitalization weights. In addition, the BoJ decided to purchase ETFs as necessary from April 2021 and in fact dramatically reduced its purchases of ETFs, including those tracking the TOPIX, as mentioned earlier. Furthermore, on March 31, 2021, the BoJ was very unlikely to start selling ETFs in the near future, because the consumer price inflation rate continued to be far below its target of 2%, it was still purchasing a reduced amount of TOPIX ETFs, and it argued that it was not yet at the stage of considering the timing of the exit from monetary easing or the strategy to do so.[7] Even if it started selling ETFs, the pace of sales would be very slow so as not to have a significant impact on stock prices, as was the case with stocks purchased from commercial banks. All of these factors suggest that the degree of distortion in BoJ holdings was expected to remain essentially unchanged for a long time after March 2021.

[7] On March 23, 2021, Governor Kuroda stated in the House of Councillors: "[S]ince it is expected to take some time to achieve the 2% price stability target, the Bank does not intend to stop purchasing ETFs or dispose of ETFs for the time being. [...] I do not believe that we are at the stage of considering the timing of the exit from monetary easing, including the current ETF purchases, or the specific measures to be taken at that time." The original quote in Japanese is available here: https://kokkai.ndl.go.jp/#/detail?minId=120415261X01620210325&current=1.

Another consideration in the date selection is market stress. Since central bank asset purchases are likely to have a particularly large impact at times of market stress, choosing such dates may seriously affect the estimation results. In fact, D'Amico and King (2013) warn that their results may not be extrapolated to periods of relatively low market stress since the Federal Reserve's Treasury purchases were announced and implemented in the immediate aftermath of the financial crisis. The results in this study are unlikely to suffer from this problem, since the BoJ began purchasing ETFs in an effort to achieve price stability rather than financial stability. In fact, stock market volatility, a widely used indicator of stress, was not particularly high on these dates, as shown in Figure A1 in the Online Appendix.

Let us now turn to the baseline regression model, which takes the following form:

$$R_n = \gamma q_n + \rho' Z_n + \epsilon_n \tag{3}$$

where R_n is the raw or abnormal log excess total return between September 30, 2010, and March 31, 2021, on stock n, q_n represents the BoJ's holdings of that stock as a ratio to the market capitalization as of March 31, 2021, and Z_n is a vector of control variables. Excess returns are calculated using the uncollateralized overnight call rate, which is a major interbank rate and was used as the policy rate before the introduction of QQE. Since the BoJ on September 30, 2010, was not expected to purchase ETFs, q_n represents a demand shock during the period between September 30, 2010, and March 31, 2021.

Abnormal returns are computed using factor models that regress the monthly log excess total return on a constant and various factors. Specifically, different combinations of Fama and French's (2015) five factors, i.e., the market, small minus big (SMB), high minus low (HML), robust minus weak (RMW), and conservative minus aggressive (CMA), and Carhart's (1997) momentum factor (MOM) are used. The factor returns are obtained from Kenneth French's website.[8] They are converted to continuously compounded returns and from dollar into yen. Models with 1, 3, 4, 5, or 6 factors are employed. The 1-factor model is the capital asset pricing

[8] See "Fama/French Japanese 5 Factors" here:
https://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html.

model (CAPM), which includes the market factor. The 3-factor model is Fama and French's (1993) 3-factor model, which includes the market, SMB, and HML. The 4-factor model adds MOM to the 3-factor model. The 5-factor model adds RMW and CMA to the 3-factor model. The 6-factor model adds MOM to the 5-factor model. The factor models are estimated using data for the 126 months from October 2010 to March 2021. Cumulative abnormal returns are calculated by multiplying alpha by 126. Regressions are run for individual stocks rather than portfolios. The reason is that, as shown analytically and empirically by Ang et al. (2020), using portfolios is inefficient when testing asset pricing models using cross-sectional data. The inefficiency arises also in the analysis in this paper, which exploits cross-sectional dispersion to test whether the BoJ holding ratio can explain returns. However, to check the robustness of the results, Appendix D examines returns of portfolios and arrives at results that support those of the baseline estimation.

In the literature on the impact of demand shocks on stock prices, demand shocks are usually normalized using a measure of the supply of stocks. Studies using U.S. data typically employ the market capitalization of shares outstanding (i.e., shares issued minus treasury stocks) as the measure of supply. In contrast, the analysis here uses the free float market capitalization for two reasons. The first reason is data availability. Daily data on the free float market capitalization of a stock are easily obtainable if the stock is included in the TOPIX. On the other hand, no daily data of shares outstanding are publicly available. That said, annual data on treasury stocks are available in firms' annual accounting reports, and these data are used in Section 6.1 to estimate shares outstanding and check the robustness of the baseline analysis. The second reason is that the free float may better represent the supply of stocks than shares outstanding. In fact, this is the reason why many stock indexes, including the TOPIX and the S&P 500 index, adopted float adjusted weightings around 2005. The U.S. literature, which has a long history, uses shares outstanding at least in part because free float data were not readily available. In fact, Wurgler and Zhuravskaya (2002) state that the reason they do not use the free float is that they are not aware of an electronic source for insider holdings.

However, it is necessary to be careful when using the TSE-defined free float. Harada (2021) argues that although the TSE does not disclose whether it excludes BoJ holdings from the free float, it appears to do so. See Appendix B for further considerations and evidence to support her argument. Based on this evidence, the ratio of BoJ holdings to the sum of BoJ

holdings and the free float market capitalization is used in the baseline regression. For convenience, this ratio is called the BoJ holding ratio hereafter.

The baseline regression focuses on stocks that were listed in the First Section of the TSE and for which price observations were available for all business days from September 30, 2005, to March 31, 2021.[9] Data for the period before September 30, 2010, are used to calculate the control variables. In addition, since free float data are available only for TOPIX members, the analysis is restricted to stocks that were members as of March 31, 2021. Further, one stock is excluded since data for the control variables are not available. This leaves a total of 1,241 stocks that are included in the sample. The sample covers 88.5% of the weight of the TOPIX and 94.3% of the weight of the Nikkei 225 index as of September 30, 2010, and 85.2% of the weight of the TOPIX and 91.8% of the weight of the Nikkei index as of March 31, 2021.

Figure 4 plots the raw log excess total returns of individual stocks against the BoJ holdings ratio. The black circles represent stocks that were included in the Nikkei index on March 31, 2021, while the grey circles represent those that were not. When focusing on the Nikkei index members, there appears to be a clear positive relationship, which suggests that a higher BoJ holding ratio is associated with a higher return. Meanwhile, there is one notable outlier toward the right of the figure. This is Fast Retailing, whose BoJ holding ratio is more than 50%, in line with the BoJ holdings to free float ratio of 104.8% in Table 1. In the regression analysis, outliers such as this one are winsorized, as explained later. Next, looking at non-Nikkei 225 index members, all circles essentially fall on two vertical lines that are close to each other at BoJ holding ratios of around 6.9% and 7.6%. While stocks that are not included in the JPX-Nikkei 400 index are on the left line, most stocks that are included are on the right line. Since the variation in the BoJ holding ratio is small for non-Nikkei 225 members, no clear link between returns and the BoJ holding ratio can be observed.

Throughout this paper, regression results are shown for both the full sample and the subsample of Nikkei 225 members. The reason is that the behavior of Nikkei 225 members and non-members may be different. For example, Nikkei 225 members may be overvalued and generate low ex-post returns because they receive more attention from investors than non-

[9] Since price observations are not available for October 1, 2020, due to the failure of the TSE's equity trading system, this paper treats this day as a holiday.

Nikkei 225 stocks. The subsample regression focuses on stocks that were members of the Nikkei index on September 30, 2010, instead of March 31, 2021, to address potential causality from returns to the selection of stocks included in the Nikkei index. The subsample consists of 191 firms, of which 183 were also in the Nikkei index on March 31, 2021. Although the number of stocks is much smaller than that in the full sample, the subsample covers more than a half of the weight of the TOPIX since Nikkei members tend to be relatively large. Specifically, the sample covers 63.2% of the weight of the TOPIX and 94.2% of the weight of the Nikkei 225 index as of September 30, 2010, and 55.1% of the weight of the TOPIX and 86.5% of the weight of the Nikkei index as of March 31, 2021.

For the estimation, two-stage least squares with an instrumental variable is used. D'Amico and King (2013) also use two-stage least squares to address potential endogeneity that can occur if the Federal Reserve deliberately purchased securities that were underpriced. Since the BoJ purchases stocks indirectly through ETFs and follows preannounced rules in selecting the ETFs it purchases, there is little leeway for the BoJ to favor specific stocks. However, endogeneity may still be present if, for example, better firm fundamentals lead to both a higher return and a higher probability that the stock will be added to or remain in the Nikkei index, resulting in larger BoJ holdings. On the other hand, since the BoJ's target amount of purchases is flexible to some extent and the BoJ has tended to purchase ETFs when stock prices fall, causality can to some extent run from returns to BoJ holdings. To address such potential endogeneity, the ratio of the Nikkei 225 weight to the TOPIX weight of a stock on September 30, 2010, is used to instrument the BoJ holding ratio. This instrument is chosen mainly because Table 1 and Figure 3 suggest that there is a high correlation between the ratio of the weight of a stock in the Nikkei 225 index to that in the TOPIX – the "index weight ratio" – and the BoJ holding ratio on March 31, 2021. Since the index weight ratio is highly persistent, the ratio on September 30, 2010, is also highly correlated with the BoJ holding ratio more than 10 years ahead, as will be shown later. Note that this instrumental variable regression assumes that the index weight ratio affects returns only through BoJ holdings. One concern is that stocks with high Nikkei 225 weights may have been overvalued on September 30, 2010, possibly due to demand from index traders. In this case, such stocks may have yielded lower returns during the period of interest between the end of September 2010 and the end of March 2021. If this is

the case, the assumption does not hold, and the regression underestimates the effect of BoJ holdings. This issue will be discussed in Section 6.3.

The instrumental variable regression essentially tests whether the Nikkei 225 weight-to-TOPIX weight ratio contains information on future long-term returns beyond the control variables. As controls, a constant and at least six variables are used: beta, firm size, the book-to-market ratio, profitability, asset growth, and lagged returns. The first five variables are the firm characteristics of interest in Fama and French's (2015) 5-factor model. The lagged returns are used to control for mean reversion rather than for momentum, since mean reversion is often observed for long-term returns in the literature (e.g., Bondt and Thaler 1985). The full-sample regression also includes a dummy variable for Nikkei 225 members on September 30, 2010, to control for possible differences in the behavior of Nikkei 225 members and non-members.

All control variables are calculated using data up to September 30, 2010, to avoid potential endogeneity. Following Frazzini and Pedersen (2014), beta is estimated by calculating the volatilities of stock and market excess returns and the correlation between them separately, using daily returns for 1 year and overlapping 3-day returns for 5 years, respectively, to September 30, 2010. Market excess returns are calculated from the TSE First Section Total Return Index. Firm size is measured in terms of the log of the market capitalization of shares outstanding on September 30, 2010. The book-to-market ratio is also logged. Profitability is measured in terms of the return on equity (ROE, i.e., firms' current earnings-to-book equity). While Fama and French (2015) use operating profits, here current earnings are used following Kubota and Takehara (2018), who argue that current earnings are widely used by financial analysts in Japan. The book-to-market ratio, profitability, and asset growth are calculated from the latest annual accounting data up to March 2010. Note that in Japan the financial year of firms typically ends in March. In fact, 1,023 out of the 1,241 firms in the sample closed their books for financial year 2009 in March 2010. Following Fama and French (1993), a gap of at least 6 months is left between the end of the accounting period and the return to ensure that the accounting variables are known before the return. Firm size is also calculated using the annual accounting data. Specifically, first the ratio of treasury stocks to issued stocks is calculated using accounting data. Next, one minus this ratio is multiplied by the market value of issued stocks on September 30, 2010, to estimate shares outstanding. This means that it is implicitly assumed that the latest treasury stocks-to-issued stocks ratio up to March 2010 is a good

approximation of the ratio on September 30, 2010. The lagged returns are the 3-year returns up to the end of August 2010.

In sum, in the first stage of the two-stage least squares regression, the BoJ holding ratio on March 31, 2021, is regressed on the instrument (the Nikkei 225 weight-to-TOPIX weight ratio) and the controls. All independent variables are calculated using data for September 30, 2010, or earlier. In the second stage, the return between September 30, 2010, and March 31, 2021, is regressed on the fitted value of the BoJ holding ratio and the controls. To address outliers, all variables, including the instrument, are winsorized at the 1 and 99% levels. See Table 2 for summary statistics for winsorized variables that are used in the baseline regression. Moreover, standard errors are clustered at the industry level, since the residuals in the same industry likely move together, in particular after controlling for firm size, the book-to-market ratio, and other characteristics. Thirty-three industry classifications are used following the definition of the TSE. Although it is rare, firms' industry classification can change. To address this issue, the classification as of September 30, 2010, is used.

Finally, it is worth noting potential estimation biases. One concern is that stocks with a high Nikkei 225 weight may have been overvalued on September 30, 2010, which could lead to underestimation of the effect of BoJ holdings, as mentioned above and will be further discussed in Section 6.3. On the other hand, if investors other than the BoJ increased their exposure to the Nikkei 225 index during this period, the regression may overstate the impact of BoJ holdings. To investigate this possibility, Appendix E examines the behavior of other investors and finds that the baseline regression results are unlikely to be seriously biased for such reason.

5. Baseline Results

This section presents the baseline results. Columns (1) and (2) of Table 3 report the results of the first-stage regressions for the full sample and the Nikkei-225-member subsample, respectively. The coefficient on the index weight ratio (the Nikkei 225 weight-to-TOPIX weight ratio) is significantly positive for both samples. The t-statistics are 12.4 and 20.9, respectively. For both samples, the R-squared is slightly less than 0.8, which is high, particularly when taking into account that a more-than-10-years-ahead variable is predicted.

Overall, the results show that the index weight ratio is very useful in predicting the BoJ holding ratio. Several coefficients on the control variables are also significantly different from zero. In particular, the coefficient on firm size is significantly positive for both samples. This is likely because firm size is a good predictor of whether a stock will remain in or be added to the Nikkei 225 index in the future. In fact, the average size of firms that were included in the index on September 30, 2010, but not on March 31, 2021, is smaller than that of firms that remained in the index and of firms that were newly added.

The second-stage regression results suggest that BoJ holdings have a significant impact on returns. The full-sample result for the raw return is reported in column (1) of Table 4, while the results for the abnormal returns are reported in columns (2) to (6). As can be seen, the coefficients on the BoJ holding ratio are positive and significant, with a *t*-statistic of at least 3. The size of the coefficients is around 5, which suggests that a 1 percentage point higher share of BoJ holdings in the free float market capitalization of a stock is associated with around 5 percentage point higher returns. In other words, the price multiplier is around 5. Table 5 reports the results for the subsample of Nikkei 225 members and shows that the coefficients on the BoJ holding ratio are again around 5, and the *t*-statistics are larger than in Table 4. The estimated size of the impact of BoJ holdings compared to estimates of the impact of demand shocks on returns in other studies, which often normalize demand shocks by the market capitalization of shares outstanding instead of the free float, is discussed in Section 6.1.

Let us briefly look at the coefficients on the control variables in the second-stage regressions. Although many coefficients are insignificant, as one would expect given the difficulty of predicting long-term returns, some coefficients in the full-sample regression are significant and have a high *t*-statistic. Moreover, the signs of the significant coefficients are all in line with what one would expect. The coefficient on beta is negative but insignificant for the raw return, while it is negative and significant for the abnormal returns. The former result is somewhat consistent with Black et al. (1972), Fama and French (1992), Baker et al. (2011), and Frazzini and Pedersen (2014), who find that the CAPM beta estimated from time-series regressions has a weak or even negative cross-sectional correlation with stock returns, contrary to the prediction of the CAPM. The negative and significant coefficient on the beta for abnormal returns is also inconsistent with the CAPM, which predicts no correlation between beta and abnormal returns, but consistent with Frazzini and Pedersen (2014), who theoretically

and empirically show that a high beta is associated with a low alpha. The positive coefficient on profitability and the negative coefficient on asset growth are consistent with the results by Novy-Marx (2013) and Titman et al. (2004), respectively, which motivate Fama and French's (2015) 5-factor model.

Next, the impact of BoJ holdings on relative returns is examined. The cross-sectional regression in this paper fails to capture part of the policy effect by which returns on all stocks change in parallel, since this effect is absorbed by the constant term. However, it is still possible to examine the relative impact of the BoJ's holdings on returns. Note that the abnormal returns regressions also do not capture the impact of the BoJ's holdings through the factors; that said, this impact appears to play a limited role in the analysis here since the multiplier estimated using the raw return is close to the multipliers estimated using the abnormal returns.

The analysis here focuses on 211 stocks that were Nikkei 225 members as of March 31, 2021, that were listed on the First Section of the TSE throughout the entire period from September 30, 2010, to March 31, 2021, and for which price observations are available for all business days during this period. In this sample, the first percentile, the median, and the 99th percentile of the BoJ holding ratio are 7.5%, 11.2%, and 29.8%, respectively. These figures imply that the distribution of the BoJ holding ratio is skewed toward higher values. Since the baseline analysis suggests that the price multiplier is around 5, the impact on the relative return can be approximated by multiplying the difference in the BoJ holding ratio between two stocks by 5. Multiplying the difference between the 1st and 99th percentiles by 5 gives 111.4 percentage points, which can be interpreted as the difference in log cumulative returns that is generated by the BoJ's ETF holdings. Since this is the 10.5-year return difference, the annualized difference is 10.6 percentage points. Relative to the median stock, the annualized difference is 8.9 percentage points for the 99th percentile and -1.7 percentage points for the first percentile. This result suggests that a small number of stocks benefited much more from BoJ holdings than others.

6. Discussion

This section discusses several issues related to the results obtained in the previous section. To this end, a variety of regressions, many of which are modifications of the baseline, are

estimated. As such, these regressions, in addition to the analyses presented in the Appendix, also serve to check the robustness of the baseline results. Specifically, in Section 6.1, BoJ holdings are normalized using the market capitalization of shares outstanding instead of the free float in order to evaluate the magnitude of the price multiplier in comparison with those in the literature using U.S. data. Section 6.2 investigates the persistence of the effect of BoJ holdings by examining returns after the BoJ terminated its purchases of Nikkei 225 ETFs on March 31, 2021. Section 6.3 investigates whether the index weight ratio contained information to predict long-term returns only after the first announcement of the BoJ's ETF purchases. Section 6.4 explores the impact of BoJ holdings on firms' profitability.

6.1. Normalizing BoJ holdings using shares outstanding

The previous section suggests that a 1 percentage point higher share of BoJ holdings in the free float market capitalization of a stock was associated with a roughly 5 percentage point higher return. This subsection assesses the magnitude of this effect by comparing it with the estimates of preceding studies. Many studies using U.S. data employ the market capitalization of shares outstanding instead of the free float to normalize demand shocks. Therefore, to make the result in this paper comparable to those in the U.S. studies, BoJ holdings here are normalized by the estimated market capitalization of shares outstanding. Similar to the firm size variable used in the baseline regression, the market capitalization of shares outstanding on March 31, 2021, is estimated by multiplying one minus the latest ratio of treasury stocks to issued stocks up to March 2021 by the market capitalization of issued stocks as of March 31, 2021. This means it is implicitly assumed that the latest treasury stocks-to-issued stocks ratio up to March 2021 is a good approximation of the ratio on March 31, 2021. This assumption makes sense particularly because for most firms in Japan financial year 2020 ended in March 2021.

Recall that in the baseline regressions, the Nikkei 225 weight-to-TOPIX weight ratio on September 30, 2010, was used as the instrumental variable. This ratio is essentially proportional to the ratio of the Nikkei 225 weight to the free float market capitalization since the TOPIX weights are determined based on the free float market capitalization. On the other hand, in line with the alternative normalization of BoJ holdings, here the ratio of the Nikkei

225 weight to the market capitalization of shares outstanding on September 30, 2010, is used as the instrumental variable.

Table 6 presents the results of the regressions for 12 combinations of the 6 types of returns (raw and abnormal returns) and two different samples (the full sample and the Nikkei 225-member subsample) used in the baseline analysis. To save space, the table only shows the coefficient estimates for normalized BoJ holdings and the corresponding t-statistics, since the other coefficients remain essentially unchanged from the baseline results. Panel A shows the results when BoJ holdings are normalized by the market capitalization of shares outstanding. As in the baseline results, the coefficient on normalized BoJ holdings is significantly positive in all 12 cases. The t-statistic is at least around 3, although slightly lower than in the baseline. The estimated value of the coefficient is around 7 to 8, which is larger than in the baseline regressions reported in Tables 4 and 5. This is not surprising. Given that the TSE-defined free float excludes not only treasury stocks but also other stocks such as those held by the top 10 largest shareholders, the estimated market capitalization of shares outstanding exceeds the sum of BoJ holdings and the TSE-defined free float market capitalization for all stocks in the sample. Thus, the dispersion of the ratio of BoJ holdings to the market capitalization of shares outstanding is lower than that of the BoJ holding ratio, so that a larger multiplier is needed to explain the dispersion of returns.

Many studies examine the impact of demand shocks on stock prices. Shleifer (1986) and Harris and Gurel (1986), for example, find that the price and trading volume of a stock were relatively high after the stock was announced to be newly included in the S&P 500 index. They interpret this result as representing the positive effect of demand from index funds on stock prices. While Shleifer (1986) finds that a large part of the impact persists for at least 10 to 20 trading days, Harris and Gurel (1986) find that the impact is nearly fully reversed after 2 weeks. More recent studies use granular data, such as data on assets held by mutual funds (e.g., Frazzini and Lamont 2008; Lou 2012). Surveying the literature, Gabaix and Koijen (2022) suggest that a typical price multiplier is about 1, although there is a range of estimates. Several studies report higher figures, such as 2 to 5 (Chang et al. 2015; Greenwood et al. 2022). The estimate obtained in this study is even higher than these figures.

The large multiplier may be because the BoJ is almost certainly expected to hold stocks through ETFs for much longer than other investors such as mutual funds. According to classic finance theory, demand from investors is perfectly elastic. For example, when a stock is overpriced relative to its fundamentals due to a demand or supply shock, investors immediately sell or short the stock. Because of this high demand elasticity, stock prices instantly converge to their fundamentals after a shock. However, as mentioned above, the empirical literature finds that the price impact of shocks to some extent is persistent. Finance theory has explained this finding by the limited risk-bearing capacity of arbitragers (Shleifer and Vishny 1997; Wurgler and Zhuravskaya 2002; Greenwood 2005). Recent theory focuses more on the tight mandates of investors. For instance, Gabaix and Koijen (2022) show that a combination of fund mandates and households' (end investors') bounded rationality allows demand shocks to persistently affect stock prices. Many theoretical studies suggest that the more persistent demand shocks are, not only the more persistent but also the larger is the impact on prices. Furthermore, a permanent shift in the demand for stocks can lead to a permanent change in prices.

Demand from many other investors is likely less persistent than that from the BoJ. For instance, when a stock is newly added to an index, demand from index funds for the stock increases. If the end investors of index funds realize that the index is overvalued, however, they are likely to redeem the funds, leading to a decline in demand from index funds. This process may be slow possibly due to end investors' bounded rationality, but as long as end investors are interested in the profitability of their investment, they would not freeze their investment positions regardless of price developments. In contrast, the BoJ does not sell ETFs even when it realizes that the ETF prices are overvalued since its objective is to attain the price stability target rather than make a profit. This behavior of the BoJ likely leads market participants to expect the BoJ's holdings to be semipermanent. This is likely the reason why the price multiplier estimates in this paper are larger than those in other studies.

Finally, let us compare the results obtained here with those in the literature on the impact of the BoJ's ETF purchases. As mentioned, a limited number of studies on the stock effects of ETF purchases do exist. Among them, only Barbon and Gianinazzi (2019) estimate the price multiplier. They conduct an event study, focusing on two BoJ announcements: one on October 31, 2014, and one on July 29, 2016. They then find that the price multiplier is only

around 1, which is much smaller than the estimate obtained here. There are several possible reasons for the large difference. The event study by Barbon and Gianinazzi (2019) may underestimate the true effect, possibly because at previous announcements, such as that on April 4 in 2013, when QQE was introduced, market prices may to some extent have reflected the value of state-contingent actions to do more if the situation worsens. This possibility is consistent with previous empirical evidence that earlier-stage announcements of central bank asset purchases in the US and Europe have large effects on asset prices but later-stage announcements have little to no effect (Meaning and Zhu, 2011; Bernanke, 2020; Haddad et al., 2023). On the other hand, the estimate in the present study may overstate the effect if there are other factors that caused the greater increase in prices of stocks with a higher Nikkei 225 weight relative to the TOPIX weight. In particular, this could be the case if non-BoJ investors increased their exposure to the Nikkei 225 index during the period of interest. However, as shown in Appendix E, examining the investment flows of non-BoJ investors suggests that this was not the case.

6.2. Are the effects permanent?

This subsection examines whether the effects of BoJ holdings are permanent. To this end, an extended sample to the end of December 2021 (December 30, 2021), i.e., 9 months after the BoJ stopped purchasing Nikkei 225 ETFs at the end of March 2021, is used. This exercise is important also as a robustness check of the baseline results. The reason is that the stock effect estimated in the baseline analysis might be overestimated for at least two reasons. First, although the BoJ announced the termination of Nikkei 225 ETF purchases more than 1 week before the end of March 2021, stock prices might take time to reflect the termination of such purchases. Second, the cumulative return to March 31, 2021, may to some extent have been pushed upward by short-term price pressures, since the BoJ purchased ETFs frequently until the end of March 2021. In contrast, from April to December 2021, the BoJ purchased ETFs only on April 21, June 21, September 29, and October 1. In particular, since the BoJ did not purchase ETFs for around 3 months up to December 30, 2021, short-term price pressures can be ignored when examining the cumulative returns up to this day. If the stock effect is

overestimated due to short-term price pressures in the baseline analysis, a return reversal is expected to be observed.

Two types of regressions are used for this analysis. First, the baseline regression is modified by using returns from September 30, 2010, to the end of December 2021 (December 30, 2021). The factor models are re-estimated using the extended sample. In line with this, the BoJ holding ratio is calculated from the BoJ holdings and the free float market capitalization on December 30, 2021. The full sample and the subsample include 1,232 and 190 stocks, respectively, for which data on returns are available for all business days from September 30, 2005, to December 30, 2021. If the effect of BoJ holdings diminished after the termination of Nikkei 225 ETF purchases, the estimated coefficient on the BoJ holding ratio should be smaller than in the baseline estimation.

Panel B in Table 6 reports the results. Again, the coefficient on the BoJ holding ratio is positive and significant in all 12 regressions. Although the size of the coefficient estimates is somewhat larger than in the baseline regressions, the difference is within the standard error of the regressions. Therefore, these alternative regression results do not provide any evidence suggesting that the effect of BoJ holdings had diminished 9 months after the termination of Nikkei 225 purchases. Note that the sample size is slightly smaller than in the baseline regressions, which means that the results may not be directly comparable. To address this potential issue, the baseline regression is rerun using the reduced sample. The results are presented in Panel C and are essentially unchanged from the baseline results. In all 12 combinations of returns and samples, the coefficient is around 5. Overall, the exercise here does not rule out the possibility that the BoJ holdings have a permanent impact on stock prices.

The second type of regressions examines returns from March 31, 2021. Specifically, the 9-month return from March 31 to December 30, 2021, is regressed on the BoJ holding ratio on March 31, 2021, and controls using ordinary least square (OLS). If the upward impact of BoJ holdings on returns reversed after the BoJ terminated its purchases of Nikkei 225 ETFs, the coefficient on the BoJ holding ratio should be negative. Abnormal returns are calculated by cumulating the sums of alpha and the residual from April to December 2021 after estimating the factor models using monthly return data from October 2010 to December 2021. The controls are calculated as in the baseline regression, although data up to March 31, 2021,

instead of September 30, 2010, are used. Firm size, the book-to-market ratio, profitability, and asset growth are calculated using the latest annual accounting data up to March 2021. As in the baseline analysis, all variables are winsorized at the 1 and 99% levels. Standard errors are clustered at the industry level as of March 31, 2021. The sample covers stocks for which prices are available for all business days from September 30, 2010, to December 30, 2021, and that were included in the TOPIX on March 31, 2021. The subsample consists of the Nikkei 225 members as of March 31, 2021. As a result, the full sample consists of 1,395 stocks, while the subsample comprises 210 stocks.

The regression results are presented in Table 7 and generate little evidence of a return reversal. The coefficient on the BoJ holding ratio is insignificant in 11 of the 12 estimations, indicating that there is no strong evidence of a diminishing effect after the termination of Nikkei 225 ETF purchases. The coefficient is negative and significant (with a t-statistic of -2.14) only in the full sample regression for the 6-factor model. Since this is the only significant coefficient among the 12 coefficients and the t-statistic is not very large, this result may be attributable to chance. Even if it is not due to chance, since the absolute value of the coefficient (-0.63) is much smaller than the corresponding coefficient (4.82) in Table 4, it seems safe to say that a large part, if not all, of the effect of BoJ holdings persisted 9 months after the termination of purchases of Nikkei 225 ETFs.

6.3. When did the index weight ratio predict returns?

The baseline regression uses the Nikkei 225 weight-to-TOPIX weight ratio on September 30, 2010, to instrument the BoJ holding ratio on March 31, 2021. In this instrumental variable regression, it is assumed that the index weight ratio contained information beyond the control variables to predict the returns between September 30, 2010, and March 31, 2021, only through the BoJ holding ratio. If this assumption holds, the index weight ratio should be able to predict future returns only after the BoJ made the first announcement of ETF purchases. This subsection checks this prediction by running two types of regressions.

The first type is a slightly modified version of the baseline regression. In the baseline, raw or abnormal returns are regressed on the BoJ holding ratio and the control variables using

the index weight ratio to instrument the BoJ holding ratio. In the modified version here, the returns are regressed on the index weight ratio and the controls using OLS. The coefficient estimates for the index weight ratio using the same 12 combinations of returns and samples as above are presented in Panel A of Table 8. The coefficient is positive and significant, as expected, with a t-statistic of more than 3 in all 12 cases. Meanwhile, Panel B reports the results when regressing the returns between September 30, 2000, and September 30, 2010 (i.e., approximately 10 years before the BoJ's first announcement of ETF purchases) on the index weight ratio on September 30, 2000, and the controls. The controls are exactly the same as those in the baseline regression, except that they are calculated using data up to September 30, 2000. The regression for the pre-announcement data can be interpreted as a placebo test. In contrast with Panel A, Panel B shows no significant coefficient. This result suggests that a higher index weight ratio predicted a higher return only after the BoJ's first announcement of ETF purchases, supporting the assumption underlying the baseline regression.

The second type of regressions is Fama-MacBeth (1973) regressions. Specifically, using monthly data, the one-month raw log excess total return in a month is regressed on the index weight ratio at the end of the previous month and the controls. The controls are calculated using data up to the previous month. While the controls are essentially the same as those used in the baseline regression, they differ in two respects. First, following Fama and French (1993), who employ a 6-month gap between returns and accounting data, and given that in Japan the financial year of firms typically ends in March, the latest accounting data by March of year t are used for returns in October of year t through September of year $t+1$. Second, the 11-month lagged return, skipping the most recent month, instead of the 3-year lagged return is used. The baseline regression uses the 3-year lagged return as a control variable to capture mean reversion, since it uses the long-term return as the dependent variable. On the other hand, since the Fama-MacBeth (1973) regression focuses on monthly returns, the 11-month lagged return is used here to capture the momentum effect. The regressions are run for the full sample and the subsample of firms that were Nikkei 225 members as of the end of the previous month. All variables are winsorized for each month at the 1 and 99% levels.

Following the convention of Fama-MacBeth (1973) regressions, the coefficients are obtained by taking the averages of the coefficients estimated in the cross-sectional regression for each month. Since, on average, market participants must have revised their expectations of

BoJ holdings of Nikkei 225 ETFs upward from the time before the BoJ's first announcement of ETF purchases to the time after the termination of Nikkei 225 ETF purchases, the average returns of stocks with a higher index weight ratio are expected to be higher. Therefore, the coefficient on the index weight ratio is expected to be positive when using the sample during the baseline period.

To start with, this regression is run for two observation periods. The first period corresponds to the baseline period and includes monthly returns from October 2010 through March 2021. The second period corresponds to the 10 years just before the baseline period and includes returns from October 2000 through September 2010. The regression for this pre-baseline period represents another placebo test to examine whether the index weight ratio can predict returns only after the BoJ made the first announcement of ETF purchases. The results for the baseline observation period for the full sample and the Nikkei-225-member subsample are reported in columns (1) and (2) of Table 9, respectively. The coefficient on the index weight ratio is positive and significant for both samples. The *t*-statistics are 2.07 for the full sample and 2.86 for the subsample. On the other hand, columns (3) and (4) report the results for the period before the BoJ's first announcement of the ETF purchases and show that the coefficient on the index weight ratio is insignificant for both samples. These results suggest that while a stock with a higher index weight ratio earned a higher return on average after the first announcement of ETF purchases there was no significant link between the two before that, again supporting the assumption underlying the baseline regression.

Next, 5-year rolling Fama-Macbeth (1973) regressions are estimated up to the 5-year sample ending in December 2021. Panels A and B in Figure 5 respectively show the coefficient estimates and t statistics for the index weight ratio. The coefficient is positive for the period after the BoJ made the first announcement in October 2010, while this is not necessarily the case before the announcement. The coefficient and the t statistic are relatively high from the 5-year sample ending in the first half of 2018 to that ending in early 2021. This suggests that in the period between the first half of 2013 and early 2021, stocks with a high index weight ratio benefited the most. During this period, the BoJ dramatically increased the pace of its ETF purchases. In April 2013, with the introduction of QQE, the BoJ moved to open-ended purchases at an annual pace of increase in the amount outstanding of 1 trillion yen. In October 2014, the BoJ tripled the annual pace to 3 trillion yen, while in July 2016, it further doubled

the pace to 6 trillion yen. Finally, in March 2020, in light of the outbreak of the COVID-19 pandemic, it announced that it would actively purchase ETFs so that the amounts outstanding would increase at an annual pace with an upper limit of about 12 trillion yen. While stock prices may not have fully factored in the consequences of these policy changes immediately after the announcements were made, they are likely to have reflected the policy changes at least gradually as investors observed actual purchases. Furthermore, observing that the BoJ continued to fail to meet its 2% inflation target, market participants probably expected the BoJ to continue with its ETF purchases for longer, resulting in additional distorting impacts on stock prices. Although this period also coincides with the decline in the share of Nikkei 225 ETFs in the BoJ's purchases, the rolling regression results suggest that the impact of the increase in the size of purchases exceeded that of the decline in this share. One possible reason is that the increase in the size of purchases was more of a surprise to market participants than the decrease in the share of Nikkei 225 ETF purchases, since many regarded the BoJ's ability to take on equity risk to be limited and the purchases of Nikkei 225 ETFs to have serious side effects.

Interestingly, the coefficient estimates and t statistics sharply decrease from the sample ending in February 2021 onward. This decrease is likely related to the BoJ's announcement in March 2021 that under the main program from April it would purchase ETFs as necessary and only TOPIX ETFs. It appears that the stock market began to reflect the policy change slightly earlier than March 2021. This is likely due to information revealed by the BoJ. In fact, the BoJ announced at the December 2020 MPM that it would conduct an assessment for further effective and sustainable monetary easing and would make its findings public likely at the March 2021 MPM. Subsequently, BoJ officials spoke publicly on the side effects of ETF purchases. For instance, in his speech in February 2021, board member Nakamura stated that it was "necessary to bear in mind that large-scale purchases and prolonged holding of assets—not limited to ETFs—could affect market functioning."[10] This episode also illustrates how the policy effect is difficult to capture by event studies that focus on MPM dates.

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[10] Nakamura, Toyoaki. 2021. "Economic Activity, Prices, and Monetary Policy in Japan." Speech at a Meeting with Local Leaders in Kochi (via webcast). February 10, 2021:

https://www.boj.or.jp/en/about/press/koen_2021/ko210215a.htm.

6.4. Have BoJ holdings improved firms' profitability?

Since the BoJ has been purchasing ETFs for more than a decade and its ETF holdings have distorted the stock market, another important question is whether the distortions in the stock market have led to distortions in the allocation of resources in the real economy. That this indeed may be the case is suggested by Charoenwong et al. (2021), who, examining the effect of purchases (i.e., flows) rather than holdings, find that the BoJ's ETF purchases are associated with increased investment by firms with weak corporate governance. Put differently, the estimate of the price multiplier obtained in this study may capture not only pure demand effects but also effects through firm behavior. In particular, the distorting impact on stock prices may have been amplified by the impact on firms' profitability, which is an important determinant of stock returns, due to different capital costs. This might be another reason for the large effects of BoJ holdings.

To see whether BoJ holdings have affected firms' profitability, this subsection utilizes two types of regressions. The first is a modification of the baseline regressions where instead of the cumulative return the average profitability is used as the dependent variable. The average profitability of a firm is calculated as the simple average of the ROE over the 10 financial years up to March 2021. The results for the full sample and the Nikkei-225-member subsample are presented in columns (1) and (2) of Table 10, respectively. They show that the coefficient on the BoJ holding ratio is insignificant for both samples. This suggests that BoJ holdings did not have any distributional impact on firms' profitability.

The second type of regressions uses annual panel data from financial year 2011 to 2020. Specifically, firms' profitability in financial year t is regressed on the index weight ratio at the end of financial year $t-1$ and the controls. The controls are firm size, the book-to-market ratio, profitability, and asset growth in financial year $t-1$. In the full-sample regression, a dummy variable for Nikkei 225 members at the end of financial year $t-1$ is also included. All variables are winsorized at the 1 and 99% levels for each financial year. Firm and time fixed effects are also added. The standard errors are clustered at the industry level as of September 30, 2010. To deal with the possibility that the effect on profitability has a longer lag, the regressions are also run using values for financial year $t-2$ for all independent

variables. The results for these regressions are shown in columns (1) to (4) of Table 11. All columns show that the coefficient on the index weight ratio is insignificant. Taking the results in the previous subsection into account, the results here suggest that upward revisions of market expectations with respect to the BoJ's purchases of Nikkei 225 ETFs had a distributional effect on stock returns, but not on profitability.

7. Conclusion

This paper examined the stock effect of the BoJ's ETF holdings on stock returns. The analysis showed that the effect is large and persistent. The regression results suggest that the price multiplier is around 5 when BoJ holdings are normalized by the free float market capitalization and around 7 to 8 when normalized by the market capitalization of shares outstanding. The multiplier is higher than that estimated in the majority of studies on the impact of demand shocks on stock returns. A small number of stocks benefited much more than others, and the BoJ holdings generated annualized return differences of more than 10 percentage points across Nikkei 225 member stocks. There is little evidence of a return reversal in the 9 months after the BoJ terminated purchases of Nikkei 225 ETFs. Moreover, the large and persistent effect of BoJ holdings is not attributable to any impact on profitability.

The literature provides a wide range of estimates of the price multiplier. Furthermore, no consensus has yet been reached regarding the determinants of the multiplier. The large impact of the BoJ's ETF holdings implies that the multiplier is larger when demand shocks originate from investors that are expected to hold assets for a longer period of time, irrespective of price developments. Obviously, however, this study on one type of demand shock is not sufficient to identify the determinants of the multiplier. Therefore, what determines the size of the multiplier remains an important issue for future research.

Finally, the BoJ has adjusted its ETF purchases so that the purchases are largely market neutral on a flow basis. However, it still holds a large amount of Nikkei 225 ETFs. The results obtained in this paper suggest that the BoJ holdings of Nikkei 225 ETFs have large distributional effects on stock prices even after the end of purchases. Therefore, further adjustments might be appropriate.

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Table 1. Top 10 Firms in Terms of BoJ Holdings to Free Float

Ranking	Firm name	(1) BoJ holdings to free float (%)	(2) Nikkei 225 weight to TOPIX weight (multiple)	(3) BoJ holdings (trill. yen)
1	Fast Retailing Co Ltd	104.8	25.1	1.96
2	Konami Group Corp	44.0	9.3	0.17
3	Advantest Corp	42.5	8.9	0.49
4	Taiyo Yuden Co Ltd	36.9	7.4	0.14
5	Hitachi Construction Machinery Co Ltd	35.5	7.1	0.09
6	COMSYS Holdings Corp	34.7	6.9	0.09
7	TDK Corp	34.6	6.8	0.41
8	Matsui Securities Co Ltd	33.8	6.8	0.02
9	NTT Data Corp	32.6	6.3	0.24
10	Trend Micro Inc/Japan	32.5	6.3	0.15

Note: The table shows the top 10 firms in terms of the ratio of estimated Bank of Japan holdings to the free float market capitalization on March 31, 2021. Columns (1), (2), and (3) show the ratio of BoJ holdings to the free float market capitalization (in %), the ratio of the Nikkei 225 weight to the TOPIX weight (in terms of multiples), and the outstanding amount of BoJ holdings (trillion yen), respectively.

Table 2. Summary Statistics

	(1) Mean	(2) Median	(3) Std. dev.	(4) Min	(5) Max
Raw return	0.901	0.888	0.724	-1.710	4.027
Abnormal return (1 factor)	-0.154	-0.114	0.851	-3.593	2.786
Abnormal return (3 factors)	-0.268	-0.219	0.801	-3.566	2.745
Abnormal return (4 factors)	-0.314	-0.258	0.828	-3.564	2.619
Abnormal return (5 factors)	-0.151	-0.110	0.776	-3.427	2.973
Abnormal return (6 factors)	-0.184	-0.148	0.821	-3.687	2.794
BoJ holding ratio	0.080	0.069	0.029	0.069	0.231
Index weight ratio	0.392	0.000	1.251	0.000	6.933
Beta	0.925	0.917	0.307	0.294	1.559
Firm size	24.520	24.315	1.570	21.731	28.610
Book-to-market ratio	0.101	0.144	0.516	-1.344	1.281
Profitability	0.082	0.077	0.105	-0.235	0.482
Asset growth	0.002	0.003	0.089	-0.280	0.298
Lagged returns	-0.505	-0.490	0.377	-1.539	0.372
Nikkei 225 member	0.154	0.000	0.361	0.000	1.000

Note: The table presents summary statistics of the variables used in the baseline regression. Columns (1) to (5) show the mean, median, standard deviation, minimum value, and maximum value, respectively. All variables are winsorized at the 1 and 99% levels. The number of observations is 1,241 for all variables. "Raw return" is the log excess total return from September 30, 2010, to March 31, 2021. "Abnormal return" is the abnormal returns computed by asset pricing models with 1, 3, 4, 5, or 6 factors. "BoJ holding ratio" is the ratio of BoJ holdings to the sum of BoJ holdings and the free float market capitalization on March 31, 2021. The other variables are calculated using data up to September 30, 2010. "Index weight ratio" is the ratio of the Nikkei 225 weight to the TOPIX weight. "Beta," "Firm size," "Book-to-market ratio," "Profitability," and "Asset growth" are the firm characteristics of interest in Fama and French's (2015) 5-factor model. "Lagged return" is the 3-year return to August 31, 2010. "Nikkei 225 member" takes 1 if the stock was included in the Nikkei 225 index on September 30, 2010, and 0 otherwise.

Table 3. First-stage Regressions

	(1) Full sample	(2) Subsample
Index weight ratio	0.0194**	0.0182**
	(12.37)	(20.88)
Beta	-0.0005	-0.0065
	(-0.42)	(-1.04)
Firm size	0.0031**	0.0058**
	(4.37)	(2.82)
Book to market ratio	-0.0024	-0.0103
	(-1.94)	(-1.19)
Profitability	-0.0049	-0.0145
	(-0.72)	(-0.95)
Asset growth	-0.0075	-0.0128
	(-1.54)	(-0.54)
Lagged returns	-0.0039*	-0.0074
	(-2.10)	(-0.88)
Nikkei 225 member	-0.0037	
	(-1.18)	
Observations	1,241	191
R-squared	0.781	0.792

Note: The table reports the results of the first-stage regressions of the baseline analysis. The dependent variable is the BoJ holding ratio, which is defined as the ratio of BoJ holdings to the sum of BoJ holdings and the free float market capitalization on March 31, 2021. The independent variables are calculated using data up to September 30, 2010. "Index weight ratio" is the ratio of the Nikkei 225 weight to the TOPIX weight. "Beta," "Firm size," "Book to market ratio," "Profitability," and "Asset growth" are the firm characteristics of interest in Fama and French's (2015) 5-factor model. "Lagged returns" is the 3-year return to August 31, 2010. "Nikkei 225 member" takes 1 if the stock was included in the Nikkei 225 index on September 30, 2010, and 0 otherwise. Column (1) reports the full-sample results, while column (2) reports the results for the subsample of Nikkei 225 members on September 30, 2010. A constant term is included in the regressions, but the coefficient estimates are suppressed. t-statistics are shown in parentheses. ** and * denote statistical significance at the 1 and 5% levels, respectively. Standard errors are clustered at the industry level (33 industries).

Table 4. Second-stage Regressions for the Full Sample

	(1)	(2)	(3)	(4)	(5)	(6)
	Raw	1 factor	3 factors	4 factors	5 factors	6 factors
BoJ holdings	4.89**	5.21**	5.42**	5.79**	4.42**	4.82**
	(4.05)	(3.61)	(3.79)	(3.96)	(3.11)	(3.21)
Beta	-0.24	-0.91**	-0.68**	-0.75**	-0.61**	-0.68**
	(-1.45)	(-4.87)	(-4.05)	(-4.29)	(-3.70)	(-3.78)
Firm size	-0.00	-0.01	0.07	0.08	0.04	0.05
	(-0.10)	(-0.13)	(1.63)	(1.82)	(0.96)	(1.11)
Book to market ratio	0.04	0.10	0.22	0.23	0.27*	0.33*
	(0.30)	(0.73)	(1.61)	(1.72)	(2.09)	(2.63)
Profitability	1.52**	2.11**	2.13**	2.23**	2.19**	2.40**
	(4.53)	(6.89)	(7.71)	(7.82)	(7.17)	(7.20)
Asset growth	-0.90*	-1.35**	-1.31**	-1.32**	-1.42**	-1.43**
	(-2.60)	(-3.20)	(-3.18)	(-3.27)	(-3.20)	(-3.21)
Lagged returns	-0.22*	-0.03	-0.00	-0.00	-0.01	0.01
	(-2.42)	(-0.31)	(-0.05)	(-0.03)	(-0.09)	(0.19)
Nikkei 225 member	-0.26	-0.29	-0.24	-0.26	-0.22	-0.26
	(-1.92)	(-1.98)	(-1.67)	(-1.83)	(-1.56)	(-1.95)

Note: The table presents the results of the second-stage regressions of the baseline analysis for the full sample. Column (1) reports the results for the raw return, while columns (2) to (6) report those for the abnormal returns computed using the 1-, 3-, 4-, 5-, and 6-factor models, respectively, from September 30, 2010, to March 31, 2021. "BoJ holdings" is the ratio of BoJ holdings to the sum of BoJ holdings and the free float market capitalization on March 31, 2021, and is instrumented by the index weight ratio, which is defined as the ratio of the Nikkei 225 weight to the TOPIX weight, on September 30, 2010. The other independent variables are calculated using data up to September 30, 2010. "Beta," "Firm size," "Book to market ratio," "Profitability," and "Asset growth" are the firm characteristics of interest in Fama and French's (2015) 5-factor model. "Lagged return" is the 3-year return to August 31, 2010. "Nikkei 225 member" takes 1 if the stock is included in the Nikkei 225 index on September 30, 2010, and 0 otherwise. A constant term is included in the regressions, but the coefficient estimates are suppressed. t-statistics are reported in parentheses. ** and * denote statistical significance at the 1 and 5% levels, respectively. Standard errors are clustered at the industry level (33 industries). The number of observations is 1,241 for all regressions.

Table 5. Second-stage Regressions for the Nikkei 225 Member Subsample

	(1) Raw	(2) 1 factor	(3) 3 factors	(4) 4 factors	(5) 5 factors	(6) 6 factors
BoJ holdings	5.37**	5.57**	5.51**	5.82**	4.62**	4.91**
	(5.59)	(4.90)	(4.95)	(5.17)	(4.01)	(4.02)
Beta	-0.14	-0.72*	-0.44	-0.56	-0.37	-0.50
	(-0.51)	(-2.13)	(-1.42)	(-1.76)	(-1.23)	(-1.56)
Firm size	0.07	0.07	0.12	0.13*	0.09	0.09
	(1.26)	(1.07)	(1.95)	(2.08)	(1.47)	(1.46)
Book to market ratio	0.21	0.28	0.43	0.45	0.48*	0.56*
	(1.22)	(1.32)	(1.96)	(2.02)	(2.26)	(2.54)
Profitability	0.49	1.17	1.36	1.48	1.69*	2.09*
	(0.65)	(1.37)	(1.57)	(1.66)	(2.09)	(2.51)
Asset growth	-0.28	-1.04	-1.03	-1.02	-1.23	-1.18
	(-0.52)	(-1.45)	(-1.51)	(-1.45)	(-1.70)	(-1.51)
Lagged returns	0.12	0.33	0.26	0.28	0.23	0.24
	(0.68)	(1.75)	(1.51)	(1.49)	(1.29)	(1.22)

Note: The table presents the results of the second-stage regressions of the baseline analysis for the subsample of Nikkei 225 members on September 30, 2010. Column (1) reports the results for the raw return, while columns (2) to (6) report those for the abnormal returns computed using the 1-, 3-, 4-, 5-, and 6-factor models, respectively, from September 30, 2010, to March 31, 2021. "BoJ holdings" is the ratio of BoJ holdings to the sum of BoJ holdings and the free float market capitalization on March 31, 2021, and is instrumented by the index weight ratio, which is defined as the ratio of the Nikkei 225 weight to the TOPIX weight, on September 30, 2010. The other independent variables are calculated using data up to September 30, 2010. "Beta," "Firm size," "Book to market ratio," "Profitability," and "Asset growth" are the firm characteristics of interest in Fama and French's (2015) 5-factor model. "Lagged returns" is the 3-year return to August 31, 2010. A constant term is included in the regressions, but the coefficient estimates are suppressed. t-statistics are reported in parentheses. ** and * denote statistical significance at the 1 and 5% levels, respectively. Standard errors are clustered at the industry level (33 industries). The number of observations is 191 for all regressions.

Table 6. Price Multipliers for Alternative Regressions

	(1) Raw	(2) 1 factor	(3) 3 factors	(4) 4 factors	(5) 5 factors	(6) 6 factors	(7) Observations
Panel A: Normalizing BoJ holdings by shares outstanding							
Full sample	6.64**	7.35**	7.67**	8.18**	6.26**	6.80**	1,241
	(3.76)	(3.45)	(3.62)	(3.75)	(2.95)	(3.03)	
Subsample	7.58**	8.11**	8.18**	8.67**	6.86**	7.33**	191
	(5.09)	(4.47)	(4.55)	(4.68)	(3.70)	(3.75)	
Panel B: Using returns to December 30, 2021							
Full sample	5.32**	5.61**	5.85**	6.03**	4.63**	4.94**	1,232
	(4.29)	(3.50)	(3.49)	(3.57)	(2.74)	(2.84)	
Subsample	5.75**	6.44**	6.43**	6.59**	5.35**	5.57**	190
	(5.57)	(4.59)	(4.37)	(4.44)	(3.59)	(3.62)	
Panel C: Baseline with matched data							
Full sample	4.92**	5.24**	5.45**	5.83**	4.45**	4.85**	1,232
	(4.05)	(3.59)	(3.78)	(3.95)	(3.09)	(3.20)	
Subsample	5.40**	5.61**	5.54**	5.86**	4.65**	4.94**	190
	(5.61)	(4.93)	(4.99)	(5.21)	(4.04)	(4.05)	

Note: The table presents the coefficient on the normalized BoJ holdings for the modified second-stage regressions for the full sample and the subsample of Nikkei 225 members on September 30, 2010. In Panel A, BoJ holdings are normalized by the market capitalization of the estimated shares outstanding. Panel B reports the results when returns are calculated up to the end of December 2021. Panel C reports the baseline regression results when the same sample as for the regressions in Panel B is used. Column (1) presents the results for the raw return, while columns (2) to (6) report those for the abnormal returns computed using the 1-, 3-, 4-, 5-, and 6-factor models, respectively, from September 30, 2010, to March 31, 2021. Column (7) reports the number of observations, which is identical across the raw and abnormal returns used as the dependent variable in a particular row. t-statistics are reported in parentheses. ** denotes statistical significance at the 1% level. Standard errors are clustered at the industry level (33 industries).

Table 7. Regressions of Ex-post Returns

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Raw	1 factor	3 factors	4 factors	5 factors	6 factors	Observations
Full sample	-0.44	-0.43	-0.42	-0.59	-0.54	-0.63*	1,395
	(-1.48)	(-1.45)	(-1.47)	(-1.97)	(-1.94)	(-2.14)	
Subsample	-0.14	-0.13	-0.13	-0.23	-0.24	-0.28	203
	(-0.29)	(-0.28)	(-0.28)	(-0.49)	(-0.54)	(-0.60)	

Note: The table presents the results of regressing returns from March 31, 2021, to December 30, 2021, on the BoJ holding ratio, which is defined as BoJ holdings to the sum of BoJ holdings and the free float market capitalization, on March 31, 2021, and control variables. The table only shows the coefficients on the BoJ holding ratio. Column (1) reports the results for the raw return, while columns (2) to (6) report those for the abnormal returns computed using the 1-, 3-, 4-, 5-, and 6-factor models, respectively. Column (7) reports the number of observations, which is identical across the raw and abnormal returns used as the dependent variable . t-statistics are reported in parentheses. * denotes statistical significance at the 5% level. Standard errors are clustered at the industry level (33 industries).

Table 8. OLS Regressions of Returns on the Index Weight Ratio

	(1) Raw	(2) 1 factor	(3) 3 factors	(4) 4 factors	(5) 5 factors	(6) 6 factors	(7) Observations
Panel A: Baseline sample (September 30, 2010, to March 31, 2021)							
Full sample	0.0949**	0.1019**	0.1065**	0.1122**	0.0875**	0.0936**	1,241
	(3.83)	(3.46)	(3.75)	(3.91)	(3.08)	(3.19)	
Subsample	0.0979**	0.1016**	0.1004**	0.1062**	0.0842**	0.0895**	191
	(5.53)	(4.76)	(4.86)	(5.14)	(3.94)	(4.02)	
Panel B: Alernative sample (September 30, 2000, to September 30, 2010							
Full sample	-0.0053	0.0004	0.0008	0.0107	0.0349	0.0398	797
	(-0.31)	(0.02)	(0.04)	(0.53)	(1.72)	(1.88)	
Subsample	-0.0182	-0.0100	-0.0107	0.0028	0.0412	0.0481	167
	(-0.65)	(-0.34)	(-0.36)	(0.09)	(1.09)	(1.25)	

Note: The table presents the estimated coefficients on the index weight ratio, which is defined as the ratio of the Nikkei 225 weight to the TOPIX weight, when regressing the return on the index weight ratio and controls. Column (1) reports the results for the raw return, while columns (2) to (6) report those for the abnormal returns computed using the 1-, 3-, 4-, 5-, and 6-factor models, respectively. Panel A uses the return between September 30, 2010, and March 31, 2021, and the index weight ratio on September 30, 2010. Panel B uses the return between September 30, 2000, and September 30, 2010, and the index weight ratio on September 30, 2000. t-statistics are reported in parentheses. ** denotes statistical significance at the 1% level. Standard errors are clustered at the industry level (33 industries).

Table 9. Fama-MacBeth Regressions

	(1)	(2)	(3)	(4)
	Oct. 2010-Mar. 2021		Oct. 2000-Sep. 2010	
	Full sample	Subsample	Full sample	Subsample
Index weight ratio	0.00084*	0.00115**	-0.00021	-0.00099
	(2.07)	(2.86)	(-0.45)	(-1.79)
Beta	0.00038	-0.00051	-0.00333	-0.00043
	(0.09)	(-0.08)	(-0.57)	(-0.07)
Firm size	-0.00044	0.00009	-0.00115	-0.00354*
	(-0.75)	(0.12)	(-1.18)	(-2.30)
Book to market ratio	-0.00022	0.00258	0.00435**	0.00258
	(-0.20)	(1.34)	(3.79)	(0.86)
Profitability	0.01343**	0.01214	0.00763	0.00613
	(3.89)	(1.63)	(1.82)	(0.74)
Asset growth	0.00234	-0.00463	-0.00559	0.00095
	(0.78)	(-0.76)	(-1.74)	(0.12)
Lagged returns	-0.00706	0.00839	-0.05027	-0.05628
	(-0.17)	(0.16)	(-1.44)	(-1.09)
Nikkei 225 member	-0.00109		0.00441	
	(-0.55)		(1.68)	
Observations	212,973	26,880	138,893	21,886
Number of months	126	126	120	120
R-squared	0.088	0.157	0.113	0.189

Note: The table presents the results of Fama-MacBeth (1973) regressions of the monthly log excess total return in a month on independent variables calculated using data up to the end of the previous month. Columns (1) and (2) report the results for monthly returns from October 2010 to March 2021, while columns (3) and (4) report those for returns from October 2000 to September 2010. Columns (1) and (3) report the full-sample results, while columns (2) and (4) report the results for the subsample of stocks that were included in the Nikkei 225 index at the end of the previous month. "Index weight ratio" is the ratio of the Nikkei 225 weight to the TOPIX weight. "Beta," "Firm size," "Book to market ratio," "Profitability," and "Asset growth" are the firm characteristics of interest in Fama and French's (2015) 5-factor model. "Lagged return" is the 11-month return with an additional 1-month lag. "Nikkei 225 member" takes 1 if the stock is included in the Nikkei 225 index at the end of the previous month and 0 otherwise. A constant term is included in the regressions, but the coefficient estimates are suppressed. t-statistics are reported in parentheses. ** and * denote statistical significance at the 1 and 5% levels.

Table 10. Cross-sectional Regression Results on Profitability

	(1)	(2)
	Full sample	Subsample
BoJ holding ratio	-0.0568	-0.0026
	(-0.62)	(-0.04)
Beta	0.0131	0.0057
	(1.37)	(0.30)
Firm size	-0.0017	-0.0008
	(-0.75)	(-0.18)
Book to market ratio	-0.0276**	-0.0392**
	(-3.20)	(-3.88)
Profitability	0.3224**	0.1226
	(4.01)	(1.52)
Asset growth	-0.0666	-0.0079
	(-1.91)	(-0.15)
Lagged returns	0.0032	0.0054
	(0.35)	(0.28)
Nikkei 225 member	0.0117	
	(1.13)	
Observations	1,241	191
R-squared	0.183	0.210

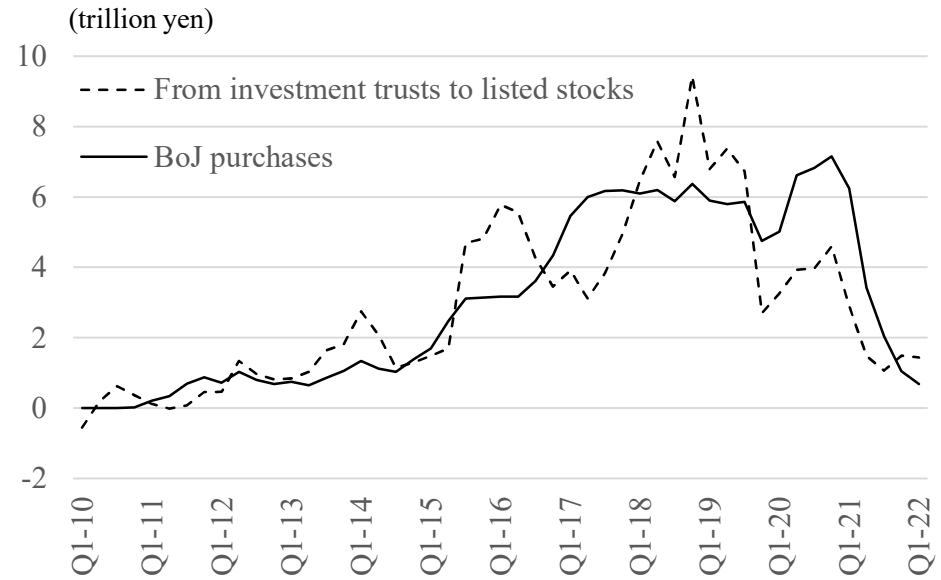
Note: The table presents the results of cross-sectional regressions of profitability. Columns (1) and (2) report the results for the full sample and the Nikkei-225-member subsample, respectively, when regressing the simple average of the return on equity over the latest 10 financial years up to March 2021 on the variables shown. "BoJ holdings" is the ratio of BoJ holdings to the sum of BoJ holdings and the free float market capitalization on March 31, 2021, and is instrumented by the index weight ratio, which is defined as the ratio of the Nikkei 225 weight to the TOPIX weight, on September 30, 2010. The other independent variables are calculated using data up to September 30, 2010. "Beta," "Firm size," "Book to market ratio," "Profitability," and "Asset growth" are the firm characteristics of interest in Fama and French's (2015) 5-factor model. "Lagged return" is the 3-year return to August 31, 2010. "Nikkei 225 member" takes 1 if the stock is included in the Nikkei 225 index on September 30, 2010, and 0 otherwise. A constant term is included in the regressions, but the estimated coefficient is not reported. t-statistics are reported in parentheses. ** denotes statistical significance at the 1% level. Standard errors are clustered at the industry level (33 industries).

Table 11. Panel Regression Results on Profitability

	(1)	(2)	(3)	(4)
	1-year lag		2-year lag	
	Full sample	Subsample	Full sample	Subsample
Index weight ratio	-0.0006	0.0013	0.0021	0.0022
	(-0.33)	(0.54)	(0.83)	(0.59)
Firm size	-0.0274**	-0.0612**	-0.0525**	-0.0910**
	(-3.31)	(-3.77)	(-5.77)	(-4.23)
Book to market ratio	-0.0342**	-0.0845**	-0.0484**	-0.1008**
	(-3.98)	(-4.24)	(-5.72)	(-4.84)
Profitability	0.4772**	0.4003**	0.1067**	0.1166*
	(20.34)	(9.58)	(5.71)	(2.51)
Asset growth	0.0090	0.0307	0.0134	-0.0109
	(0.59)	(0.88)	(0.96)	(-0.36)
Nikkei 225 member	-0.0062		-0.0254	
	(-0.50)		(-1.21)	
Observations	13,005	1,860	11,495	1,660
R-squared	0.258	0.281	0.099	0.162

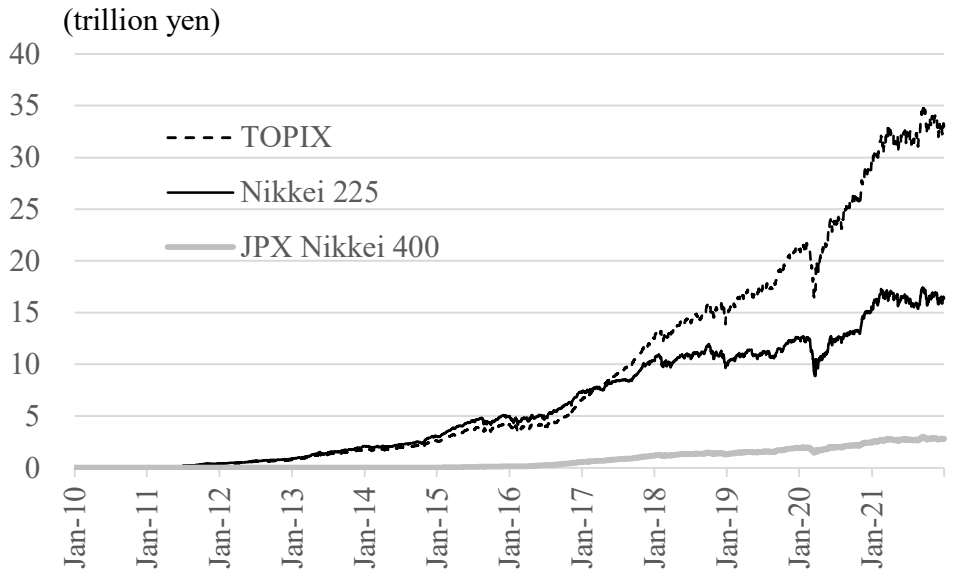
Note: The table presents the results of annual panel regressions of profitability. "Index weight ratio" is the ratio of the Nikkei 225 weight to the TOPIX weight. "Firm size," "Book to market ratio," "Profitability," and "Asset growth" are firm characteristics of interest in Fama and French's (2015) 5-factor model. "Nikkei 225 member" takes 1 if the stock was included in the Nikkei 225 index at the end of the previous financial year and 0 otherwise. The sample period is from financial year 2011 to 2020. In columns (1) and (2), all independent variables are those in the previous financial year. In columns (3) and (4), all independent variables are lagged by 2 years. Columns (1) and (3) report the results for the full sample, while columns (2) and (4) report those for the Nikkei-225-member subsample. In all regressions, firm and time fixed effects are included. t-statistics are reported in parentheses. ** and * denote statistical significance at the 1 and 5% levels. Standard errors are clustered at the industry level (33 industries).

Figure 1. Flows from the BoJ to Funds and from Funds to Listed Stocks



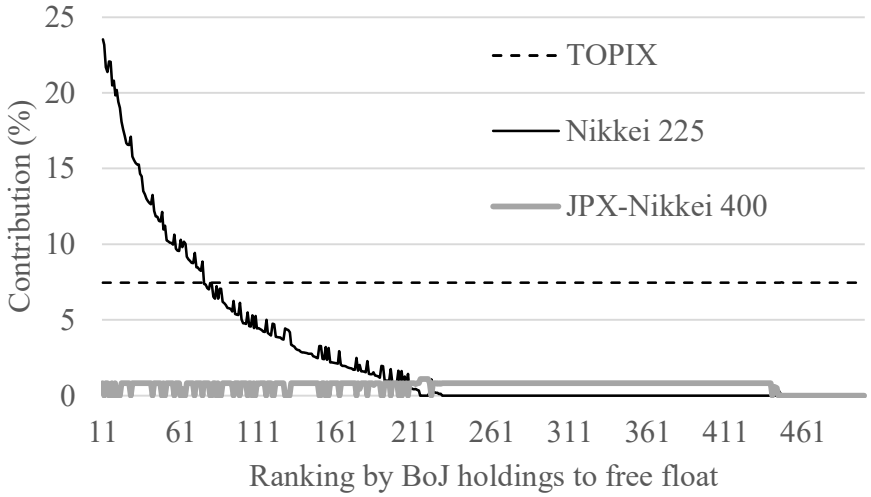
Note: The figure shows 4-quarter moving sums of flows from the Bank of Japan (BoJ) into investment funds (solid line) and from investment funds into listed stocks (broken line) from the first quarter of 2010 to the first quarter of 2022. The former and latter flows are those from the "Central bank" into "Investment trust beneficiary certificates" and from "Security investment trusts" and "Collectively managed trusts" into "Listed shares," respectively, in the Flow of Funds Accounts.

Figure 2. Estimated BoJ Holdings of ETFs by Index



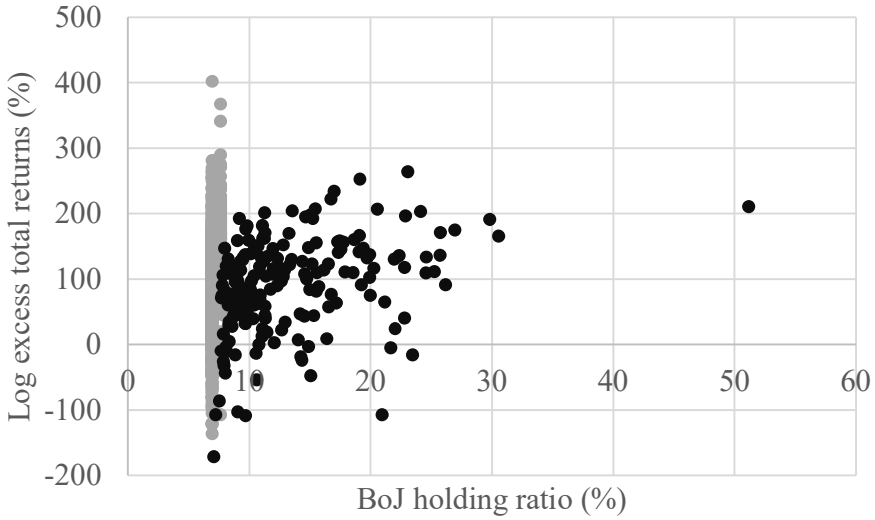
Note: The figure shows the estimated Bank of Japan holdings of ETFs that track the Tokyo Stock Price Index (TOPIX, broken line), the Nikkei 225 index (black line), and the JPX Nikkei 400 index (grey line) from January 1, 2010, to December 31, 2021.

Figure 3. Contributions of Indexes to the Ratio of BoJ Holdings to the Free Float



Note: The figure shows the contributions of the Tokyo Stock Price Index (TOPIX, black line), the Nikkei 225 (grey line), and the JPX Nikkei 400 (broken line) to the ratio of BoJ holdings to the free float market capitalization for the top 11 to 500 stocks ranked in terms of the ratio of BoJ holdings to the free float market capitalization on March 31, 2021. The horizontal axis indicates the ranking.

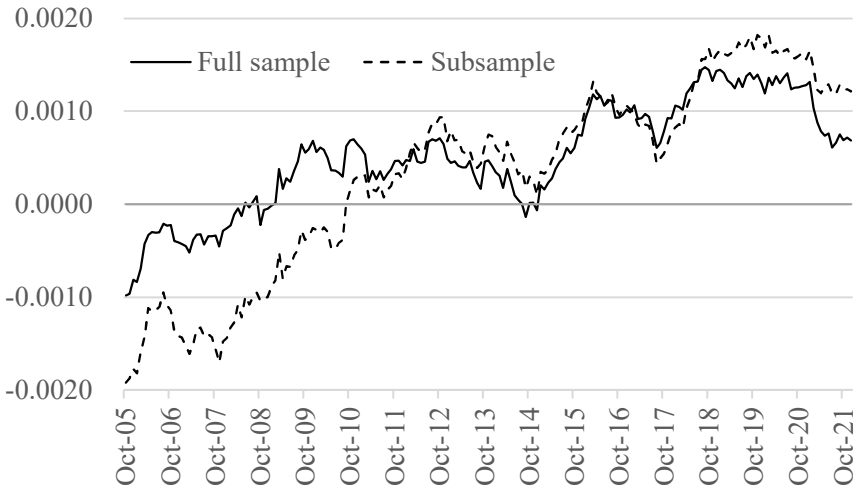
Figure 4. Total Returns against the BoJ Holding Ratio



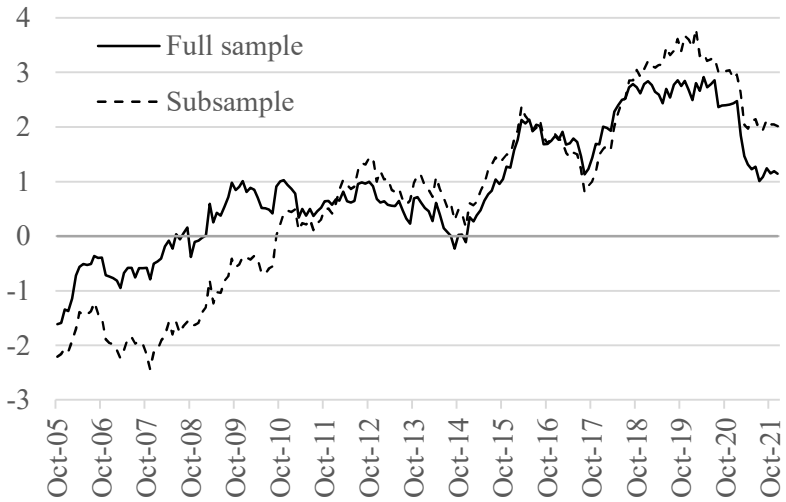
Note: The figure shows the log excess total return between September 30, 2010, and March 31, 2021 (in %) against the BoJ holding ratio (the ratio of Bank of Japan holdings to the free float market capitalization) on March 31, 2021 (in %). The black circles represent Nikkei 225 members on March 31, 2021, while the grey circles represent other stocks.

Figure 5. Rolling Fama-MacBeth Regressions

A. Coefficients



B. t-statistics



Note: Panels A and B respectively show the coefficient and t-statistic of the index weight ratio (the Nikkei 225 weight to the TOPIX weight) for 5-year rolling Fama-MacBeth (1973) regressions. The solid line represents the results for the full sample, while the broken line represents those for the subsample of Nikkei 225 members at the end of the previous month. The monthly log excess total return in a month is regressed on independent variables calculated using data up to the end of the previous month. The observation period is from the 5-year sample ending in October 2005 to that ending in December 2021.

Online Appendix:

"Stock Effects of the Bank of Japan's Equity Holdings"[11]

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[11] This research was supported by a grant from the Keio University Academic Development Fund.

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A. Estimation of the BoJ's Indirect Stock Holdings

As outlined in Section 2, this study estimates the BoJ's indirect holdings of individual stocks in three steps. This appendix provides more details on the first two steps. In the first step, the BoJ's daily purchases of each ETF are estimated. The BoJ has published daily data of total ETF purchases for both the main and the supplementary program. Using these data, the amount of daily purchases of each ETF is estimated based on several assumptions. For instance, when the BoJ purchased ETFs roughly in proportion to their total market value, it is assumed that the BoJ purchased them exactly in proportion to their market value on the previous day. When the BoJ purchased ETFs taking the amount outstanding in circulation of ETFs into account, it is assumed that the BoJ purchased them in proportion to the market value minus its holdings on the previous day. As for the supplementary program, it is assumed that the BoJ allocated all funds for the program to JPX-Nikkei 400 ETFs. Data on the market value of ETFs are from Nikkei NEEDS. The data cover all 27 equity index ETFs that track the TOPIX, the Nikkei 225, or the JPX-Nikkei 400, excluding leveraged and inverse ETFs, which, according to fund management firms that issue ETFs, are not eligible for the ETF purchase programs.

In the second step, the BoJ's holdings of each ETF are estimated. To this end, returns and flows are cumulated as follows:

$$h_{j,t} = h_{j,t-1}\left(1 + r_{j,t}\right) + f_{j,t}$$

where $h_{j,t}$ represents the BoJ's holdings of ETF j at the end of day t, $r_{j,t}$ is the day t daily rate of return of the index tracked by ETF j, and $f_{j,t}$ is the amount of BoJ purchases of ETF j on day t

estimated in the first step. The cumulation starts from the day before the first ETF purchase, when BoJ holdings were equal to zero. Moreover, BoJ data on the market value of its total ETF holdings are used to adjust for the estimated holdings. The BoJ makes data on the market value of its holdings at the end of March and September of each year going back several years available on its website, although older data appear to be removed as new data are released.[13] Therefore, the analysis here uses data from 2015 through 2021, since data for the period before 2015 were not available on the website. Further, data for March are used, since the data for September are only an approximation based on March prices. The estimated BoJ holdings of each ETF are adjusted by the same adjustment rate so that the sum of the adjusted BoJ holdings is equal to the BoJ's accounting data for each end of March from 2015. The adjustment rate is then linearly interpolated for all days from April 1, 2015, to March 30, 2021, and a constant rate of adjustment is assumed up to the end of March 2015 and from the end of March 2021. Although the adjustment rate is time-varying, it varies in a narrow range, between 1 and 2%, as shown in Table A3. The unadjusted estimates understate the BoJ's ETF holdings, likely in part because in the estimation it is assumed that the BoJ purchased ETFs at the closing price, while in practice it likely purchased ETFs at a lower price due to its *de facto* rule of purchasing ETFs in the afternoon of days on which stock prices fell sharply in the morning.

Note that the BoJ's holdings are needed for the first step but are estimated in the second step. Therefore, in the first step, the BoJ's purchases are initially estimated based on the

[13] The data are available in the financial statements here:

https://www.boj.or.jp/en/about/account/index.htm.

assumption that the BoJ purchased ETFs in proportion to the market value of these ETFs. Next, the estimated purchases are used to estimate the BoJ's holdings in the second step. Furthermore, the estimated holdings are used to estimate purchases in the first step again. These estimations are iteratively carried out 10 times, which is sufficient for achieving convergence.

B. Issues Regarding the Free Float

Harada (2021) argues that the TSE appears to exclude BoJ holdings from its definition of free float. According to its documents, the TSE in principle excludes stocks held by the top 10 largest shareholders, treasury stocks, and so forth.[14] Many of the top 10 shareholders are trust banks, which serve as custodians of assets held by ETFs. Although the TSE can make an exception when trust banks manage stocks held by an unspecified large number of investors, stocks held by the BoJ through ETFs do not seem to satisfy the condition for this exception. In support of her argument, Harada (2021) shows that the TSE-defined free float ratio (the ratio of the free float to shares issued) is much lower than the Bloomberg-defined free float ratio for the 15 stocks for which the BoJ share of the market capitalization appears to be high. This result suggests that BoJ holdings are excluded from the TSE-defined free float but not from the Bloomberg-defined free float.

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[14] The documents are available here (in Japanese only):

https://www.jpx.co.jp/markets/indices/line-up/files/cal2_1_FFW.pdf;

https://www.jpx.co.jp/equities/market-restructure/revisions-indices/nlsgeu000005mjg9-att/deta_j.pdf.

To further support Harada's (2021) argument, 2,177 stocks that were listed on the first section of the TSE on March 31, 2021, are examined. Figure A2 plots the difference between the TSE- and Bloomberg-defined free float ratios against the ratio of BoJ holdings to the market capitalization of issued shares. There seems to be a negative correlation between the difference between the two free float ratios and the ratio of BoJ holdings to the market capitalization. In fact, regressing this difference on the ratio of BoJ holdings to the market capitalization (after winsorizing both variables at the 1 and 99% levels, and including a constant), yields a significantly negative slope coefficient of -1.1731. Since the standard error is 0.0854, the hypothesis that the slope is -1 cannot be rejected at the 5% level, which suggests that the TSE-defined free float decreases to the extent that BoJ holdings increase.

Figure A2 and the associated regression result also imply a large discrepancy between the TSE and Bloomberg definitions. The adjusted R-squared is only 0.0798, which suggests that BoJ holdings are not the dominant determinant of the discrepancy. The constant is -0.0695 and is highly significant, with a *t*-statistic of -16.7. This suggests that the TSE-defined ratio on average is around 7 percentage points lower than the Bloomberg-defined ratio after controlling for BoJ holdings.

To address this issue regarding the definition of the free float, Panel A in Table A4 examines the robustness of the baseline regression results to using the Bloomberg- instead of the TSE-defined free float market capitalization. Like Table 6, the table reports only the coefficient estimates for the normalized BoJ holdings with the corresponding t-statistics. Again, 12 combinations of 6 types of returns and two types of samples are used. The t-statistics are greater than 3 in all 12 cases, although they are slightly lower than those in the baseline results in Tables

4 and 5. The coefficient is larger than that in the baseline analysis but smaller than that when BoJ holdings are normalized by the market capitalization of shares outstanding. This makes sense. As shown above, the Bloomberg-defined free float ratio on average is higher than the TSE-defined ratio even after taking into account that the TSE-defined free float market capitalization does not include BoJ holdings. On the other hand, for all 1,241 stocks in the regression sample, the Bloomberg-defined free float market capitalization is smaller than the market capitalization of shares outstanding, which suggests that the Bloomberg-defined free float excludes more than treasury stocks. As a result, the estimate of the multiplier is between that obtained when the BoJ holding ratio is used and that obtained when the BoJ holdings are normalized by the market capitalization of shares outstanding.

C. ETF weights vs. index weights

In Section 3, BoJ holdings were estimated based on several assumptions. For instance, when the BoJ purchased ETFs *roughly* in proportion to their total market value, it was assumed that the BoJ purchased them *exactly* in proportion to the market value on the previous day. It was also assumed that the weights of individual stocks in the indexes are a good approximation of those in index ETFs. In practice, however, index ETFs may not perfectly replicate the benchmark index, for example due to transaction costs, potentially leading to estimation bias.

Therefore, to check the robustness of the baseline results, BoJ holdings here are estimated based on alternative assumptions, using data on the weights of individual stocks in ETFs. Unfortunately, these data cannot be obtained for three ETFs that are eligible for BoJ purchases. The total market value of these ETFs is, however, only 35.0 billion yen, which is much smaller

than the total market value of eligible ETFs of 56.5 trillion yen, as of March 31, 2021. Since the BoJ's annual accounting reports that its total holdings of ETFs were 51.5 trillion yen on that day, the BoJ holding share of eligible ETFs reached 91.2%. This overwhelming share indicates that these ETFs have been issued primarily to meet demand from the BoJ. This fact means that one can assume that the weights of individual stocks indirectly held by the BoJ are well approximated by the weights of stocks held by all eligible ETFs. Based on this assumption, the weights in the BoJ's holdings are estimated by taking the weighted average of the weights in the ETFs based on the market values of the ETFs. The estimated weights are then multiplied by the BoJ's total holdings of ETFs to estimate the BoJ's indirect holdings of each stock. Note that only half of the total market value of ETFs tracking indexes composed of firms that proactively invest in physical and human capital is counted, since the BoJ purchased only up to half of the market value of these ETFs. That said, since the market value of these ETFs is small relative to that of many other ETFs, how they are treated in the calculation does not make much difference for the results.

Next, the difference between the BoJ holding ratio estimated in Section 3 based on index weights and that estimated here based on ETF weights is examined. Figure A3 shows this difference against the adjusted free float market capitalization (i.e., the TSE-defined free float market capitalization plus BoJ holdings) on March 31, 2021. The figure reveals that the two estimated BoJ holding ratios substantially deviate from each other only for a very small number of stocks, indicating that the estimated BoJ holdings used in the baseline analysis are largely robust. The large deviations are concentrated in relatively small cap stocks, likely because fund managers are aware that tracking errors in such stocks have little impact on the overall index tracking performance. When a stock is held by index funds far out of proportion to its market capitalization,

its price is likely distorted. Although this problem can arise in the case of all index funds, it may be more serious for index ETFs held dominantly by the BoJ, since the impact of BoJ holdings appears to be larger than that of other end investors. Note that the BoJ holding ratio estimated from ETFs' weights is greater than that estimated from index weights for only 64 out of the 1,241 stocks. This is because ETFs' allocation to positions other than stocks, typically cash and index futures, is ignored when estimating the BoJ holding ratio from index weights. However, since the ETF market value-weighted average of the weight of positions other than stocks is only 2.3%, ignoring these positions is unlikely to seriously affect the baseline results.

To check whether the baseline results are indeed robust to using BoJ holdings estimated from ETF weights instead of index weights, regressions for the same 12 combinations of returns and samples as in the baseline are estimated. The results are presented in Panel B of Table A4 and show that the coefficient estimate for the BoJ holding ratio is significantly different from zero with a t-statistic of more than 3 in all 12 cases. Again, the size of the coefficients is around 5, indicating that the baseline results are robust.

D. Portfolio analysis

The baseline analysis uses data of individual stocks instead of grouping the stocks into portfolios, since using portfolios is likely inefficient in the cross-sectional analysis. However, to provide further support for the results of the baseline analysis, this appendix examines the returns of portfolios.

Specifically, the analysis in this appendix focuses on Nikkei 225 members. The portfolios are constructed for the end of each month using the Nikkei 225 weight-to-TOPIX weight ratio,

since this ratio, as shown in Section 6.3, contains information about one-month future returns. Table A5 reports the raw and abnormal cumulative returns for the top 30%, middle 40%, and bottom 30% portfolios. The results are reported for two different observation periods. First, as in the baseline analysis, data for the 126 months from October 2010 to March 2021 are used. Second, data for the 120 months from October 2000 to September 2010 are used. The abnormal cumulative returns are calculated by multiplying alpha by 126 and 120 for these two samples, respectively. When using the sample from October 2010 to March 2021, all columns in the table show that the return is highest for the top 30% and lowest for the bottom 30%, as expected. The abnormal cumulative return is positive for the top 30%, although not significantly different from zero. On the other hand, the abnormal cumulative return is negative and significant for the bottom 30%. In contrast, this relationship cannot be seen when using the sample from October 2000 to September 2010. These results are at least qualitatively consistent with the individual stock-level analysis in the main text.

E. Do other investors' stock holdings contaminate the baseline results?

This appendix explores investment demand from non-BoJ investors to see whether such demand contaminates the identification in the baseline analysis. The baseline regression could overstate the impact of BoJ holdings if the stocks purchased by other long-term investors are similar to those purchased by the BoJ via ETFs.

A plausible candidate of such investors is Nikkei 225 index funds other than ETFs held by the BoJ. To check this possibility, data on the total flows (sales minus repurchases and redemptions) into publicly offered Nikkei 225 index funds published by the Investment Trusts

Association, Japan, are used. Unfortunately, monthly data are available only from August 2012, while annual data are available from 2010. Therefore, monthly data from January 2010 are constructed by dividing the flows in 2010 and 2011 by 12 and the flows from January to July 2012 by 7. Figure A4 compares the 12-month moving sum of the total flows with that of BoJ purchases of Nikkei 225 ETFs estimated in Section 2 in terms of the value as of March 31, 2021. To calculate the value as of March 31, 2021, monthly flows are divided by the monthly average prices of the Nikkei 225 index relative to the price on March 31, 2021. The figure shows that the total flows and BoJ purchases are broadly similar. The total flows and BoJ purchases from December 2010 to March 2021 amount to 13.7 trillion yen and 16.2 trillion yen, respectively. That is, non-BoJ investors sold 2.5 trillion yen of Nikkei 225 index funds, possibly because they regarded the index to be overvalued due to BoJ holdings. Overall, there is no evidence that the approach in this paper overestimates the effect of BoJ holdings due to other investors' investment in Nikkei 225 index funds.

Another possibility is that long-term institutional investors, primarily insurance companies and pension funds, may have invested in portfolios that track the Nikkei index, without purchasing index funds. Since these investors tend to keep the allocation weight for domestic stocks constant, they often sell stocks when stock prices increase. This behavior differs from that of the BoJ, which does not sell ETFs when their prices increase. Therefore, the impact of long-term institutional investors' holdings on returns can be expected to be weaker than that of the BoJ's holdings. However, because their investment is long term, they are likely to have a larger impact than short-term investors, so that the analysis here focuses on their behavior.

Figure A5 presents the 4-quarter moving sums of flows from public pension funds, private pension funds, and private insurance companies into listed stocks. The figure shows that while flows from private insurance companies and pension funds were in general negative during this period, public pension funds aggressively purchased stocks from 2014 to 2016. The large flows from public pension funds were due to the reform of the Government Pension Investment Fund (GPIF), the world's largest institutional investor. On October 31, 2014, the GPIF announced a new asset mix, in which the target allocation to domestic equities increased from 12% to 25%. Given that the GPIF increased its holdings of domestic stocks during the period this paper focuses on, the important question for the analysis here is whether its allocation of purchases is skewed in a similar fashion as the BoJ's.

To reveal the implicit benchmark of the GPIF, data on the GPIF's holdings at the individual stock level are used. The GPIF has published data for the end of March every year from 2015, although for some reason it did not publish these data in 2017. The GPIF's holdings (in trillion yen) of each TSE First Section stock are regressed on the weights of the TOPIX, Nikkei 225, and JPX-Nikkei 400 as of the end of March each year. The coefficient on an index weight can be interpreted as the exposure to the index in trillion yen.

Table A6 reports the regression results. The coefficients on the index weights are significant for all indexes and years. Column (6) suggests that the GPIF's exposure to the TOPIX amounted to 43.34 trillion yen, while that to the Nikkei 225 index amounted to only 0.18 trillion yen and that to the JPX-Nikkei 400 index to 2.79 trillion yen as of the end of March 2021. The sum of these figures is slightly smaller than the aggregate holdings of 47.23 trillion yen. The residual, 0.92 trillion yen, may partly be due to the fact that the GPIF holds stocks other than those

listed on the First Section of the TSE. Alternative assets, such as private equity and real estate, which are included in the GPIF's definition of domestic equity, may also be responsible for the residual.

The most important implication of these results for this paper is that the GPIF's main exposure is to the TOPIX and its exposure to the Nikkei 225 index is very limited. This finding holds for the entire period. The coefficient on the TOPIX weight is positive and significant for all years. The size of the coefficient is close to and often larger than the total size of the GPIF portfolio. On the other hand, except for the exposure to the TOPIX, the GPIF's holdings vary only in the range from -2.3 trillion yen to 3.9 trillion yen. The coefficients for the Nikkei 225 and the JPX-Nikkei 400 are much smaller in absolute value than that for the TOPIX and often negative. The negative values for these indexes may be because the GPIF or delegated active funds underweighted the index component stocks, possibly because they regarded the prices of the stocks to be overvalued due to BoJ holdings. Overall, taking into account that the GPIF reports that as of the end of March 2021, 92.97% of its funds were passively managed and only 7.03% were actively managed, it appears that the GPIF's long-term exposure focuses mostly on the TOPIX while its exposure to the Nikkei 225 and JPX-Nikkei 400 indexes is relatively small and short-term. Therefore, the GPIF's stock holdings are unlikely to seriously contaminate the identification in the baseline analysis.

Finally, to further support the conclusion that the baseline results are not materially affected by the holdings of public pension funds, the amount of stocks purchased by them during the period when the BoJ purchased Nikkei 225 ETFs (i.e., from the fourth quarter of 2010 to the first quarter of 2021) is estimated using the Flow of Funds Accounts data. The quarterly returns

on purchased stocks are estimated by subtracting flows during the quarter from changes in stocks between the beginning and end of the quarter. The estimated returns and flow data suggest that the aggregate amount of stocks purchased by public pension funds during the period of interest was 17.0 trillion yen in terms of the value as of March 31, 2021. This figure is considerably smaller than the total holdings of 61.9 trillion yen on that day. This is because public pension funds already held 19.8 trillion yen in the end of September 2010, and this value more than doubled to the end of March 2021. The value of stocks purchased by public pension funds during the period of interest is also much smaller than the BoJ's holdings of 51.5 trillion yen. This comparison indicates that even if one were to focus only on the size of the investments and ignore the composition, the impact of public pension fund holdings is likely to be much smaller than that of BoJ holdings.

Table A1. Key BoJ Announcements

Date	Summary of announcements
October 5, 2010	The BoJ will examine establishing, as a temporary measure, a program to purchase various financial assets, such as government securities and ETFs.
October 28, 2010	The maximum outstanding amount will be about 0.45 trillion yen. The BoJ will conduct purchases until around the end of 2011.
November 5, 2010	ETFs that track the TOPIX or the Nikkei 225 will be eligible. The maximum amount of each ETF to be purchased shall be set so that the BoJ's purchases are roughly proportionate to the total market value of that ETF.
December 14, 2010	ETFs will be purchased, depending on market conditions, from tomorrow.
March 14, 2011	Purchases will be increased to 0.9 trillion yen. The BoJ intends to complete the increased purchases by around the end of June 2012.
August 4, 2011	Purchases will be increased to 1.4 trillion yen. The BoJ intends to complete the increased purchases by around the end of 2012.
April 27, 2012	Purchases will be increased to 1.6 trillion yen. The BoJ intends to complete the increased purchases by around the end of 2013.
October 30, 2012	Purchases will be increased to 2.1 trillion yen.
April 4, 2013	The BoJ decided the introduction of QQE, as part of which it will purchase ETFs so that the amount outstanding of its ETF holdings will increase by 1 trillion yen per year.
October 31, 2014	The amount outstanding of the BoJ's ETF holdings will increase by about 3 trillion yen per year.
November 19, 2014	ETFs that track the JPX-Nikkei 400 will also be eligible.
December 1, 2014	ETFs that track the JPX-Nikkei 400 shall be purchased from tomorrow.
December 18, 2015	The BoJ will establish a supplementary program under which it will purchase ETFs composed of stocks issued by firms that are proactively investing in physical and human capital. It will purchase such ETFs at an annual pace of around 0.3 trillion yen from April 2016.
March 15, 2016	Under the supplementary program, the BoJ will purchase ETFs that track indexes deemed eligible in accordance with the criteria set out by the BoJ. In principle, it will purchase up to half of the total market value of those ETFs or JPX-Nikkei 400 ETFs.
July 29, 2016	The amount outstanding will increase by about 6 trillion yen per year.
September 21, 2016	From October, 3 trillion yen per year will be used for ETFs that track either of the three indexes as before, and 2.7 trillion yen per year will be used exclusively for TOPIX ETFs.

Table A1. Key BoJ Announcements (continued)

Date	Summary of announcements
July 29, 2018	From August 6, 1.5 trillion yen per year will be used for ETFs that track either of the three indexes, and 4.2 trillion yen per year will be used exclusively for TOPIX ETFs.
March 16, 2020	In light of the impact of COVID-19, the BoJ will actively purchase ETFs for the time being with an upper limit of about 12 trillion yen per year.
April 27, 2020	From May, the maximum amount of each ETF to be purchased shall be set taking into account the amount outstanding in circulation of that ETF.
April 30, 2020	From May, about 25% of the funds for ETF purchases under the main program will be used for ETFs that track either of the three indices, and about 75% will be used exclusively for TOPIX ETFs.
December 18, 2020	The BoJ will conduct an assessment for further effective and sustainable monetary easing and will make public its findings, likely at the March MPM.
March 19, 2021	Only TOPIX ETFs will be purchased as necessary under the main program. As for the supplementary program, the BoJ will only continue to purchase those that track the indexes deemed eligible in accordance with the BoJ's criteria.
March 23, 2021	From April, the BoJ will change the amount of each ETF to be purchased.

Table A2. List of Data

	Frequency	Source
Flow of Funds Accounts	Quarterly	BoJ
BoJ ETF purchases	Daily	BoJ
Market capitalization of ETFs	Daily	Nikkei NEEDS
Last prices of indexes	Daily	Bloomberg
BoJ's total ETF holdings	Annual	BoJ
Weights of indexes	Daily	Bloomberg
Stock prices	Daily	Bloomberg
TSE-defined free float	Daily	Bloomberg
Bloomberg-defined free float weights	Daily	Bloomberg
Total return indexes of individual stocks	Daily	Financial Data Solutions Inc.
Uncollateralized overnight call rate	Daily	BoJ
Fama-French-Carhart 6 factors	Monthly	Kenneth French
Exchange rates	Monthly	BoJ
TSE First Section Total Return Index	Daily	Bloomberg
Book values	Annual	Nikkei NEEDS
Current earnings	Annual	Nikkei NEEDS
Total assets	Annual	Nikkei NEEDS
Treasury stocks	Annual	Nikkei NEEDS
Weights of ETFs	Daily	Bloomberg
Total flows into publicly offered Nikkei 225 index funds	Monthly	Investment Trusts Association, Japan
GPIF's exposures to individual stocks	Annual	GPIF
Nikkei Stock Average Volatility Index	Daily	Bloomberg

Table A3. Total Bank of Japan Holdings

	2015	2016	2017	2018	2019	2020	2021
Adjusted holdings (trillion yen)	7.0	8.8	15.9	24.5	28.9	31.2	51.5
Pre-adjusted holdings (trillion yen)	6.9	8.6	15.7	24.2	28.5	30.6	50.7
Adjustment rate (%)	1.31	1.50	1.27	1.24	1.40	1.96	1.58

Note: “Adjusted holdings” refers to the total Bank of Japan (BoJ) holdings on a market value basis based on the BoJ’s accounting data. “Pre-adjusted holdings” are estimated from data other than the BoJ’s accounting data. “Adjustment rate” is the percentage deviation of the adjusted holdings from the pre-adjusted holdings. These figures are reported for the end of March from 2015 to 2021.

Table A4. Price Multipliers for Alternative Assumptions about BoJ Holdings

	(1) Raw	(2) 1 factor	(3) 3 factors	(4) 4 factors	(5) 5 factors	(6) 6 factors	(7) Observations
Panel A: Normalizing BoJ holdings by Bloomberg free float weights							
Full sample	5.53**	5.92**	6.08**	6.52**	4.97**	5.46**	1,241
	(3.93)	(3.58)	(3.76)	(3.95)	(3.08)	(3.20)	
Subsample	5.96**	6.19**	6.13**	6.52**	5.18**	5.58**	191
	(5.08)	(4.48)	(4.58)	(4.81)	(3.78)	(3.85)	
Panel B: Estimating BoJ holdings using investment weights of ETFs							
Full sample	4.58**	4.89**	5.09**	5.43**	4.15**	4.52**	1,241
	(4.04)	(3.60)	(3.78)	(3.94)	(3.10)	(3.19)	
Subsample	5.10**	5.29**	5.23**	5.53**	4.39**	4.66**	191
	(5.57)	(4.89)	(4.94)	(5.16)	(4.00)	(4.02)	

Note: The table presents – for the full sample and the subsample of Nikkei 225 members as of September 30, 2010 – the estimated coefficients on the normalized BoJ holdings for the modified second-stage regressions. The number of observations is 1,241 for the full sample and 191 for the subsample. In Panel A, BoJ holdings are normalized by the Bloomberg-defined free float. Panel B reports the results when BoJ holdings are estimated using the ETF weights. Column (1) reports the results for the raw return, while columns (2) to (6) report those for the abnormal returns computed using the 1-, 3-, 4-, 5-, and 6-factor models, respectively, from September 30, 2010, to March 31, 2021. Column (7) reports the number of observations, which is identical across the raw and abnormal returns used as the dependent variable. t-statistics are reported in parentheses. ** denotes statistical significance at the 1% level. Standard errors are clustered at the industry level (33 industries).

Table A5. Portfolio Alpha

	(1)	(2)	(3)	(4)	(5)	(6)
	Raw	1 factor	3 factors	4 factors	5 factors	6 factors
Panel A: Baseline sample (October 2010 to March 2021)						
Top 30%	118.5*	6.6	10.3	11.8	0.9	2.8
	(2.02)	(0.27)	(0.42)	(0.48)	(0.04)	(0.12)
Middle 40%	77.8	-32.3*	-25.2*	-25.2*	-26.6*	-28.4*
	(1.43)	(-2.52)	(-2.02)	(-2.01)	(-2.15)	(-2.29)
Bottom 30%	61.1	-65.0**	-41.0*	-43.5**	-38.9*	-42.8*
	(0.95)	(-3.03)	(-2.50)	(-2.69)	(-2.35)	(-2.61)
Panel B: Alternative sample (October 2000 to September 2010)						
Top 30%	-86.9	-10.4	-7.4	-7.4	5.8	3.5
	(-1.10)	(-0.32)	(-0.23)	(-0.22)	(0.17)	(0.10)
Middle 40%	-55.2	6.3	-1.3	2.2	14.5	17.1
	(-0.90)	(0.32)	(-0.07)	(0.11)	(0.80)	(0.93)
Bottom 30%	-79.2	-12.6	-24.8	-34.0	-21.3	-28.1
	(-1.19)	(-0.55)	(-1.20)	(-1.66)	(-1.02)	(-1.36)

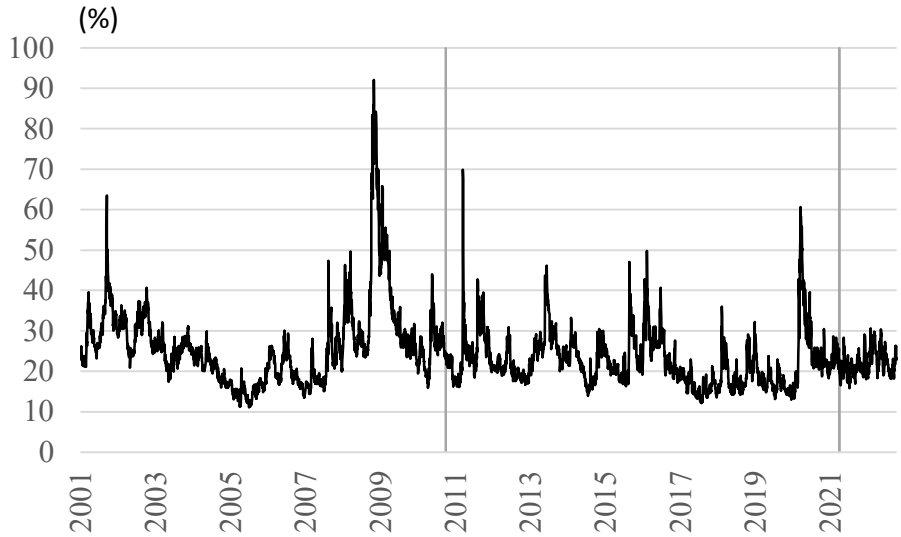
Note: This table reports the estimated cumulative returns (in %) of three portfolios of Nikkei 225 members. The portfolios are constructed at the end of each month using the Nikkei 225 weight-to-TOPIX weight ratio. The breakpoints are the 30th and 70th percentiles. Column (1) reports the raw cumulative return, while columns (2) to (6) report the abnormal returns computed using the 1-, 3-, 4-, 5-, and 6-factor models, respectively. Panel A presents the results for the sample from October 2010 to March 2021, while Panel B presents those for the sample from October 2000 to September 2010. Abnormal returns are calculated by multiplying alpha by 126 and 120 for these observation periods, respectively. t-statistics are reported in parentheses. The t-statistics for the raw return are obtained by regressing the return on a constant. ** and * indicate statistical significance at the 1 and 5% levels, respectively.

Table A6. Estimated Exposures of the GPIF Portfolio to Indexes

Year	(1) 2015	(2) 2016	(3) 2018	(4) 2019	(5) 2020	(6) 2021
TOPIX	29.95**	30.07**	38.52**	40.95**	36.89**	43.34**
	(436.43)	(286.40)	(216.91)	(165.69)	(93.45)	(182.85)
Nikkei 225	-0.28**	-0.29**	-0.45**	-0.30**	0.42**	0.18**
	(-11.59)	(-9.24)	(-9.86)	(-6.09)	(4.78)	(3.81)
JPX-Nikkei 400	1.74**	0.70**	2.13**	-1.91**	-2.53**	2.79**
	(23.26)	(6.77)	(12.79)	(-8.45)	(-6.67)	(12.05)
Constant	-0.00	-0.00	0.00	-0.00	-0.00	0.00
	(-0.16)	(-1.17)	(0.27)	(-1.89)	(-0.75)	(0.87)
Total	31.67	30.58	40.70	38.66	35.56	47.23
Other than TOPIX	1.72	0.51	2.18	-2.30	-1.33	3.89
Other than 3 indexes	0.27	0.10	0.50	-0.09	0.78	0.92
Observations	1,858	1,937	2,061	2,124	2,159	2,185
R-squared	0.998	0.995	0.993	0.990	0.966	0.993

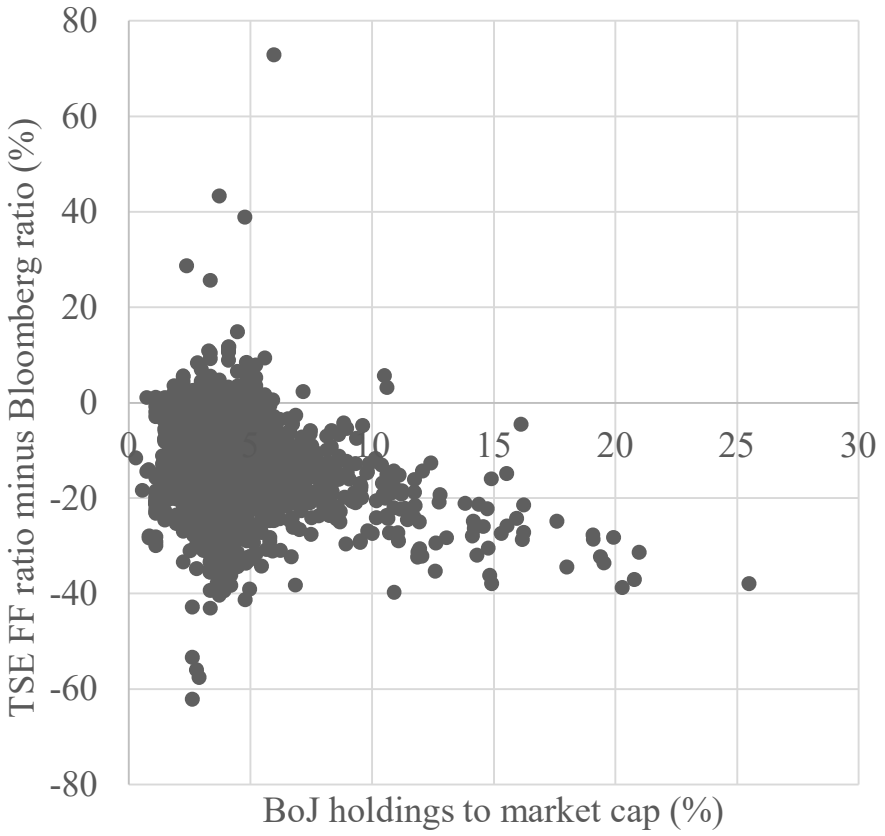
Note: The table shows the estimated exposures (in trillion yen) of the Government Pension Investment Fund (GPIF) to the Tokyo Stock Price Index (TOPIX), the Nikkei 225, and the JPX Nikkei 400 at the end of March of the year. The estimated exposures are obtained by regressing GPIF holdings of individual stocks listed on the First Section of the Tokyo Stock Exchange (in trillion yen) on a constant and the weights of the three indexes at the end of March of each year. t-statistics are reported in parentheses. ** denotes statistical significance at the 1% level. "Total" shows the total amount of the GPIF portfolio of domestic stocks. "Other than TOPIX" is calculated by subtracting the estimated exposure to the TOPIX from "Total." "Other than 3 indexes" is calculated by subtracting the estimated exposures to the three indexes from "Total."

Figure A1. Volatility Index



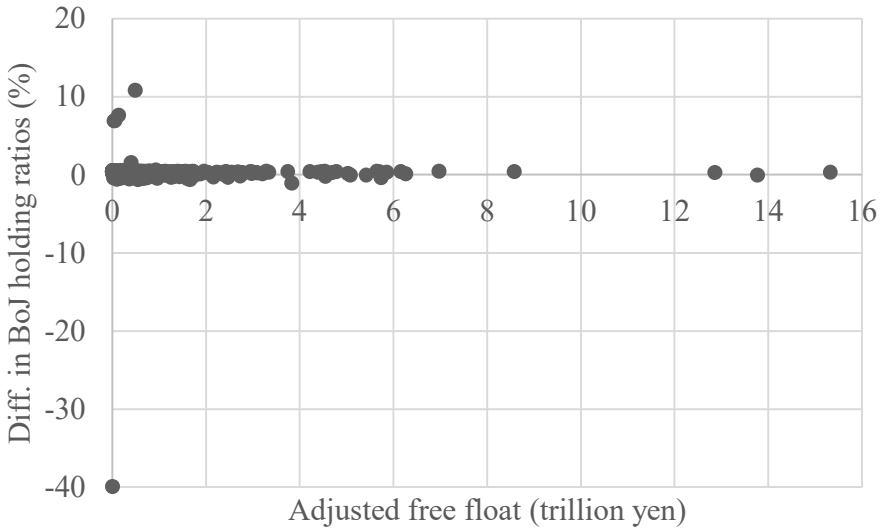
Note: The black line represents the Nikkei Stock Average Volatility Index (in %) from January 4, 2001, to December 30, 2021. The two vertical grey lines represent September 30, 2010, and March 31, 2021.

Figure A2. BoJ Holdings and Difference in the Free Float Ratio



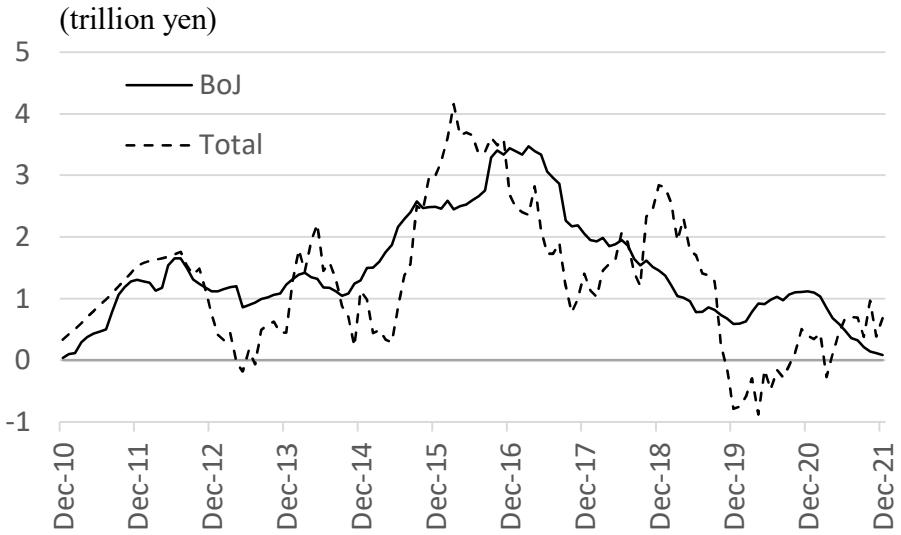
Note: The figure plots the difference between the Tokyo Stock Exchange- and Bloomberg-defined free float ratios against the ratio of Bank of Japan holdings to the market capitalization of issued stocks on March 31, 2021, for all stocks listed on the First Section of the Tokyo Stock Exchange on March 31, 2021.

Figure A3. ETF Weights versus Index Weights



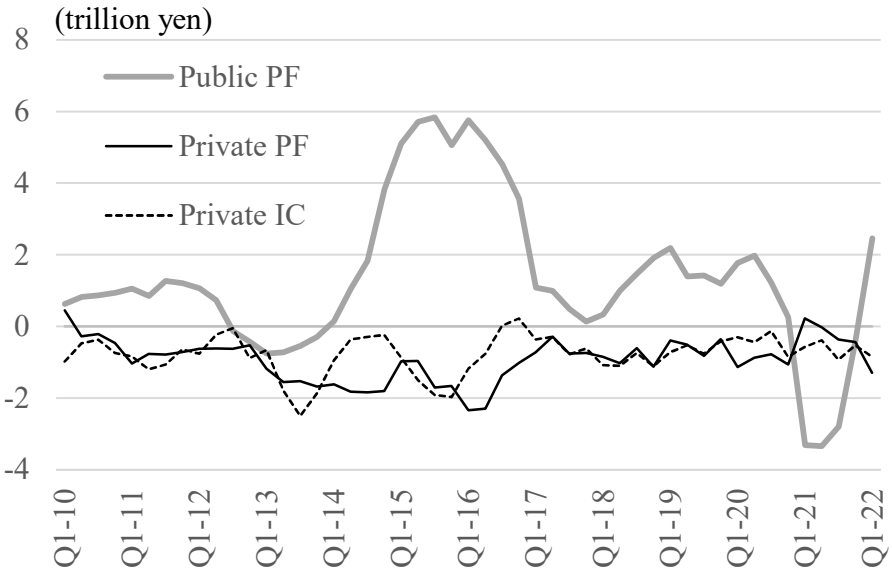
Note: The figure plots the difference between the Bank of Japan holding ratio estimated based on ETF weights and that estimated based on index weights (in %) on the vertical axis against the adjusted free float (i.e., the TSE-defined free float market capitalization plus BoJ holdings in trillion yen) on the horizontal axis.

Figure A4. BoJ Purchases of Nikkei 225 ETFs and Total Flows into Nikkei 225 Index Funds



Note: The figure shows the 12-month moving sums of Bank of Japan purchases of Nikkei 225 ETFs (solid line) and total flows into Nikkei 225 index funds (broken line) in terms of the value as of March 31, 2021, for the period from December 2010, to December 2021. The original data of the total flows are from the Investment Trusts Association, Japan. Annual data are divided by 12 for 2010 and 2011, and the flows from January to July 2012 are divided by 7. The value as of March 31, 2021, is calculated using the Nikkei 225 index price on March 31, 2021, and its monthly averages.

Figure A5. Flows from Pension Funds and Insurers into Listed Stocks



Note: This figure shows the 4-quarter moving sums of flows from public pension funds (Public PF, grey line), private pension funds (Private PF, solid line), and private insurance companies (Private IC, broken line) into listed stocks from the first quarter of 2010 to the first quarter of 2022. The original data are from the Flow of Funds Accounts.