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and Corporate Bond Purchases on Firms' Capital Structure

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Nguyen Thuy Linh,

Graduate School of Economics, Hitotsubashi University

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Abstract

This study examines the effects of the Bank of Japan's (BOJ's) exchange traded fund (ETF) and corporate bond (CB) purchases on the capital structure of Japanese listed firms. The results suggest that following the expansion of ETF purchases, treatment firms actively issued more stocks and became less dependent on bond debt and bank loans than control firms, resulting in a lower level of leverage. In contrast, following the introduction of CB purchases, firms whose bonds were eligible for CB purchases issued more corporate bonds, while reducing long-term bank debt by a smaller extent, thus they have a higher leverage ratio than ineligible firms. Moreover, evidence further suggests the existence of an interaction between these two purchasing programs. These results indicate that the BOJ's ETF and CB purchases have had a considerable impact, implying that the supply of capital plays an important role in determining firms' capital structure.

JEL classification: E52; E58; G32

Keywords: Unconventional monetary policy; Risk asset purchases; Difference in differences; Capital structure; Supply-side effects

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1. Introduction

Ever since Modigliani and Miller (1958) introduced the irrelevance theory of capital structure, the determination of firms' capital structure has been regarded as one of the most intriguing and widely discussed but also controversial topics in the field of corporate finance. Studies to date have primarily concentrated on testing whether the traditional theories of capital structure such as the trade-off and the pecking order theory hold, and have been able to explain a variety of broad patterns of capital structures. However, they have been unable to explain why they observed that, after taking these patterns into account, firms' capital structures change and firms' decision to issue securities are still not uniform. Graham and Leary (2011) noted that a key problem with much of the literature on this topic is that supply-side effects on firms' capital structure have not been thoroughly examined. That is, many studies, in line with Modigliani and Miller (1958), assume that the supply of capital is perfectly elastic and that firms' capital structure is determined entirely by firms' demand for outside financing.

Against this background, this study focuses on the Bank of Japan's (BOJ's) purchases of exchange-traded funds (ETFs) and corporate bonds (CBs) as part of their unconventional monetary policy that was unprecedented at the time. Due to the continuous and massive scale of the purchases, this asset purchase program provides an ideal and unique case study to identify the policy impact on firms' capital structure while taking supply side factors into sufficient consideration.

The research questions this study attempts to answer are the following: (1) Did the BOJ's ETF and CB purchases act as a capital supply shock and affect the firms' access to external financing sources? (2) Did the ETF and CB purchasing program had a significant impact on firms' capital structure and their financing choices, and if so, through which mechanism? And (3) Are there any substitution effects among financing sources, such as between bank loans and bond debt, or equity and debt capital?

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To assess the policy impact, I use data for non-financial firms listed on the first and second sections of the Tokyo Stock Exchange (TSE1 and TSE2) covering the period from 2009 to 2018. Exploiting the fact that it is possible to identify firms whose stocks have been indirectly purchased via ETFs and firms whose bonds are eligible for CB purchases by the BOJ, a difference-in-differences (DID) framework was used to measure the average treatment effects of the purchasing program. Panel data regression techniques and logit models were also employed to complete the analysis.

The results show that the ETF and CB purchases by the BOJ have had a considerable impact on corporate capital structure with the following four major findings. First, following the considerable expansion of the BOJ's ETF purchases, the leverage ratio of firms that belong to the treatment group (i.e., firms that were included in the Nikkei 225 Stock Average) declined. These firms relied more on stock issuance and became less dependent on bond issuance and long-term bank debt than firms in the control group (i.e., non-Nikkei 225 firms). Second, following the introduction of CB purchases by the BOJ, eligible firms have been issuing more bonds, while reducing long-term bank debt by a smaller extent. As a result, they have a higher leverage ratio than firms not eligible for CB purchases. Third, categorizing firms into four groups based on whether their stocks were included in ETF purchases and/or their bonds were eligible for CB purchases shows that the policy impacts on firms' leverage ratio have differed depending on which group a firm fell in. After the policy intervention, the leverage ratio of firms in the group eligible for CB purchases only increased. In contrast, firms included in BOJ ETF purchases only saw a decrease in their leverage. Firms in the group subject to both ETF and CB purchases strengthened their bond and stock issuance activities; however, the impact on their leverage ratio is small, because the positive and negative impacts cancelled each other out. Fourth, evidence on the impacts of the BOJ's ETF and CB purchases on securities issuance of firms in each group further suggests the existence of an interaction between these two

purchasing programs. In particular, the positive effect of ETF (or CB) purchases on targeted firms' stock (or bond) issuance is 1.3 to 2.25 times greater if these firms were not subjected to the other policy – CB (or ETF) purchases. This could be because when there is a need to raise external capital, firms included in both ETF and CB purchases have lower costs of equity and bond debt, thus they can flexibly choose to issue bonds or stocks. In contrast, firms included in solely ETF purchases have a lower cost of equity, but their cost of bond debt is relatively high compared to firms included in CB purchases. As a result, firms included in solely ETF purchases relied more on stock issuance and may have tended to replace bonds with stocks to take advantage of the market conditions. A similar argument could be made for firms included in solely CB purchases. Various supplemental analyses and robustness checks confirm these findings.

To the best of the author's knowledge, this study is the first to examine the impact of the BOJ purchases of risky assets on capital structure, and is most closely related to several studies that concentrate on the effects of a similar policy measure – the European Central Bank's (ECB's) asset purchases on firms' capital structure. For instance, Grosse-Rueschkamp et al. (2019) examine the ECB's Corporate Sector Purchase Programme (CSPP) implemented since 2016, under which the ECB purchases corporate sector bonds. The authors propose a "capital structure channel" of monetary policy: direct corporate bond purchases by central banks reduce the bond yields of firms whose bonds are eligible for these purchases. These firms then substitute bank loans with bond debt. As a result, weak banks experience a decline in loan demand. Due to an increase in banks' lending capacity, those banks later provide credit to firms that might previously have been constrained (e.g., private firms), generating spillovers to the real economy.

The existence of this capital structure channel is corroborated by Betz and De Santis (2019). Employing data on the exact bonds purchased by the ECB, they also show that the CSPP improves the provision of financing to bank-dependent firms including SMEs but argue that the spillover

effect is independent of the quality of bank balance sheets as measured by Tier 1 and non-performing loans ratios. On the other hand, Adelino et al. (2020) show that the CSPP can have spillover effects on firms' capital structure through the "trade credit channel". In particular, eligible firms under the CSPP (large, unconstrained firms) can pass on the additional funding liquidity to their customers through trade credit, thereby enhancing their competitive position in the market.

However, the current study differs from that by Grosse-Rueschkamp et al. (2019) and other existing studies (such as Betz and De Santis (2019) and Adelino et al. (2020)) in a number of ways. The first difference is that whereas these existing studies focus on CB purchases only, this study focuses on purchases of CBs and ETFs. This focus of interest not only reflects the difference between the ECB's and BOJ's asset purchase programs, but also allows me to gauge the impact of an interaction between ETF or CB purchases as presented in the last major finding. Second, this study finds evidence of considerable direct effects of central bank purchases of risky assets (BOJ purchases of ETFs and CBs) on firms' capital structure. In contrast, previous studies that focus on ECB purchases under the CSPP find that the impact of central bank risky asset purchases (ECB purchases under the CSPP) on firms' leverage ratio is insignificant; rather, they divert their attention to the indirect effects on the capital structure of private firms which were not the target of CB purchases by the ECB. Presumably, the difference is due to a smaller extent of substitution between bond and bank debt for listed firms in Japan than that in ECB's member countries. Grosse-Rueschkamp et al. (2019) show that on average, the bond debt to total asset ratio is 15.9% for European firms, while I find that the bond dependence ratio is less than 10% in Japan. This indicates that Japanese firms may have more space to increase their bond issuance without reducing their bank debt and that bond debt is more likely to be a close substitute for bank loans in Europe than in Japan. Third, while Grosse-Rueschkamp et al. (2019) use a treatment group dummy variable, this study takes one step further in its supplementary analysis by measuring the different levels of exposure of

treatment firms to ETF purchases using the calculation method proposed by Gunji et al. (2019), which takes changes in the BOJ's total purchasing amount and the amount allocated to each type of ETF into account. This enables me to quantify the magnitude of the treatment effect more precisely.

The remainder of the study is organized as follows. Section 2 provides a review of the literature. Section 3 describes the institutional framework of the BOJ's ETF and CB purchases, while Section 4 presents the hypotheses and describes the empirical approach and data used. Next, Section 5 provides summary statistics as well as the results of preliminary analyses and the regression results. Finally, Section 6 offers conclusions and suggestions for future research.

2. Literature Review

2.1. Previous studies on capital structure

Capital structure theory originated with the seminal paper by Modigliani and Miller (1958). The relaxation of some of their restrictive assumptions has led to the formation of two major theories of capital structure: the trade-off theory, pecking order theory. Specifically, the trade-off theory stipulates that firms set a leverage target that balances the various benefits and costs of borrowing (Modigliani and Miller (1963), Miller (1977)). On the other hand, the pecking order theory suggests that under asymmetric information, firms, in order to minimize adverse selection costs related to the issuance of securities, will rely on internal finance first, followed by the issuance of debt, and finally the issuance of equity (Myers and Majluf (1984)).

Empirical studies on capital structure have focused on testing the implications of the various theories. They were able to show causal relationships between the leverage ratio and the use of different financing sources on the one hand and various firm characteristics on the other. However, findings on the direction in which some of these firm-specific factors affect capital structure are rather mixed. Graham and Leary (2011) argue that empirical research has

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failed to explain the heterogeneity in firms' debt composition, changes in leverage, and decision to issue securities. They further argue that it is not only corporate demand for outside financing that determines firms' capital structure; rather, the supply of capital may potentially also affect their capital structure.

Several studies have taken the supply side into consideration and concluded that supply factors are relevant for firm financing and capital structure choices. For instance, Faulkender and Petersen (2006) found that firms have notably different leverage ratios depending on whether they have access to the public bond market, which they measure based on whether a firm has a credit rating. Baker and Wurgler (2002) proposed the market timing hypothesis, which suggests that firms tend to issue equity when their shares are overvalued and buy back equity when their shares are undervalued in the market.

Another approach to examine the relevance of supply side factors for leverage is to focus on supply shocks. For instance, focusing on the introduction of syndicated loan ratings by Moody's in 1995, Sufi (2009) concluded that this resulted in an increase in debt issuance and investment by firms that obtained a rating. Meanwhile, Leary (2009) examined the impact on firms' capital structures of two changes in bank funding constraints: the introduction of negotiable CDs in the early 1960s and the imposition of regulatory interest rate ceilings in 1966. He showed that these loan supply shocks had differential effects on both the leverage ratios and the mix of bank vs. non-bank debt of small firms relative to large firms.

Furthermore, when examining supply shocks faced by firms, it is important to control for macroeconomic conditions. This is illustrated by Korajczyk and Levy (2003), who found that firms' target leverage is counter-cyclical to macroeconomic conditions for unconstrained firms but pro-cyclical for relatively constrained firms. Meanwhile, examining the speed with which firms adjust their capital structure, Cook and Tang (2010) concluded that firms adjust their leverage toward the target faster in good than in bad macroeconomic states.

2.2. Literature on the impact of central banks' risky asset purchases

The preceding subsection highlighted the importance of supply side factors as determinants of firms' capital structure and described how studies have focused on supply-side shocks to examine these links. One of the potential sources for the supply shocks is the unconventional monetary policy that include risk asset purchases.

The BOJ was the first to introduce such measures. Regarding the BOJ's purchases of CBs and/or ETFs, several authors have found significant impacts of the policy on different aspects, including credit spreads, the stock market and stock prices, and firm performance and investment, while none of them have focused on firms' capital structure.

For the study on the purchases of corporate bonds, Suganuma and Ueno (2018) show that the BOJ's corporate and government bond purchases have a significant impact on Japanese firms' credit spreads through several channels: the default risk channel, the local and global supply channels, and the risk-taking channel.

For the studies on ETF purchases, Harada and Okimoto (2019) find that following the introduction of the BOJ's ETF purchasing program, the afternoon returns of Nikkei 225 stocks have been significantly higher than those of non-Nikkei 225 stocks on days when the BOJ purchased ETFs, implying that the BOJ's interventions have a considerable impact on daily stock prices. Gunji et al. (2019) estimate the influence of the BOJ's ETF purchases on corporate performance. Their DID analysis suggests that the policy has lowered firms' profits. They explain that because the BOJ purchases ETFs via trust banks, the exercise of voting rights is delegated to the trust banks. However, trust banks as passive investors are more likely to focus on the short term and may not exercise sufficient monitoring, so that stock holdings via trust banks may have a negative effect on corporate performance and governance. Charoenwong et al. (2019) find evidence consistent with Harada and Okimoto's (2019) result that the BOJ's ETF purchases boost share prices. Importantly, they further argue that the BOJ's ETF

purchases increase firms' cash holdings and short-term investment. On the other hand, they find no significant impact on real tangible capital investment, implying that the BOJ's ETF purchases do not prove to be an effective way to stimulate corporate investment.

The BOJ's unconventional monetary policy of risky asset purchases was followed by the ECB. Several studies concentrate on asset purchases implemented by the ECB, and investigate the effects on firms' capital structure; however, they do not necessarily find evidence for the direct impact on firms' capital structure and examine the impact on the capital structure of unlisted firms that are not eligible for the ECB's CB purchases. As mentioned, Grosse-Rueschkamp et al. (2019) examine the ECB's CSPP and propose a "capital structure channel" of monetary policy: Following the ECB's CB purchases, eligible firms substitute bank loans with bond debt. Consequently, the purchase program leads to an increase in weak banks' lending capacity, and those banks later provide credit to financially constrained firms (e.g., private firms). The authors conclude that central banks' purchases of CBs strengthen the bank lending channel because they change the financing incentives of large firms with access to public debt. Evidence by Betz and De Santis (2019) suggests that the above capital structure channel does exist. However, the authors argue that the spillover effect does not depend on the bank balance sheets quality. Another channel through which the CSPP can have spillover effects on firms' capital structure is the "trade credit channel," as highlighted by Adelino et al. (2020). They show that eligible firms can provide more trade credit to their customers. As a result, those customer firms of eligible suppliers increase employment and investment, and may expand trade credit to their own customers.

To sum up, there are a number of studies examining the impact of risky asset purchases by the BOJ from a variety of angles. However, to date, there are no studies examining the impact on firms' corporate structure through the various potential channels identified. To the best of the author's knowledge, this study therefore is the first to examine the impact of the BOJ

purchases of risky assets on capital structure, and to find evidence of considerable direct impacts of central bank risky asset purchases on firms' capital structure.

3. The BOJ's Purchases of Risky Assets

This section provides an overview of the BOJ's policy of purchasing risky assets. It starts with a brief review of unconventional monetary policy in Japan and then describes the BOJ's policy of purchasing ETFs and CBs.

3.1. Unconventional monetary policy in Japan

Unconventional monetary policy is defined as interventions by the central bank to achieve further monetary loosening after the policy interest rate has more or less fallen to zero percent. The BOJ introduced the world's first unconventional monetary policies, namely the zero interest rate policy during February 1999 to August 2000, and quantitative easing (QE) during March 2001 to March 2006. Figure 1 shows the evolution of unconventional monetary policy in Japan.

[Figure 1]

Following the implementation of QE, the BOJ in 2010 introduced Comprehensive Monetary Easing (CME) and expanded it in the following years in order to mitigate the negative impact of the global financial crisis in 2008. The most important element of CME was the credit easing policy, under which the BOJ purchased risky assets, including asset-backed securities, commercial paper, CBs, ETFs and Japan real estate investment trusts (J-REITs) through the establishment of the Asset Purchase Program to compress the risk premium.

Although CME led to an improvement in the economy and rising prices, that improvement did not last. Therefore, in April 2013, the BOJ introduced Quantitative and Qualitative Monetary Easing (QQE). Under this policy, the BOJ conducted operations to increase the monetary base at an annual pace of about 60–70 trillion yen and set an inflation target of 2

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percent. In addition, the BOJ increased its purchases of Japanese government bonds (JGBs) and risky assets, especially ETFs, on a massive scale.

QQE quickly had a considerable impact and contributed to the economic recovery, but the price stability target of 2 percent was not attained. In January 2016, it introduced QQE with a Negative Interest Rate, under which a negative interest rate of minus 0.1 percent is applied to part of the current account balances that financial institutions hold at the BOJ. Further, in September 2016, the BOJ announced the adoption of QQE with Yield Curve Control. QQE with Yield Curve Control consists of two main components. The first is "yield curve control," under which the BOJ controls short-term and long-term interest rates through market operations. The second component is an "inflation-overshooting commitment," under which the BOJ commits itself to expanding the monetary base until the yearly increase in the consumer price index (CPI) exceeds the 2 percent price stability target.

3.2. The BOJ's ETF and CB purchasing policy

A key component of the BOJ's unconventional monetary policy, as mentioned, is the Asset Purchase Program. To give an impression of the scale of the program and the relative importance of the different types of asset purchases, Figure 2 shows the total outstanding amount of the BOJ's commercial paper, CB, ETF and J-REIT holdings from 2010 to 2019.

[Figure 2]

At the beginning of 2011, when the BOJ started to buy risk assets, the outstanding amount of commercial paper was the largest, followed by CBs, ETFs, and J-REITs, respectively. However, since the introduction of QQE in 2013, the outstanding amount of ETFs purchased by the BOJ has increased dramatically and has surpassed all other risk assets purchased by the BOJ: the BOJ's ETF holdings rose from 0.185 trillion in 2010 to 2.5 trillion in 2013 and 23.5 trillion at the end of 2018, whereas the outstanding amount of CBs, J-REITs, and commercial paper holdings since 2013 has remained more or less unchanged.

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According to the BOJ's statistics, the bank's total assets had reached 572.2 trillion yen as of October 10, 2019, of which CB and ETF holdings amounted to 3.1 and 27.5 trillion yen. Because of the large scale of such purchases and the continuing nature of this intervention, the BOJ's ETF and CB purchases can be regarded as a positive supply shock in the availability of funds for firms that were subjected to the purchases.

3.2.1. Outline of ETF purchases

Exchange traded funds (ETFs) are a type of investment security that involves a basket of securities such as stocks, bonds, and commodities. ETFs often track underlying indexes and are traded on stock exchanges as ordinary stocks. To date, the BOJ is the only central bank in the world that indirectly holds company stocks through the purchase of ETFs. According to the BOJ's principal terms and conditions,[1] since October 2014 the ETFs to be purchased by the BOJ are ETFs whose prices track the Tokyo Stock Price Index (TOPIX), the Nikkei 225 Stock Average (Nikkei 225), or the JPX-Nikkei Index 400.

Furthermore, the principal terms and conditions specify that the BOJ purchases ETFs via trust banks, conforming to a standard prescribed by the BOJ and taking into account conditions in the market. Moreover, the BOJ tends to make interventions after witnessing a decline in stock prices and stops intervening when stock prices are on an upward trend. This can be seen in Figure 3, which was constructed by Samikawa and Takano (2018) and shows developments in the Nikkei 225 and the amount of ETF purchases on a daily basis for the period from July 2016 to March 2018. The data underlying Figure 3 also suggest that the BOJ intervened on about one-third of business days.

[Figure 3]

Through the purchase of ETFs that track the TOPIX, Nikkei 225, or JPX-Nikkei Index 400, the BOJ indirectly holds firms' stocks and has become a top shareholder of many listed

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[1] For details, see: https://www.boj.or.jp/en/mopo/measures/term_cond/yoryo85.htm/.

companies. Some researchers (e.g., Samikawa and Takano (2018), Gunji et al. (2019)) have tried to estimate the percentage of shares the BOJ holds in various companies. Stocks that have higher Nikkei 225 and/or TOPIX weights are likely to have a higher percentage of shares held by the BOJ.

[Table 1]

Table 1 presents the 26 companies with the highest BOJ shareholding rates as of July 2018. The table indicates that Advantest, Fast Retailing, Taiyo Yuden, TDK, and Family Mart UNY Holdings are the five companies with the highest BOJ indirect shareholding ratios. Remarkably, on a floating stock basis, the ratio of shares indirectly held by the BOJ for Fast Retailing – a company that owns various fashion brands such as UNIQLO and GU – was 88.3 percent as of July 2018, substantially higher than for all other companies.

3.2.2. Outline of purchases of CBs

Unlike in the case of ETFs, where the names of the companies' whose stocks were purchased by the BOJ are clearly known, data on companies whose bonds were purchased by the BOJ are highly confidential and not available to researchers. However, the BOJ does publish the principal terms and conditions for outright purchases of CBs,[2] including which CBs are eligible for purchase, the purchasing methodology, and the maximum outstanding amount to be bought. Specifically, eligible CBs must fulfill the general criteria,[3] have a remaining maturity of 1 to 3 years and have a rating of BBB or higher by an eligible rating agency or, if they do not have a rating of BBB or higher, must be fully guaranteed by a company rated BBB

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[2] For details, see: https://www.boj.or.jp/en/mopo/measures/term_cond/yoryo83.htm/.
[3] The general criteria are as follows: Eligible CBs must "(a) Satisfy the eligible collateral standard set forth in the "Guidelines on Eligible Collateral" (Policy Board Decision on October 13, 2000). Criteria prescribed in 4.(2) through (7) shall also be satisfied, if applicable; (b) [be] issued on or before the day of auction" (Source: Bank of Japan, "Establishment and Abolishment of Principal Terms and Conditions in Accordance with the Introduction of the "Quantitative and Qualitative Monetary Easing," April 4, 2013. Online: https://www.boj.or.jp/en/announcements/release_2013/rel130404a.pdf).

or higher by an eligible rating agency. Thus, the CB purchase program focuses on short-term bonds with a high credit rating.

Moreover, the BOJ's terms and conditions stipulate that the maximum outstanding amount of CBs by a single issuer that the BOJ shall purchase is 100 billion yen and that if the outstanding amount of a single issuer's CBs purchased by the BOJ at the time of purchase exceeds 25 percent of the total issued amount, such CBs would be excluded. Regarding the method used for the outright purchases of CBs, the BOJ relies on multiple-price competitive auctions, where counterparties bid their desired yield at which they wish to sell CBs to the BOJ. The CBs purchasing price will then be determined using the yield from the competitive auction.

3.2.3. Purchasing rules for ETFs and CBs

Table 2 provides an overview of the BOJ's major revisions of the ETF and CB purchase program. With the purpose of ensuring stability in financial markets and facilitating corporate financing, the BOJ started the outright purchases of CBs in February 2009. To be eligible, corporate bonds had to be rated A or higher and have a remaining maturity of less than one year.[4] Outright purchases of CBs ended on December 31, 2009, before restarting again in October 2010 under the CME policy.

[Table 2]

When the BOJ introduced CME in October 2010, the purchasing of risk assets including ETFs and CBs was meant to be temporary. Only ETFs that track the TOPIX or the Nikkei 225 were to be purchased, and the amount of each ETF to be purchased would be roughly proportionate to the total market value of that ETF issued. Eligibility criteria for CBs were that they were rated BBB or higher and had a remaining maturity of 1 to 2 years. However, in practice, the BOJ did not abolish the policy at the end of 2011 as scheduled but in fact extended the program. From 2010 to 2012, the maximum purchasing amount for CBs always exceeded

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[4] For details, see: https://www.boj.or.jp/en/mopo/measures/term_cond/yoryo44.htm/.

that for ETFs, thus it seems reasonable to conclude that before the introduction of QQE the BOJ put more emphasis on the purchase of CBs than ETFs.

Since October 2012, the eligibility criteria and the amount of CB purchases remained stable. In contrast, following the introduction of QQE, the purchasing rules for ETFs have been adjusted several times and the ETF purchase program has been substantially expanded in scale. In April 2013, the BOJ announced that ETFs would be purchased at an annual pace of 1 trillion yen; moreover, in October 2014, the BOJ tripled the annual purchase amount to 3 trillion yen and added ETFs that track the JPX-Nikkei Index 400 to those eligible for BOJ purchases. As a result, the total outstanding amount of ETFs purchased by the BOJ in September 2014 reached 3.22 trillion yen, exceeding the amount of CBs held by BOJ of 3.17 trillion yen, as shown in Figure 2.

Further, on July 29, 2016, the BOJ decided to increase the annual purchase amount from 3.3 trillion to 6 trillion yen and has maintained this annual pace up until now. On September 21, 2016, and July 31, 2018, the BOJ announced changes to the amount of money allocated for the purchase of each type of ETF shown in Figure 4.[5] According to the announcement on September 21, 2016, of the annual purchase amount of 5.7 trillion, 3 trillion yen would be distributed to ETFs that track any of the three indexes as before, while 2.7 trillion yen would be allocated to TOPIX ETFs. On July 31, 2018, the BOJ adjusted the amount allocated to ETFs tracking the three indexes from 3 trillion to 1.5 trillion, and increase the amount to be spent on TOPIX ETFs significantly from 2.7 trillion to 4.2 trillion yen.

[Figure 4]

Because the amount of each ETF purchased was to be roughly proportional to the total market value of that ETF issued, the BOJ for a long time – from the beginning of such

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[5] Figure 4 is taken from two BOJ announcements available online at:
https://www.boj.or.jp/en/announcements/release_2016/rel160921c.pdf and
https://www.boj.or.jp/en/announcements/release_2018/rel180731h.pdf.

purchases in 2010 until September 20, 2016 – focused largely on purchases of Nikkei 225 ETFs and spent more than half of its "budget" on ETFs that track this index. However, following the change in September 2016, the BOJ has gradually put more weight on ETFs tracking the TOPIX instead of the Nikkei 225. While the BOJ has not explained its reasons, one possible explanation is that the large purchases of Nikkei 225 ETFs have led to concerns about the possible distortion of stock prices and negative effects on corporate performance and governance, so that the BOJ may have adjusted the allocation of purchases to mitigate this type of impact.

4. Methodology and Data

This section provides an overview of the methodology and data used in this study. Specifically, Section 4.1 presents the hypotheses regarding the impact of the BOJ's CB and ETF purchases on firms' capital structure that will be examined. Next, Section 4.2 outlines the methodology used for the analysis, while Section 4.3 describes the data and variables employed.

4.1. Hypotheses

This subsection presents various hypotheses regarding the impact of the BOJ's CB and ETF purchases that will be empirically examined in Section 5.

Hypothesis 1 (impact of the BOJ's ETF purchases): *Following the adoption of QQE in 2013, Nikkei 225 component firms decreased their leverage ratios relative to non-Nikkei 225 firms, increased their stock issuance activities, and substituted bond financing with equity financing*.

Specifically, the large expansion in BOJ ETF purchases in 2013 may have led to a reduction in risk premiums on assets and in the cost of equity capital for Nikkei 225 component firms, providing them with easier access to equity markets than firms on the first and second sections

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of the TSE that are not components of the Nikkei 225. As a result, to raise capital, Nikkei 225 firms may have relied more on stock issuance and become less dependent on bond issuance and long-term debt, lowering their leverage ratios overall.

Hypothesis 2 (impact of the BOJ's CB purchases): *Following the introduction of CME in 2010, firms whose CBs were eligible for BOJ purchases strengthened bond issuance activities. There may exist a substitution effect between bond debt and bank debt; however, the magnitude of such effect may have been small. As a result, eligible firms increased their leverage ratio relative to firms whose CBs were not eligible for BOJ purchases.*

BOJ purchases of CBs may have reduced the yield on eligible bonds, making it easier for issuing firms of such bonds to access the public bond market. Eligible firms will likely have taken advantages of this opportunity and have increased their bond issuance. They may have substituted long-term bank debt with bond debt, although the magnitude of such a substitution effect may have been small because of the benefits provided by long-term relationships with banks such as the mitigation of information asymmetry problems and the loosening of lending constraints. In sum, it is likely that the leverage ratios of eligible firms increased following the intervention.

Hypothesis 3 (combined impact of ETF and CB purchases): *Some firms may have been eligible for both ETF and CB purchases, while others may have been eligible for one of the two or none, and the impact of the program may have differed depending on which group a firm fell in.*

Concretely, firms can be divided into four groups depending on whether both their stocks and bonds (*Both*), only their stocks (*Stocks only*), only their bonds (*Bonds only*), or neither (*Neither*) were eligible for the BOJ's ETF and CB purchases. Given Hypothesis 1 and 2, it is possible that after the policy intervention, the leverage ratio of firms in the *Bonds only* group may have increased, while firms in the *Stocks only* group may have seen a decrease in their

leverage. Firms in the *Both* group (i.e., their stocks were included in ETF purchases and their bonds were eligible for CB purchases) may have strengthened their bond and stock issuance activities; however, their leverage ratio may have remained more or less unchanged because the positive and negative impacts may have cancelled each other out.

4.2. Methodology

To investigate whether the above hypotheses are correct, I start by examining the impact of the BOJ's ETF and CB purchases on firms' capital structure separately before examining them together to gauge their simultaneous impact. The effect of the policy interventions on corporate capital structure is estimated using the DID approach and panel data regression techniques, namely pooled ordinary least squares (pooled OLS), fixed effects models (FEM), and random effects models (REM). Finally, I also examine the impact of the policy interventions on firms' issuance of stock and bonds using a logit model. The model specifications are as follows.

4.2.1. BOJ purchases of ETFs

To estimate the effect of the BOJ's ETF purchases, the following model is regressed:

$$Y_{it} = \alpha_1 + \alpha_2 N225_i + \alpha_3 ETFPost_t + \delta_{ETF}(N225_i \times ETFPost_t) + X_{it}{}' \ \beta + Z_i + \varepsilon_{it} \quad (1)$$

where $N225_i$ is a dummy variable that equals one for Nikkei 225 component firms and zero otherwise; $ETFPost_t$ is a dummy variable that equals one for the ETF purchases treatment period, i.e., the period after the introduction of QQE on April 5, 2013. X_{it} is a vector of control variables[6] consisting of firm-specific factors (size of interest tax shield, cash ratio, tangibility of assets, firm size, profitability, current ratio, market to book (MB) ratio, firm age), macroeconomic control variables (GDP growth, CPI) and industry dummies; Z_i represents unobserved firm fixed effects, and ε_{it} is the error term. For the dependent variable (Y_{it}), three alternative proxies for firms' leverage (total leverage, short-term leverage, long-term leverage) and three variables related to firms' debt structure (their bond ratio, short-term bank loan ratio,

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[6] The rationale for the choice of the control variables is provided in Section 4.3 describing the data and variables.

and long-term bank loan ratios) are used to examine the effect of the BOJ's ETF purchases on firms' capital structure and debt structure.

In model (1), δ_{ETF} is the estimator of the average treatment effect on the treated (ATT). Because time-invariant explanatory variables are included in the regression equation, model (1) is run using pooled OLS and random effects regression, both with standard errors clustered at the firm level.

It should be noted that, as discussed in Section 3.2, from October 2010 until before the announcement of the QQE policy, the BOJ put greater emphasis on purchases of CBs than ETFs. By contrast, since April 2013, the ETF purchases program has been significantly expanded and the BOJ's holdings of ETFs as a result of such purchases have come to significantly outstrip holdings of CBs and other risk assets. Therefore, in the analysis, I choose the period after the introduction of QQE in 2013 as the treatment period for ETF purchases, and the period after the introduction of CME in 2010 as the treatment period for CB purchases. In addition, because the BOJ focused largely on purchases of Nikkei 225 ETFs and spent more than half of its "budget" on ETFs that track this index until 2016, in model (1), Nikkei 225 component firms are the ETF-treatment group and non-Nikkei 225 firms listed on TSE1 and TSE2 are the ETF-control group. Meanwhile, under the CB purchasing program, the CB-treatment group consists of firms whose CBs are eligible for the BOJ's CB purchases, while the CB-control group consists of firms whose CBs are ineligible.

4.2.2. BOJ purchases of CBs

In contrast with ETF purchases, where treatment firms are explicitly known, information on which CBs the BOJ purchased is unavailable. The BOJ only publishes general information on what CBs are eligible for purchases, namely, CBs with a remaining maturity of 1 to 3 years and a rating of BBB or higher. Therefore, these criteria are used to identify firms whose bonds were eligible for the BOJ's CB purchases, and such firms are used as the treatment group for

CB purchases, although it should be noted that the BOJ may not have made purchases of all eligible CBs. Using the treatment group thus defined, the DID is framework is employed to examine the impact of the BOJ's CB purchases on firms' capital structure.

The DID model is specified as follows:

$$Y_{it} = \beta_0 + \delta_{CB}(CBEligible_{it} \times CBPost_t) + X'_{it}\beta + Z_i + \varepsilon_{it} \qquad (2)$$

where $CBEligible_{it}$ is a dummy variable that equals one for firms whose CBs are eligible for BOJ purchases and zero otherwise; $CBPost_t$ is a dummy variable that equals one for the intervention period (i.e., the period after the introduction of CME on October 28, 2010) and zero otherwise; X_{it} is a vector of the same control variables as in model (1); Z_i represents unobserved firm fixed effects, and ε_{it} is the error term. For the dependent variable (Y_{it}), the same proxies for leverage and variables related to debt structure as in model (1) are used.

To generate the $CBEligible$ dummy, bond issuance data for the 10 years prior to the estimation period (from 1999 onward) were collected to cover as many corporate bonds satisfying the eligibility criterion of having a remaining maturity of 1 to 3 years as possible. In model (2), coefficient δ_{CB} measures the intention-to-treat (ITT) effect. Because the firms whose bonds are eligible for CB purchases vary from year to year, both fixed effects and random effect models can be used to estimate model (2). Which of the two is more appropriate will be decided on the basis of the Hausman test.

4.2.3. Combination of ETF and CB purchases

As mentioned, firms can be categorized into four groups based on whether their stocks and bonds were subjected to the ETF and/or CB purchases by the BOJ. Given this, the model to estimate the impact of the BOJ's ETF and CB purchases on firms' capital structure is specified as follows:

$$Y_{it} = \gamma_0 + \gamma_1 Both_{it} + \gamma_2 Bonds\_only_{it} + \gamma_3 Stocks\_only_{it} + X'_{it}\beta + Z_i + \varepsilon_{it} \qquad (3)$$

where

$$Both_{it} = 1 \Leftrightarrow N225_i \times ETFPost_t = 1 \ \& \ CBEligible_{it} \times CBPost_t = 1,$$

$$Bonds\_only_{it} = 1 \Leftrightarrow N225_i \times ETFPost_t = 0 \ \& \ CBEligible_{it} \times CBPost_t = 1,$$

$$Stocks\_only_{it} = 1 \Leftrightarrow N225_i \times ETFPost_t = 1 \ \& \ CBEligible_{it} \times CBPost_t = 0,$$

which implies that, during the treatment period, firms in the *Both* group qualify for both ETF

and CB purchases (i.e., their stocks were included in the Nikkei 225 index and/or their bonds

were eligible for CB purchases), while firms in the *Bonds only* group qualify only for CB

purchases and firms in the *Stocks only* group qualify only for ETF purchases. X_{it} is a vector

of control variables, Z_i represents unobserved firm fixed effects, and ε_{it} is the error term.

Using model (3), Y_{it}, that is, the proxies for firms' leverage ratio and debt structure (i.e.,

bond and bank loan ratios), will be regressed on the dummies representing which group firms

fall into and control variables using the REM. Model (3) makes it possible to compare the

leverage of firms in the above three groups (*Both, Bonds only, Stocks only*) and firms whose

bonds and stocks are both ineligible for purchases by the BOJ (in the *Neither* group).

4.2.4. Impact of the BOJ's ETF and CB purchases on firms' bond and stock issuance

Another of issue of interest is the impact of the BOJ's ETF and CB purchasing programs

on firms' stock and bond issuance activities. To examine this impact, I first collect bond and

stock issuance data to construct dummies for the issuance of stocks and bonds, which are used

as the dependent variables (Y_{it}). *Stock issuance*$_{it}$ equals one if firm i issued stock that falls

into one of three types – private placement, issue at market price, or preferred stock – in year

t, and zero otherwise. *Bond issuance*$_{it}$ equals one if in year t, firm i issued straight bonds of

any maturity, and zero otherwise.

Since the dependent variable (Y) has a binary outcome and can only take a value of zero or

one, as in this case, logit estimation is employed. Specifically, the following logit model is

estimated:

$$ln\frac{p}{1-p} = \beta_0 + \beta_1 X_{1it} + \cdots + \beta_K X_{Kit} + \varepsilon_{it} \tag{4}$$

where $P(Y_{it} = 1|X) = p$ is the response probability (the probability of success), which

indicates the probability that a firm issued stocks or bonds during a given year. X $(X_{1it},...,X_{Kit})$ is a vector of independent and control variables.

Concretely, to examine whether there is a causal relationship between the probability that a firm issued stocks or bonds and its eligibility for ETF and CB purchases, the stock and bond issuance dummies ($Stock\ issuance_{it}$, $Bond\ issuance_{it}$) are regressed on (i) the interaction term between the Nikkei 225 dummy and the ETF purchases treatment period dummy ($N225_i \times ETFPost_t$), (ii) the interaction term between the CB-eligibility dummy and the CB purchases treatment period dummy ($CBEligible_{it} \times CBPost_t$), (iii) firm group dummies based on their eligibility for ETF and CB purchases ($Both, Bonds\ only, Stocks\ only$) separately, as well as firm-specific factors, namely firms' interest tax shield, cash ratio, tangibility, size, profitability, current ratio, and age.

4.3. Data and Variables

To examine the impact of the BOJ's ETF and CB purchases, I collect data on listed non-financial firms on the first and second sections of the Tokyo Stock Exchange (TSE1 and TSE2) for the period from 2009 to 2018. Firm data, including balance sheet data, annual income statement data, and historical data of stock and bond issuances, are obtained from Nikkei NEEDS Financial Quest, while macroeconomic data are obtained from the databases of the World Bank and the International Monetary Fund.

Throughout this study, I use eight dependent variables, which can be divided into three main categories: proxies for leverage, variables related to debt financing decisions, and issuance dummies. The key independent variables are related to the BOJ's purchasing program and consist of the *N225* dummy, the *ETFPost* dummy, the interaction terms *N225*ETFPost* and *CBEligible*CBPost*, and three firm group dummies based on their eligibility for ETF and CB purchases by the BOJ (*Both, Bonds only, Stocks only*). I also employ a set of variables to control for firm-specific characteristics and macroeconomic conditions. In addition, industry

dummies for 29 out of 33 industries using the TSE industry code (sector code) are used. Banks and financial services firms – i.e., firms belonging to the following four industry categories: (i) banks, (ii) securities & commodity futures, (iii) insurance, (iv) other financing business – as well as firms that are non-classifiable are excluded from the sample. Table 3 provides definitions of all the variables used in this study, while Table 4 explains the predicted signs for the impact of these variables on firms' leverage.

[Table 3]

[Table 4]

The sample of firms used for the analysis was compiled based on data for 2011, i.e., following the establishment of the Asset Purchase Program. In this study, I ignore firm entry and exit from the indexes (Nikkei 225 & TOPIX) and the stock exchange (TSE1 & TSE2). To remove outliers, firms that have a leverage ratio of less than zero or higher than one are excluded from the sample. The full sample includes 1,758 firms, of which 1,411 are list on TSE1 and 347 are listed on TSE2. Of the 1,411 TSE1 firms, 179 firms are components of the Nikkei 225 index.

[Table 5]

Table 5 provides an overview of the number of firms falling into each of the four groups in terms of their eligibility for BOJ asset purchases in the years from 2009 to 2018. The table shows that from 2013, the number of firms in each of the four groups is relatively stable: there are approximately 114 firms in the *Both* group, 105 firms in the *Bonds only* group, and 65 firms in the *Stocks only* group, while most firms (about 1,474 firms) fall into the *Neither* group. The last column shows the number of firms for which the CB-eligibility dummy equals one in the CB purchases intervention period. On average, there are around 242 eligible firms under the CB purchasing program, accounting for 14 percent of the total number of firms.

5. Empirical Results

This section presents the results of the empirical analysis based on the approach described in the preceding section. It starts with the presentation of summary statistics, then discusses the results of preliminary and regression analyses, and finally provides additional analyses to check the robustness of the baseline regression results.

5.1. Summary statistics

To gain a sense of the data, Table 6 presents summary statistics of the variables used in the study. The figures are the averages for the observation period overall from 2009–2018.

[Table 6]

Starting with the dependent variables, the mean of firms' leverage ratio is 49.0 percent, the short-term leverage ratio is 32.2 percent, and the long-term leverage ratio is 16.8 percent. On average, bond debt accounts for 9.7 percent of total liabilities, which is much smaller than the average percentage of short-term and long-term bank loans with 18.3 percent and 17.4 percent. Further, the stock and bond issuance dummies suggest that firms are more likely to issue bonds than stocks in any given year, which is consistent with the pecking-order theory that debt is usually a cheaper source of finance than equity.

Turning to the independent variables (the policy-related dummy variables and the control variables), these show that Nikkei 225 firms account for about 10 percent of total firms, while the share of firms whose bonds are eligible for BOJ purchases (*CBElibigle* dummy) is slightly higher at about 12 percent. Next, looking at the firm-specific variables, the summary statistics indicate that the firms included in the sample are quite heterogeneous. For example, looking at the minimum and maximum values, firms differ substantially in terms of their size, cash ratio, profitability, etc.

5.2. Preliminary analysis

This subsection presents the results of preliminary analyses to get an impression of developments in firms' financing during the observation period. To start with, Table 7 shows developments in leverage ratios when sample firms are divided into three groups: Nikkei 225, TSE1 Non-Nikkei 225, and TSE2 firms.

[Table 7]

The table indicates that in all years, the mean leverage of Nikkei 225 firms is highest, followed by TSE2 firms, and then TSE1 non-Nikkei 225 firms. Moreover, there is a clear downward trend in the mean leverage for all three groups. Between 2009 and 2012, the mean leverage ratios of the three groups decrease by about the same extent (about 1 percentage point); however, in the period 2013–2018, when the BOJ's purchases of ETF expanded substantially, the mean leverage of Nikkei 225 firms decreased dramatically by 4.5 percentage points, while the mean values of the other two groups decreased by only 2–2.5 percentage points. These developments suggest that the BOJ's ETF purchases appear to have led to a reduction in the leverage ratios mainly of firms whose stocks were included in ETF purchases, i.e., mainly Nikkei 225 firms. This decline in leverage ratios, in turn, suggests that when Nikkei 225 firms wanted to raise outside capital, they appear to have preferred equity financing to debt financing, relying on the issuance of stocks instead of relying on bank loans or bond debt.

Next, Table 8 examines differences between the mean debt ratios of firms whose CBs were eligible and those whose CBs were not eligible for BOJ purchases. The two debt ratios used are Bonds & convertibles/Total assets (Bonds/TA ratio) and Long-term bank loans/Total assets (Bank loans/TA).

[Table 8]

The table indicates that the ratios are always higher for eligible firms than non-eligible firms. Further, the Bonds/TA ratio of eligible firms rose from 7.51 percent in 2010 to 8.33 percent in 2012 during the period when the BOJ mainly focused on purchases of CBs. In

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contrast, the ratio of ineligible firms decreased during the same period, suggesting that eligible firms actively issued more bond debt in the wake of the BOJ's purchases, while the opposite is true for ineligible firms. However, in the period 2013–2018, the Bonds/TA ratio of eligible firms started to decrease after reaching a peak of 8.5 percent in 2013. Given that the magnitude of CB purchases remained unchanged and became relatively small compared to purchases of ETFs, it is possible that the positive impact of CB purchases on corporate bond financing has been weakening since 2013.

Moreover, turning to the figures for bank loans, Table 8 indicates that the Bank loans/TA ratio of eligible firms followed a declining trend while that of ineligible firms followed an increasing trend during the observation period. The developments can be interpreted as suggesting that after the BOJ introduced CB purchases, eligible firms not only increased their bond issuance activities but may have substituted bank loans with bond debt. Meanwhile, faced with a decrease in borrowing demand, commercial banks may have used idle funds to increase lending to ineligible firms, so that the bank loan ratio of ineligible firms may have increased due to such spillover effects. The results of this preliminary analysis are consistent with the hypotheses presented above and the findings from the regression analysis presented in the next section.

5.3. Regression Analysis

5.3.1. BOJ purchases of ETFs

First of all, it is necessary to check whether the parallel trend assumption – a key prerequisite for the DID method – holds. In particular, this assumption requires that if there were no treatment or policy changes, the changes in outcomes over time would be the same in both the treatment and the control group. To this end, Figure 5 depicts the trend in the average leverage of Nikkei 225 and non-Nikkei 225 firms. As can be seen, the average leverage ratios of the treatment group (Nikkei 225 firms) and the control group (non-Nikkei 225 firms) follow

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a common trend before the expansion of the BOJ's ETF purchase policy in 2013; however, from 2013, the average leverage of Nikkei 225 firms declined more sharply than that of non-Nikkei 225 firms, suggesting that the parallel trend assumption is not violated.

[Figure 5]

Next, Tables 9 and 10 examine the effect of the BOJ's ETF purchases on firms' capital structure using model (1) specified in Section 4.2. The key variable of interest in both tables is the interaction term *N225*ETFPost* representing the treatment effect of ETF purchases on Nikkei 225 firms. Starting with Table 9, the results indicate that for five out of the six dependent variables, the coefficient on *N225*ETFPost* is statistically significant (the exception is the short-term bank loan ratio). Notably, as shown in columns (1) and (3), Nikkei 225 firms have a 1.35 percentage point lower leverage ratio and a 2.35 percentage point lower long-term leverage ratio than non-Nikkei 225 firms. The results indicate that the BOJ's ETF purchasing program reduced the leverage, long-term leverage, bond, and long-term bank loan ratios of the treatment group (Nikkei 225 firms) relative to the control group (non-Nikkei 225 firms), which is consistent with Hypothesis 1. Further, most of the coefficients on the control variables are significant and the signs are as predicted, including the interest tax shield, cash ratio, tangibility, profitability, current ratio, firm age, and CPI level.

[Table 9]

Next, Table 10 show the results when the DID estimation is conducted using the REM. The coefficients on *N225*ETFPost* in columns (1) and (3) are still negative and significant, although they are smaller in absolute value than in Table 9, while the coefficients in columns (2), (4), and (6) have the same signs as in Table 9 but are no longer significant. The conclusion that the ETF purchasing program reduced firms' leverage and long-term leverage remains unchanged.

[Table 10]

5.3.2.BOJ purchases of CBs

Next, the impact of the BOJ's CB purchases on firms' capital structure is examined. Specifically, employing model (2), the same proxies for firms' leverage and variables for debt structure are regressed on the interaction term *CBEligible*CBPost* as well as firm-specific and macroeconomic control variables. Using different panel data regression methodologies (i.e., pooled OLS, fixed effects and random effects regression), estimates of the intention-to-treat effect are obtained and reported in Table 11. Except in column (6), the signs of the estimated treatment effects are the same in all three models. While the size of the treatment effect is largest when using the pooled OLS model, the REM and FEM provide more precise estimates since they take individual effects into account. The Hausman test statistic has a p-value of 0.0000, indicating that the FEM is the most appropriate model.

[Table 11]

The full estimation results using the FEM are presented in Table 12. As shown in Tables 11 and 12, firms whose CBs are eligible for BOJ purchases have a 0.92 percentage point higher overall leverage, a 1.31 percentage point higher long-term leverage, and a 1.57 percentage point higher bond ratio than other firms. On the other hand, the short-term leverage and bank loan ratios of eligible firms are 0.39 percentage points and 0.86-0.89 percentage points lower than those of ineligible firms after firm characteristics and macroeconomic factors are controlled for. This evidence is in line with Hypothesis 2 that after the introduction of CB purchases under the CME policy in 2010, relative to ineligible firms, eligible firms used more bond debt and replaced part of their bank loans with bond debt, but the decrease in bank debt is smaller than the increase in bond debt, resulting in a higher level of leverage overall.

[Table 12]

Most of the control variables have a statistically significant impact on firm leverage, as expected (see Table 4). However, the MB ratio and CPI level were found to have a positive and

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a negative effect on the leverage ratio, respectively, which is the opposite of what was predicted.

5.3.3. Combination of ETF and CB purchases

Next, after having examined the impact of the BOJ's purchases of ETFs and CBs individually, the combined effect is examined using model (3). The results are present in Table 13 and confirm Hypothesis 3 that the effects of the BOJ's ETF and CB purchases on corporate capital structure and changes in leverage are not uniform across firms that differ in terms of the eligibility of their stocks and bonds for BOJ purchases, reinforcing the evidence that the BOJ's ETF and CB purchase policy has a significant impact on corporate capital and debt structures.

[Table 13]

Specifically, Table 13 implies that firms belonging to the *Bonds only* group (i.e., firms that have solely better access to the public bond market following the introduction of the program, as CB purchases may have reduced the yield on eligible bonds) have a higher overall leverage ratio, long-term leverage ratio and bond ratio, but have a lower short-term leverage ratio and lower short and long-term bank loan ratios than firms in the *Neither* group (i.e., firms whose bonds and stocks are both ineligible for purchases by the BOJ). Meanwhile, firms belonging to the *Stocks only* group (i.e., firms that have solely better access to the public stock market following the introduction of the program, as ETF purchases may have reduced their cost of equity) have a 1.54 percentage point lower long-term leverage than firms in the *Neither* group. Inclusion in the BOJ's ETF purchases also has an impact on firms' leverage overall (column (1)) as well as their short- and long-term bank loan ratios, but the coefficients are significant only at the 10 percent level. Turning to firms belonging to the *Both* group, the leverage and debt ratios of these firms are not significantly different from those in the *Neither* group. This result is not very surprising, since firms in the *Both* group have easier access to both the public bond market and the public stock market, so that the impacts of CB purchases and ETF purchases on firms' leverage ratio, which work in opposite directions, seem to have

cancelled each other out.

Regarding the impact of firm-specific and macroeconomic control variables on firms'
leverage, as shown in Tables 9, 10, 12 and 13, the results of the baseline analysis are generally
consistent with the predictions shown in Table 4. Specifically, the regression results suggest
that firms' leverage ratio is positively correlated with the interest tax shield and size and
negatively correlated with firms' cash ratio, tangibility, profitability, current ratio, and age as
well as GDP growth. However, contrary to expectation, the coefficients on the CPI are negative,
while those on the MB ratio are generally insignificant.

5.3.4.Impact of the BOJ's ETF and CB purchases on firms' bond and stock issuance

Last but not least, the impact of the BOJ's asset purchases on the probability that firms
issue new stocks and bonds is examined. Table 14 presents the average marginal effects (AME)
obtained using the logit model (model (4)) to regress the stock and bond issuance dummies on
the firm group dummies, *N225*ETFPost*, and *CBEligible*CBPost* separately (while
controlling for firm characteristics).

[Table 14]

The marginal effects of *Both*, *Stocks only* and *N225*ETFPost* in columns (1) and (2)
suggest that the probability of stock issuance is 1.38 to 2.00 percentage points higher for firms
whose stocks are included in ETF purchases by the BOJ. The results indicate that ETF
purchases have made it cheaper for these firms to issue equity, and they have taken advantage
of this opportunity to increase their stock issuance, as suggested by Hypothesis 1.

In addition, the marginal effects of *Both*, *Bonds only* and *CBEligible*CBPost* in columns
(4) and (6) indicate that the probability of bond issuance is 2.13 to 4.80 percentage points higher
for firms whose bonds are eligible for CB purchases by the BOJ, which supports Hypothesis 2.
The probability that Nikkei 225 firms issued bonds decreased by 1.65 percentage points after
the introduction of the ETF purchase program, suggesting that Nikkei 225 firms substitute bond

financing with equity financing, which is consistent with Hypothesis 1. Finally, Table 14 shows that belonging to the *Both* group increased the probability that firms issued bonds and stocks, but the size of the effect is 1.45 and 2.25 times smaller than that on firms included in solely ETF or CB purchases. This evidence suggests the interaction between these two policies: the magnitude of the effects of ETF (or CB) purchases on firms' securities issuance depends on whether the firms were subjected to the CB (or ETF) purchases.

To sum up, the evidence suggests that not only do the ETF and CB purchases by the BOJ have a substantial impact on corporate capital structure, but – as a positive supply shock – the policy has also changed firms' stock and bond issuance behavior.

5.4. Additional analyses and robustness checks

5.4.1. Subsample analysis

To check the robustness of the results, I further conduct a subsample analysis in which the full sample data is divided into subsamples based on the time period. Using model specifications (1) and (2) to estimate the treatment effects of the BOJ's ETF and CB purchases yields the results reported in Table 15.

[Table 15]

Similar to the baseline results presented above, the results in Table 15(a) are based on data for all non-financial firms on the TSE1 and TSE2. However, it could be argued that the introduction of the policy may not have had a persistent impact; moreover, using non-Nikkei 225 TSE1 and TSE2 firms as the control group for ETF purchases may lead to potential bias, since part of the BOJ's ETF purchases are of those tracking the TOPIX. To address these potential issues, the analysis in Table 15(b) employs data only for non-financial firms on the TSE1 and one-year lagged values of the control variables. In this case, the control group consists of TSE1 non-Nikkei 225 firms, and the DID model measures the ATT when the BOJ spends a substantial amount on the purchase of ETFs.

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The results presented in Table 15 are consistent with the hypotheses and baseline results that the BOJ's ETF purchases have led to a reduction and the CB purchases have led to an increase in firms' long-term leverage ratio. The effects of both policies accumulate over time, as the estimated treatment effects become larger in absolute value, and are statistically significant at the 1 percent level except for the shortest periods, probably because the intervention period may have been too short to generate an impact. Moreover, looking at the marginal impact (i.e., the absolute changes in the treatment effect over time), it should be noted that from 2014 to 2018, the additional impact of ETF purchases is higher than the additional impact of CB purchases, which is in line with the fact that the BOJ has put more emphasis on the purchases of ETFs rather than CBs after the introduction of QQE.

5.4.2. Adjusting the sample

The analyses above did not consider the entry and exit of firms from the Nikkei 225 index and instead focused on firms in the index as of 2011. In addition, firms that publish their financial statements in months other than March were excluded. This may potentially affect the treatment variables and results in a significantly smaller number of firms in the sample than the actual number of firms on the TSE1 and TSE2.

Adding non-financial TSE1 and TSE2 firms with fiscal year-ends other than March and taking changes in Nikkei 225 component firms into account yields a new sample of 2,517 firms, consisting of 2,008 TSE1 firms and 509 TSE2 firms. On average, 196 firms belong to the Nikkei 225 index, as compared to 179 firms in the original sample. Rerunning the analyses in Section 4 using this new sample, the results (not shown for brevity) remain essentially unchanged, confirming the robustness of the findings of the baseline analysis. Note that the robustness tests from here on were conducted using this adjusted data set.

5.4.3. Alternative debt indicators

One of the ultimate purposes of the BOJ's ETF and CB purchases is to influence real

corporate outcomes such as investment. A study suggesting that this is being achieved is that by Charoenwong et al. (2019), which showed that the BOJ's ETF purchases stimulated corporate short-term investment, as firms whose stocks were included in the purchases increased their holdings of cash and other current assets. Consequently, when investigating the impact of ETF purchases on leverage ratios, since the denominator of the leverage ratio is total assets (see Table 3), we cannot rule out the possibility that the observed impact on leverage indicators stems from the denominator rather than the numerator (liabilities items).

Therefore, I further repeat the analysis based on models (1) and (2) using alternative debt indicators, namely, the natural logarithms of total debt, total short-term debt, and total long-term debt. Table 16 shows the treatment effects of the BOJ's ETF and CB purchases on the alternative debt indicators using the pooled OLS regression model. A notable result is that the size of the estimated treatment effects on long-term debt, with 12 percentage points for ETF purchases and 26.6 percentage points for CB purchases, are much larger than the treatment effects on leverage ratios of around 1 to 2 percentage points. This suggests that most of the change in the proxies for treatment firms' leverage is due to the change in debt items on firms' balance sheet, especially long-term debt, confirming that the observed impact on leverage indicators indeed stems from the numerator (liabilities items).

[Table 16]

5.4.4. Continuous treatment variables and the ETF purchase program

One important feature of the main analysis is that all the treatment variables used were dummy variables. This means that while I can compare differences between the capital structure of treatment and control firms, I cannot examine differences between treatment firms with different exposures to the ETF purchases policy. To focus on this aspect, instead of the *N225* and *ETFPost* dummy variables, I employ a continuous treatment variable: the BOJ's indirect shareholding ratio, which was previously mentioned in Section 3.2.

I follow the method proposed by Gunji et al. (2019)[7] to calculate the BOJ's total indirect shareholding ratio, which will be referred to as the "total exposure variable" for short. Gunji et al. (2019) calculate the BOJ's indirect shareholding ratio of TOPIX component firms as follows:

$$\rho_t = \frac{X_t^{TOPIX}}{\sum_{i=1}^{N} p_{it} q_{it}}$$

where ρ_t is the BOJ's shareholding ratio of TOPIX component firms in year t; X_t^{TOPIX} is the total outstanding amount of TOPIX ETFs purchased by the BOJ in year t; p_{it} and q_{it} are the stock price and the number of outstanding shares of firm i in year t. The authors assume for simplicity that the free float ratio is constant for all stocks and all periods, resulting in the same indirect shareholding ratio (ρ_t) for all TOPIX component firms in each year t. Note that ρ_t is equal to zero for TSE2 firms.

Moreover, the BOJ's indirect shareholding ratio of Nikkei 225 firms is:

$$\theta_{it} = \frac{50 X_t^{N225}}{\bar{p}_{it} q_{it} d_t N225_t}$$

where θ_{it} is the BOJ's shareholding ratio of Nikkei 225 component firm i in year t; X_t^{N225} is the total outstanding amount of Nikkei 225 ETFs purchased by the BOJ in year t; $\bar{p}_{it}$ is the presumed par value of firm i in year t; q_{it} is the number of outstanding shares of firm i in year t; d_t is the Nikkei 225 divisor in year t; and $N225_t$ is the Nikkei 225 index in year t. θ_{it} equals zero for non-Nikkei 225 firms.

In this additional analysis, the total exposure variable, which measures the extent to which each firm is "exposed" to ETF purchases by the BOJ, is defined as the sum of ρ_t and θ_{it}, since the stocks of Nikkei 225 firms are subject to both TOPIX and Nikkei 225 ETF purchases by the BOJ. Similar to model specification (1), leverage and debt indicators are regressed on the

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[7] See the Appendix for details of the calculation.

total exposure variable and control variables using a FEM. The results are shown in part A of Table 17. In addition, I regress the leverage and debt ratios on the Nikkei 225 exposure variable (θ_{it}) and the TOPIX exposure variable (ρ_t) to examine whether Nikkei 225 ETF purchases or TOPIX ETF purchases played a larger role in capital structure changes. The results are shown in parts B and C of Table 17, respectively.

[Table 17]

The three parts of Table 17 show that the estimated treatment effect on leverage is -1.1 percentage points in the case of total exposure, -0.4 percentage points in the case of Nikkei 225 exposure, and -2.1 percentage points in the case of TOPIX exposure. These estimates show that firms with greater exposure to BOJ ETF purchases, as measured by three proxies for the BOJ's indirect shareholding ratio, have lower leverage and debt ratios than firms with less exposure. This implies that the impact of ETF purchases on firms in the treatment group is heterogeneous and likely depends on the weight of each firm in the Nikkei 225 or TOPIX indexes as well as changes in the BOJ's purchasing rules, i.e., the purchasing amount and allocation of purchases. This finding differs from the results obtained by Harada and Okimoto (2019), who suggest that the BOJ's ETF purchases did not have an additional impact on the stock returns of firms with the largest weights in the Nikkei 225 index. Moreover, the results in parts B and C of Table 17 indicate that the TOPIX ETF purchases have a larger effect on highly exposed firms than the Nikkei 225 ETF purchases, suggesting that the BOJ's adjustment of its purchases from Nikkei 225 ETFs to TOPIX ETFs is an appropriate action.

5.4.5. Policy impact on securities issuance amounts

In the baseline estimations, I used a logit model to examine the effect of the BOJ's asset purchases on firms' decision to raise or not to raise external financing in the market. However, it is possible that some firms issue securities frequently but each time issue only a very limited amount of bonds or stocks. Therefore, in the following analysis, I further explore the effect of

the BOJ's ETF and CB purchasing program on securities issuance amounts by applying a tobit model. A tobit model is a limited dependent variable model, and such models are widely used when the dependent variable is censored from below at zero, as is the case here.

The average marginal effects (AME) from the tobit model estimation are presented in Table 18. I regress proxies for the amounts of stock and bond issuance on firm group dummies, the interaction terms *N225*ETFPost* and *CBEligible*CBPost* separately, controlling for firm-specific factors.

[Table 18]

The marginal effects of *Both*, *Stocks only* and *N225*ETFPost* in columns (1) and (2) suggest that, on average, the actual values of *Log(1+Stock issuance amounts)* are 23.31 to 39.50 percentage points higher for firms whose stocks were included in ETF purchases by the BOJ. Meanwhile, the marginal effects of *Both*, *Bonds only* and *CBEligible*CBPost* in columns (4) and (6) indicate that the *Log(1+Bond issuance amounts)* are 74.90 to 97.02 percentage points higher for firms whose bonds were eligible for CB purchases by the BOJ than for firms whose bonds were not eligible. This result suggests that treatment firms, as a result of the decline in bond and equity issuance costs due to BOJ asset purchases, have increased their bond and stock issuance: not only did they issue securities more frequently (as implied by Table 14), but they also issued securities with considerably larger amounts than before.

Last but not least, evidence from Table 14 and 18 indicates that the interaction between the BOJ's ETF and CB purchases does exist. The positive effect of ETF (or CB) purchases on targeted firms' probability and amount of stock (or bond) issuance is 1.3 to 2.25 times greater if these firms were not subjected to the other policy – CB (or ETF) purchases. Presumably, when there is a need to raise external capital, firms included in both ETF and CB purchases can flexibly choose to issue bonds or stocks. In contrast, firms included in solely ETF purchases have a lower cost of equity, but their cost of bond debt is relatively high compared to firms

included in CB purchases. As a result, these firms relied more on stock issuance and may have tended to replace bonds with stocks to take advantage of the market conditions. A similar argument could be made for firms included in solely CB purchases.

6. Conclusion

This study examined the effects of the ETF and CB purchasing program implemented by the BOJ on the capital structure of Japanese listed firms spanning the period from 2009 to 2018. The ETF and CB purchases mean that the BOJ indirectly holds stocks and directly holds bonds, so that these interventions represent a new supply of external capital for firms whose stocks and bonds are included in the purchases.

To measure the average treatment effect of the policy intervention on firms' capital structure, difference-in-differences (DID) estimation and panel data regression techniques were employed. In the DID estimation, firms whose bonds were eligible for CB purchases as well as firms whose stocks were included in ETF purchases were regarded as treatment groups. Further, the impact of the policies on firms' stock and bond issuance was examined using a logit model, and various additional analyses were conducted.

The four baseline analyses and the robustness checks confirmed the hypotheses constructed, indicating that the BOJ's ETF and CB purchases have had a significant and persistent impact on firms' capital structure and issuance of securities. Following the expansion of the BOJ's ETF purchases in 2013, Nikkei 225 firms actively issued more stocks and became less dependent on bond debt and bank loans than non-Nikkei 225 firms, resulting in a lower level of leverage. On the other hand, firms whose bonds were eligible for BOJ CB purchases issued more corporate bonds and substituted long-term bank debt with bond debt. However, the magnitude of such a substitution effect was small, so that they have a higher leverage ratio than ineligible firms. Moreover, categorizing firms into four groups based on whether their stocks

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were included in ETF purchases and/or their bonds were eligible for CB purchases shows that the policy impacts on firms' leverage ratio have differed depending on which group a firm fell in. Evidence on the impacts on firms' securities issuance further suggests that the interaction between ETF and CB purchases does exist.

Importantly, the significant impact of the BOJ's ETF and CB purchases implies that the supply of capital does have an effect on firms' capital structure. As noted by Graham and Leary (2011), previous studies have employed two major approaches to examine the role of supply side factors. The first approach studies capital market segmentation by focusing on segmentation in debt markets between financially constrained bank-dependent firms and unconstrained firms with access to arms-length lenders. The second approach studies the impact of supply conditions, as in the case of the market timing theory. In the present study, the obtained results are in line with the second approach. That is, firms whose CBs were eligible for BOJ purchases or whose stocks were included in ETF purchases appear to have taken advantage of the increase in the prices of their securities and a reduction in adverse selection costs (resulting in lower equity and bond issuance costs), indicating that changes in supply conditions brought about by the BOJ purchases have affected firms' capital structure and securities issuance.

Turning to the policy implications, the empirical evidence obtained in this study indicates that following the start of ETF and CB purchases, public firms whose stocks and/or bonds are included in the purchases have been able to raise external capital from the public market more easily, as these purchases likely lowered their cost of capital. In addition, such firms have tended to reduce their reliance on bank loans due to the substitution effect among financing sources (i.e., between bank loans and bond debt, or between equity and debt capital). Hence, it is possible that the BOJ's risk asset purchases may reinforce the bank lending channel if banks faced with a decrease in borrowing demand provide more loans to ineligible firms such as

financially constrained SMEs.

However, the BOJ needs to be cautious in continuing the asset purchases, especially on a much larger scale. The interventions can cause securities prices to substantially deviate from their fundamental values, thus potentially exacerbating the asymmetric information problem between firms and investors. Moreover, firms included in the ETF and CB purchases are large public firms that already have an advantage in raising external funds vis-à-vis firms that are not included. Therefore, the BOJ's asset purchases may increase inequality across firms if financially unconstrained firms can raise capital more easily while constrained firms find it harder to raise capital.

While the analysis in this study provides some evidence on the effects of BOJ asset purchases on firms' capital structure, a range of issues warrant further investigation.

First, the regression results of this study suggest that the demand for bank loans has declined, since eligible firms have reduced their dependence on bank loans and increased their bond and stock issuance. However, the study did not examine whether these changes affect banks' lending operations and in turn affect the supply of bank loans for firms whose bonds and stocks are not subject to BOJ purchases. This raises a number of questions, such as: If such spillover effects exist, what are the characteristics of firms that receive additional bank loans? Does this phenomenon have any connection with zombie firms – insolvent firms that receive financial assistance and continue to exist instead of restructuring or going bankrupt – which have been widely discussed by researchers in recent years?

Second, although it can be concluded that the BOJ's ETF and CB purchases have led to an increase in the availability of funding, have enhanced firms' access to outside financing, and have changed firms' stock and bond issuance behavior, further analysis is needed to understand whether the BOJ's interventions affect (i) asset prices in the short and longer term, (ii) stock and bond market returns, (iii) corporate governance and ownership structures, as well as (iv)

firm performance and investment activities.

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Tables and Figures

Table 1. Companies with highest indirect BOJ shareholding ratios as of July 2018

Company	Indirect holding ratio (%)	Floating stock base (%)	Company	Indirect holding ratio (%)	Floating stock base (%)
Advantest	19.7	43.7	Mitsubishi Logistics	12.4	20.6
Fast Retailing	17.7	88.3	Kyocera	12.2	17.4
Taiyo Yuden	17.1	28.4	Nippon Kayaku	12.1	20.2
TDK	16.3	25.1	Credit Saison	12.0	18.5
Family Mart UNY Holdings	15.7	39.2	Nisshinbo Holdings	12.0	21.9
Toho Zinc	15.6	23.9	TERUMO	11.9	18.3
Trend Micro	15.1	25.1	Alps Electric	11.7	16.7
Nissan Chemical Industries	14.4	22.2	Tokyo Dome	11.7	18.0
Comsys Holdings	14.4	32.1	Fanuc	11.6	15.5
Konami Holdings	14.2	31.6	Kikkoman	11.5	19.2
Tokyo Electron	13.3	20.5	Yamaha	11.5	20.8
Nitto Denko	13.0	18.6	Seiko Epson	11.3	18.8
Okuma	12.6	22.9	Takara Holdings	11.1	18.4

Source: Iwata and Samikawa (2018: 163).

Table 2. Changes in the BOJ's ETF and CB purchase programs

Date	Exchange traded funds		Corporate bonds	
	Purchasing amount (unit: yen)	ETFs to be purchased	Maximum outstanding amount (yen)	Eligibility criteria
19 Feb 2009– 31 Dec 2009	-	-	1 trillion yen	Rated A or higher, remaining maturity of less than one year
28 Oct 2010	Maximum outstanding amount of 0.45 trillion	TOPIX, Nikkei 225 ETFs	0.5 trillion	Rated BBB or higher, remaining maturity of one to two years.
14 Mar 2011	Maximum outstanding amount of 0.9 trillion		2 trillion	
04 Aug 2011	Maximum outstanding amount of 1.4 trillion		2.9 trillion	
27 Apr 2012	Maximum outstanding amount of 1.6 trillion		(unchanged)	Rated BBB or higher, remaining maturity of one to three years.
30 Oct 2012	Maximum outstanding amount of 2.1 trillion		3.2 trillion	
4 Apr 2013	Annual purchase amount of 1 trillion			
31 Oct 2014	Annual purchase amount of 3 trillion	TOPIX, Nikkei 225, and JPX-Nikkei Index 400 ETFs		
15 Mar 2016	Annual purchase amount of 3.3 trillion	TOPIX, Nikkei 225, JPX-Nikkei Index 400 ETFs, and "special ETFs"	(unchanged)	
	Note: BOJ uses additional 0.3 trillion to purchase ETFs that support firms proactively investing in physical and human capital.			
29 Jul 2016	Annual purchase amount of 6 trillion	(unchanged)		
21 Sep 2016	Changes in allocation: BOJ will use 3 trillion for TOPIX, Nikkei 225, and JPX-Nikkei Index 400 ETFs; 2.7 trillion for TOPIX ETFs; and 0.3 trillion for "special ETFs."			
31 Jul 2018	Changes in allocation: BOJ will use 1.5 trillion for TOPIX, Nikkei 225, and JPX-Nikkei Index 400 ETFs; 4.2 trillion for TOPIX ETFs; and 0.3 trillion for "special ETFs."			

Table 3. Definitions of all variables

Variable	Definition
Dependent variables	
Proxies for leverage	
Leverage	Total liabilities/Total assets
Short-term leverage	Current liabilities/Total assets
Long-term leverage	Non-current liabilities/Total assets
Variables related to debt structure	
Bond ratio	Bonds and convertibles/Total liabilities
Short-term bank loan ratio	Short-term loans/Total liabilities
Long-term bank loan ratio	Long-term loans/Total liabilities
Issuance dummies	
Stock issuance dummy	Equals one for year(s) in which firm issued stocks (three types considered: private placement, issue at market price, and preferred stocks)
Bond issuance dummy	Equals one for year(s) in which firm issued straight bonds of any maturity
Dummy variables related to BOJ's intervention	
N225 dummy	Equals one if the firm is a Nikkei 225 component firm
ETFPost dummy	Equals one if year $t \geq 2013$ and zero otherwise
CBEligible dummy	Equals one if the firm has issued bonds that are eligible for the BOJ's CB purchases, i.e., bonds with a remaining maturity of 1 year to 3 years and rated BBB or higher
CBPost dummy	Equals one if year $t \geq 2010$ and zero otherwise
Both dummy	Equals one if the firm's N225*ETFPost dummy and CBEligible*CBPost dummy both equal one
Bonds only dummy	Equals one if the firm's N225*ETFPost dummy equals zero but the CBEligible*CBPost dummy equals one
Stocks only dummy	Equals one if the firm's N225*ETFPost dummy equals one but the CBEligible*CBPost dummy equals zero
Control variables	
Log(interest tax shield)	Log(Corporate tax rate x Interest expenses)
Cash ratio	Cash/Total assets
Tangibility	Property, plant, and equipment/Total assets
Size	Log(Total assets)
Profitability	EBITDA/Total assets
Current ratio	Current assets/Current liabilities
Market to book ratio	Closing price x Number of shares / Shareholders' equity
Firm age	Log(1+ Firm age)
GDP growth (%)	Annual percentage growth rate of GDP at market prices
CPI	Consumer price index, base year 2010 = 100
Industry group dummies	

Table 4. Control variables

Proxy	Explanation	Predicted sign
Interest tax shield	Trade-off theory implies that firms with a higher interest tax shield should issue more debt to take advantage of debt financing. Higher tax rates further increase the tax advantage of debt.	+
Cash ratio	If firms anticipate that they may suffer from adverse selection costs or other financing costs when raising funds in the future, they might hold more liquid assets including cash in order to preserve financial flexibility.	-
Tangibility	Trade-off theory predicts a positive relationship between tangibility and leverage because firms which have more tangible, easy to value assets are expected to have lower costs of financial distress. In contrast, pecking order theory suggests that tangible assets mitigate the adverse impact of asymmetric information, resulting in a lower leverage ratio.	+/-
Size	Larger firms are less risky and more diversified, so that the probability of distress and the expected costs of financial distress are lower.	+
Profitability	Trade-off theory argues that profitable firms have greater needs to shield income from corporate tax and should borrow more than less profitable firms, while pecking order theory suggests an inverse relationship between profitability and the level of debt.	+/-
Current ratio	The current ratio is a liquidity ratio that measures a firm's ability to meet its short-term obligations. Pecking order theory suggests that firms with large amounts of current assets will first use their reserves rather than external funds.	-
MB ratio (Growth opportunities)	The MB ratio reflects firms' intangible assets and growth opportunities. High-growth firms often have a small amount of taxable income. Moreover, as stated by Rajan and Zingales (1995), a high MB ratio coincides with high financial distress costs and overvalued stocks.	-

Firm age	In older companies, information asymmetry between management and external investors is less significant. Stocks of such firms are less likely to be undervalued in the market and such firms therefore have a greater incentive to issue stocks.	-
GDP growth	During an economic expansion, expected bankruptcy costs are likely to decrease while taxable income and collateral values are likely to increase, implying that leverage is procyclical with GDP growth (Frank and Goyal (2009)). However, during an expansion, firms may already have sufficient internal funds to finance their projects, stock prices are likely to rise, and manager-shareholder agency costs will be diminished.	+/-
CPI	The consumer price index (CPI) level reflects price stability and is a proxy for the inflation rate. A fall in prices will lead to an increase in real interest rates and the real value of debt, making borrowing more costly for firms (recall the Fisher equation). As a result, a relatively low CPI level compared to other years in the observation period, which corresponds to a low or negative inflation rate, will reduce firms' incentive to use leverage, suggesting a positive relationship between the CPI and firms' leverage.	+

Table 5. Number of firms by group

Year	Both	Bonds only	Stocks only	Neither	CBEligible* CBPost =1
2009	0	0	0	1,758	0
2010	0	310	0	1,448	310
2011	0	296	0	1,462	296
2012	0	255	0	1,503	255
2013	119	111	60	1,468	230
2014	114	115	65	1,464	229
2015	108	112	71	1,467	220
2016	112	98	67	1,481	210
2017	117	92	62	1,487	209
2018	114	101	65	1,478	215
Total		**1,758**			**-**

Table 6. Summary statistics

Variable	Mean	SD	Min	Max
Dependent variables				
Leverage	0.490	0.196	0.006	0.999
Short-term leverage	0.322	0.148	0.006	0.998
Long-term leverage	0.168	0.133	0.000	0.846
Bond ratio	0.097	0.097	0.000	0.856
Short-term bank loan ratio	0.183	0.135	0.000	0.957
Long-term bank loans ratio	0.174	0.143	0.000	0.902
Stock issuance dummy	0.034	0.180	0	1
Bond issuance dummy	0.058	0.233	0	1
Dummy variables related to BOJ's asset purchases				
N225 dummy	0.102	0.302	0	1
ETFPost dummy	0.600	0.490	0	1
CBEligible dummy	0.124	0.329	0	1
CBPost dummy	0.900	0.300	0	1
Both dummy	0.039	0.193	0	1
Bonds only dummy	0.085	0.279	0	1
Stocks only dummy	0.022	0.147	0	1
Control variables				
Log(Interest tax shield)	3.860	2.219	-4.605	12.262
Cash ratio	0.167	0.123	0.001	0.931
Tangibility	0.292	0.181	0.001	0.938
Size	11.115	1.706	4.644	19.505
Profitability	0.082	0.064	-1.772	0.656
Current ratio	2.177	1.981	0.072	58.451
Market to book ratio	1.595	5.029	0.003	422.8
Log(1+ Firm age)	3.901	0.808	0	4.927
GDP growth (%)	0.708	2.334	-5.416	4.192
CPI	101.898	1.951	99.681	104.981
Industry group	17.054	8.422	1	29

Table 7. Mean leverage ratio by group (in %)

Year	Nikkei 225	TSE1 Non-Nikkei	TSE2
2009	59.27	50.14	52.04
2010	58.22	49.39	50.59
2011	58.03	49.20	50.84
2012	58.68	49.24	50.96
2013	57.37	47.93	49.94
2014	56.00	47.57	49.46
2015	54.66	46.63	48.44
2016	54.66	46.20	48.39
2017	53.82	45.70	47.98
2018	52.93	45.07	47.88
Average	56.39	47.67	49.62

Table 8. Comparison of means based on eligibility for CB purchases (in %)

Year	Bonds & convertibles/Total assets		Long-term bank loans/Total assets	
	Eligible	**Non-Eligible**	**Eligible**	**Non-Eligible**
2009	5.84		10.76	
2010	7.51	3.50	14.80	9.38
2011	7.77	3.69	14.59	8.83
2012	8.33	3.16	14.19	9.10
2013	8.50	2.81	13.65	9.18
2014	8.12	2.87	13.34	9.27
2015	7.73	3.04	13.44	9.27
2016	7.80	3.44	13.39	9.77
2017	7.88	4.13	14.31	9.85
2018	7.71	3.95	14.00	9.42

Table 9. Impact of BOJ ETF purchases on firms' capital structure: Pooled OLS

	(1)	(2)	(3)	(4)	(5)	(6)
	Leverage	Short-term leverage	Long-term leverage	Bond ratio	ST bank loan ratio	LT bank loan ratio
N225 dummy	0.0224***	-0.0157***	0.0380***	-0.0043	0.0059	0.0296***
	(0.0053)	(0.0043)	(0.0044)	(0.0055)	(0.0048)	(0.0062)
ETF Post dummy	-0.0015	-0.0044	0.0028	-0.0058	0.0008	0.0073**
	(0.0036)	(0.0029)	(0.0025)	(0.0045)	(0.0035)	(0.0036)
N225*ETFPost	-0.0135**	0.0103**	-0.0235***	-0.0104*	0.0032	-0.0195***
	(0.0057)	(0.0046)	(0.0048)	(0.0055)	(0.0052)	(0.0070)
Log(Interest tax shield)	0.0466***	0.0157***	0.0309***	0.0053***	0.0287***	0.0423***
	(0.0014)	(0.0012)	(0.0007)	(0.0019)	(0.0010)	(0.0012)
Cash ratio	-0.0680***	-0.0716***	0.0020	-0.0548**	-0.0358**	0.0239
	(0.0220)	(0.0198)	(0.0103)	(0.0260)	(0.0152)	(0.0173)
Tangibility	-0.0849***	-0.3511***	0.2653***	0.1325***	-0.0217**	0.2445***
	(0.0096)	(0.0081)	(0.0073)	(0.0130)	(0.0089)	(0.0104)
Size	-0.0423***	-0.0242***	-0.0182***	0.0083***	-0.0489***	-0.0372***
	(0.0016)	(0.0014)	(0.0010)	(0.0022)	(0.0013)	(0.0015)
Profitability	-0.6200***	-0.1910***	-0.4266***	0.1585***	-0.2734***	-0.1570***
	(0.0328)	(0.0221)	(0.0229)	(0.0416)	(0.0268)	(0.0302)
Current ratio	-0.0628***	-0.0602***	-0.0026***	0.0486***	-0.0319***	0.0206***
	(0.0053)	(0.0049)	(0.0008)	(0.0045)	(0.0018)	(0.0023)
MB ratio	0.0058**	0.0020**	0.0038**	0.0032***	0.0006*	0.0024***
	(0.0025)	(0.0010)	(0.0015)	(0.0007)	(0.0003)	(0.0008)
Firm age	-0.0240***	-0.0176***	-0.0063***	0.0082***	-0.0094***	-0.0180***
	(0.0018)	(0.0017)	(0.0015)	(0.0018)	(0.0018)	(0.0023)
GDP growth	0.0007	-0.0005	0.0013***	0.0000	0.0001	0.0017***
	(0.0005)	(0.0004)	(0.0004)	(0.0006)	(0.0005)	(0.0005)
CPI	0.0021**	-0.0018***	0.0040***	-0.0010	0.0009	0.0080***
	(0.0009)	(0.0007)	(0.0006)	(0.0011)	(0.0008)	(0.0009)
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	12,353	12,353	12,344	3,726	11,484	10,174
R-squared	0.6488	0.6350	0.6265	0.4071	0.3422	0.4406

* p<0.1, ** p<0.05, *** p<0.01. Figures in parentheses are cluster-robust standard errors.

Table 10. Impact of BOJ ETF purchases on firms' capital structure: REM

	(1)	(2)	(3)	(4)	(5)	(6)
	Leverage	Short-term leverage	Long-term leverage	Bond ratio	ST bank loan ratio	LT bank loan ratio
N225 dummy	-0.0475***	-0.0326***	0.0074	-0.0013	0.0050	0.0149
	(0.0138)	(0.0099)	(0.0099)	(0.0097)	(0.0098)	(0.0122)
ETF Post dummy	-0.0067***	-0.0055***	-0.0006	-0.0115***	-0.0023	0.0009
	(0.0015)	(0.0013)	(0.0014)	(0.0035)	(0.0020)	(0.0024)
N225*ETFPost	-0.0090**	0.0046	-0.0139***	-0.0051	0.0050	-0.0045
	(0.0043)	(0.0031)	(0.0044)	(0.0058)	(0.0040)	(0.0066)
Log(Interest tax shield)	0.0209***	0.0065***	0.0159***	0.0017	0.0155***	0.0242***
	(0.0011)	(0.0009)	(0.0009)	(0.0026)	(0.0013)	(0.0016)
Cash ratio	0.0406*	-0.0253	-0.0112	-0.0262	0.0888***	-0.0310
	(0.0214)	(0.0193)	(0.0185)	(0.0371)	(0.0267)	(0.0293)
Tangibility	-0.0802***	-0.3197***	0.2447***	0.1100***	-0.0712***	0.3043***
	(0.0246)	(0.0190)	(0.0205)	(0.0244)	(0.0243)	(0.0286)
Size	0.0106***	-0.0080***	0.0094***	0.0104***	-0.0346***	-0.0118***
	(0.0034)	(0.0026)	(0.0024)	(0.0031)	(0.0028)	(0.0029)
Profitability	-0.4036***	-0.0784***	-0.3291***	0.0143	-0.4436***	-0.3739***
	(0.0337)	(0.0298)	(0.0260)	(0.0587)	(0.0361)	(0.0401)
Current ratio	-0.0492***	-0.0590***	0.0074***	0.0410***	-0.0650***	0.0325***
	(0.0039)	(0.0046)	(0.0024)	(0.0075)	(0.0055)	(0.0054)
MB ratio	0.0008**	0.0002	0.0006*	0.0011***	0.0004*	0.0016***
	(0.0004)	(0.0002)	(0.0003)	(0.0004)	(0.0002)	(0.0002)
Firm age	-0.0149***	-0.0100*	-0.0041	0.0036	-0.0100**	-0.0164***
	(0.0053)	(0.0054)	(0.0042)	(0.0033)	(0.0044)	(0.0052)
GDP growth	-0.0009***	-0.0013***	0.0005***	-0.0001	-0.0012***	0.0005*
	(0.0002)	(0.0002)	(0.0002)	(0.0003)	(0.0003)	(0.0003)
CPI	-0.0042***	-0.0040***	0.0005	-0.0013	-0.0005	0.0045***
	(0.0004)	(0.0004)	(0.0004)	(0.0009)	(0.0006)	(0.0007)
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	12,353	12,353	12,344	3726	11,484	10,174
R-squared between	0.5450	0.6002	0.5642	0.4014	0.2920	0.4285

* $p<0.1$, ** $p<0.05$, *** $p<0.01$. Figures in parentheses are cluster-robust standard errors.

Table 11. Estimated treatment effect of BOJ CB purchases

Model	(1) Leverage	(2) ST leverage	(3) LT leverage	(4) Bond ratio	(5) ST bank loan ratio	(6) LT bank loan ratio
Pooled OLS	0.0317***	-0.0164***	0.0480***	0.0367***	-0.0132***	0.0029
REM	0.0091***	-0.0049**	0.0154***	0.0188***	-0.0092***	-0.0069*
FEM	0.0092***	-0.0039*	0.0131***	0.0157***	-0.0089***	-0.0086**

***, **, *: significant at the 1%, 5%, and 10% level, respectively.

Table 12. Impact of BOJ CB purchases on firms' capital structure: FEM

	(1) Leverage	(2) Short-term leverage	(3) Long-term leverage	(4) Bond ratio	(5) Short-term bank loan ratio	(6) Long-term bank loan ratio
CBEligible*CBPost	0.0092***	-0.0039*	0.0131***	0.0157***	-0.0089***	-0.0086**
	(0.0025)	(0.0020)	(0.0024)	(0.0039)	(0.0028)	(0.0038)
Log(Interest tax shield)	0.0175***	0.0054***	0.0121***	0.0009	0.0135***	0.0179***
	(0.0012)	(0.0009)	(0.0010)	(0.0029)	(0.0014)	(0.0018)
Cash ratio	-0.0491**	-0.0193	-0.0296	-0.0321	0.1109***	-0.0625*
	(0.0218)	(0.0204)	(0.0210)	(0.0492)	(0.0321)	(0.0368)
Tangibility	-0.0769***	-0.3092***	0.2323***	0.1302**	-0.1085***	0.3692***
	(0.0295)	(0.0248)	(0.0286)	(0.0539)	(0.0374)	(0.0498)
Size	0.0609***	0.0051	0.0559***	-0.0049	-0.0305***	0.0452***
	(0.0082)	(0.0062)	(0.0068)	(0.0123)	(0.0083)	(0.0106)
Profitability	-0.3829***	-0.0680**	-0.3152***	-0.0363	-0.5050***	-0.4295***
	(0.0365)	(0.0321)	(0.0289)	(0.0699)	(0.0391)	(0.0472)
Current ratio	-0.0444***	-0.0594***	0.0150***	0.0402***	-0.0770***	0.0413***
	(0.0035)	(0.0043)	(0.0029)	(0.0096)	(0.0063)	(0.0074)
MB ratio	0.0006**	0.0002	0.0004*	0.0005	0.0003	0.0016***
	(0.0003)	(0.0001)	(0.0002)	(0.0003)	(0.0002)	(0.0003)
Firm age	-0.0306***	-0.0127	-0.0180**	-0.0189*	-0.0048	-0.0012
	(0.0081)	(0.0100)	(0.0087)	(0.0097)	(0.0094)	(0.0107)
GDP growth	-0.0021***	-0.0016***	-0.0005***	-0.0012***	-0.0013***	-0.0003
	(0.0002)	(0.0002)	(0.0002)	(0.0004)	(0.0003)	(0.0003)
CPI	-0.0088***	-0.0058***	-0.0030***	-0.0022**	-0.0012*	-0.0002
	(0.0006)	(0.0005)	(0.0005)	(0.0010)	(0.0007)	(0.0008)
Industry dummies	No	No	No	No	No	No
Number of observations	12,353	12,353	12,344	3,726	11,484	10,174
R-squared within	0.4367	0.4347	0.2003	0.1082	0.3156	0.1553

* p<0.1, ** p<0.05, *** p<0.01. Figures in parentheses are cluster-robust standard errors.

Table 13. Policy impact on firms' capital structure: Combination of ETF and CB purchases, REM

	(1)	(2)	(3)	(4)	(5)	(6)
	Leverage	Short-term leverage	Long-term leverage	Bond ratio	ST bank loan ratio	LT bank loan ratio
Both	-0.0044	-0.0044	0.0020	0.0054	-0.0017	-0.0022
	(0.0048)	(0.0034)	(0.0051)	(0.0058)	(0.0046)	(0.0068)
Bonds only	0.0112***	-0.0047**	0.0173***	0.0213***	-0.0097***	-0.0102***
	(0.0026)	(0.0021)	(0.0024)	(0.0041)	(0.0028)	(0.0039)
Stocks only	-0.0108*	0.0051	-0.0154***	-0.0092	0.0097*	-0.0167*
	(0.0059)	(0.0043)	(0.0054)	(0.0081)	(0.0054)	(0.0097)
Log(Interest tax shield)	0.0207***	0.0067***	0.0154***	0.0010	0.0159***	0.0242***
	(0.0013)	(0.0009)	(0.0010)	(0.0026)	(0.0014)	(0.0017)
Cash ratio	-0.0406*	-0.0238	-0.0140	-0.0150	0.0884***	-0.0357
	(0.0235)	(0.0201)	(0.0196)	(0.0376)	(0.0277)	(0.0304)
Tangibility	-0.0902***	-0.3148***	0.2281***	0.1085***	-0.0820***	0.2889***
	(0.0258)	(0.0195)	(0.0208)	(0.0243)	(0.0246)	(0.0293)
Size	0.0068**	-0.0105***	0.0096***	0.0095***	-0.0346***	-0.0082***
	(0.0029)	(0.0023)	(0.0020)	(0.0030)	(0.0025)	(0.0027)
Profitability	-0.2787***	-0.0469	-0.2354***	-0.0754	-0.3195***	-0.2499***
	(0.0791)	(0.0493)	(0.0389)	(0.0603)	(0.0763)	(0.0547)
Current ratio	-0.0475***	-0.0580***	0.0080***	0.0415***	-0.0631***	0.0334***
	(0.0039)	(0.0046)	(0.0024)	(0.0075)	(0.0055)	(0.0055)
MB ratio	0.0006	0.0002	0.0006	0.0013***	0.0002	0.0015***
	(0.0004)	(0.0001)	(0.0004)	(0.0004)	(0.0002)	(0.0002)
Firm age	-0.0152***	-0.0095*	-0.0043	-0.0010	-0.0072	-0.0164***
	(0.0053)	(0.0056)	(0.0047)	(0.0038)	(0.0044)	(0.0058)
GDP growth	-0.0011***	-0.0013***	0.0004**	-0.0016***	-0.0008***	0.0010***
	(0.0002)	(0.0002)	(0.0002)	(0.0004)	(0.0003)	(0.0003)
CPI	-0.0047***	-0.0047***	0.0007**	-0.0026***	-0.0007	0.0045***
	(0.0004)	(0.0003)	(0.0004)	(0.0009)	(0.0005)	(0.0006)
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	12,159	12,159	12,150	3,670	11,304	10,012
R-squared between	0.5541	0.6005	0.5725	0.4219	0.3016	0.4315

* $p<0.1$, ** $p<0.05$, *** $p<0.01$. Figures in parentheses are cluster-robust standard errors.

Table 14. Average marginal effects of BOJ asset purchases on securities issuance: Logit model

	Stock issuance dummy			Bond issuance dummy		
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Both	0.0138*			0.0213***		
	(0.0080)			(0.0064)		
Bonds only	0.0019			0.0480***		
	(0.0054)			(0.0046)		
Stocks only	0.0200**			-0.0036		
	(0.0092)			(0.0094)		
N225*ETFPost		0.0157**			-0.0165***	
		(0.0063)			(0.0053)	
CBEligible*CBPost			0.0026			0.0424***
			(0.0048)			(0.0043)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	12,175	12,175	12,175	12,175	12,175	12,175
R-squared	0.0412	0.0411	0.0394	0.4674	0.4450	0.4627

* $p<0.1$, ** $p<0.05$, *** $p<0.01$. Figures in parentheses are cluster-robust standard errors.

Table 15. Robustness checks: Estimation of treatment effect on firms' long-term leverage

(a)				(b)		
Period	**ETF purchases**	**CB purchases**		**Period**	**ETF purchases**	**CB purchases**
2009 – 2011	-	0.0030		2010 – 2011	-	0.0081
2009 – 2012	-	0.0089***		2010 – 2012	-	0.0142**
2009 – 2013	-0.0045	0.0099***		2010 – 2013	-0.0088**	0.0131***
2009 – 2014	-0.0082**	0.0108***		2010 – 2014	-0.0130***	0.0165***
2009 – 2015	-0.0094**	0.0117***		2010 – 2015	-0.0150***	0.0167***
2009 – 2016	-0.0114***	0.0121***		2010 – 2016	-0.0162***	0.0167***
2009 – 2017	-0.0133***	0.0128***		2010 – 2017	-0.0188***	0.0169***
2009 – 2018	-0.0139***	0.0131***		2010 – 2018	-0.0202***	0.0169***
Lagged control variables	No	No		Lagged control variables	Yes	Yes
Industry dummies	Yes	No		Industry dummies	Yes	No
Companies	All	All		Companies	TSE1	TSE1
Model	REM	FEM		Model	REM	FEM

Table 16. Estimation of treatment effect using alternative debt indicators

	ETF purchases			CB purchases		
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
	log(debt)	log(STdebt)	log(LTdebt)	log(debt)	log(STdebt)	log(LTdebt)
N225 dummy	0.0580***	-0.0443***	0.2855***			
	(0.0093)	(0.0114)	(0.0262)			
ETF Post dummy	0.0073	-0.0050	0.0774***			
	(0.0067)	(0.0070)	(0.0184)			
N225*ETFPost	-0.0192*	0.0117	-0.1203***			
	(0.0101)	(0.0128)	(0.0270)			
CBEligible*CBPost				0.0746***	-0.0464***	0.2659***
				(0.0056)	(0.0064)	(0.0145)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	16,754	16,754	16,727	16,754	16,754	16,727
R-squared	0.9798	0.9766	0.8866	0.9799	0.9767	0.8872

* $p<0.1$, ** $p<0.05$, *** $p<0.01$. Figures in parentheses are cluster-robust standard errors.

Table 17. Continuous treatment variables and BOJ ETF purchases: FEM

	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
	Leverage	ST leverage	LT leverage	Bond ratio	ST bank loan ratio	LT bank loan ratio
A. Treatment variable: Total exposure						
Treatment effect	-0.0110***	-0.0069***	-0.0042***	-0.0024*	-0.0018*	0.0023
	(0.0013)	(0.0009)	(0.0010)	(0.0013)	(0.0010)	(0.0015)
R-squared within	0.3763	0.4081	0.1867	0.0619	0.1886	0.1631
B. Treatment variable: N225 exposure						
Treatment effect	-0.0042***	-0.0017**	-0.0025*	-0.0029*	0.0008	0.0012
	(0.0016)	(0.0007)	(0.0015)	(0.0017)	(0.0013)	(0.0021)
R-squared within	0.3617	0.4003	0.1837	0.0617	0.1882	0.1627
C. Treatment variable: TOPIX exposure						
Treatment effect	-0.0206***	-0.0138***	-0.0069***	-0.0027	-0.0052***	0.0042*
	(0.0015)	(0.0013)	(0.0013)	(0.0027)	(0.0018)	(0.0023)
R-squared within	0.3851	0.4143	0.1875	0.0609	0.1896	0.1633
Number of observations	16,752	16,754	16,727	4,747	13,426	13,653

* $p<0.1$, ** $p<0.05$, *** $p<0.01$. Figures in parentheses are cluster-robust standard errors.

Table 18. Average marginal effects of BOJ asset purchases on firms' securities issuance amounts

	Log(1+Stock issuance amounts)			Log(1+Bond issuance amounts)		
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Both	0.2331*			0.7490***		
	(0.1383)			(0.0832)		
Bonds only	0.0508			0.9702***		
	(0.0832)			(0.0643)		
Stocks only	0.3950***			0.0332		
	(0.1507)			(0.1194)		
N225*ETFPost		0.2879***			-0.0090	
		(0.1075)			(0.0676)	
CBEligible*CBPost			0.0582			0.9107***
			(0.0715)			(0.0590)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	16,600	16,600	16,600	16,600	16,600	16,600
R-squared	0.0365	0.0364	0.0358	0.2512	0.2322	0.2506

* $p<0.1$, ** $p<0.05$, *** $p<0.01$. Figures in parentheses are cluster-robust standard errors.

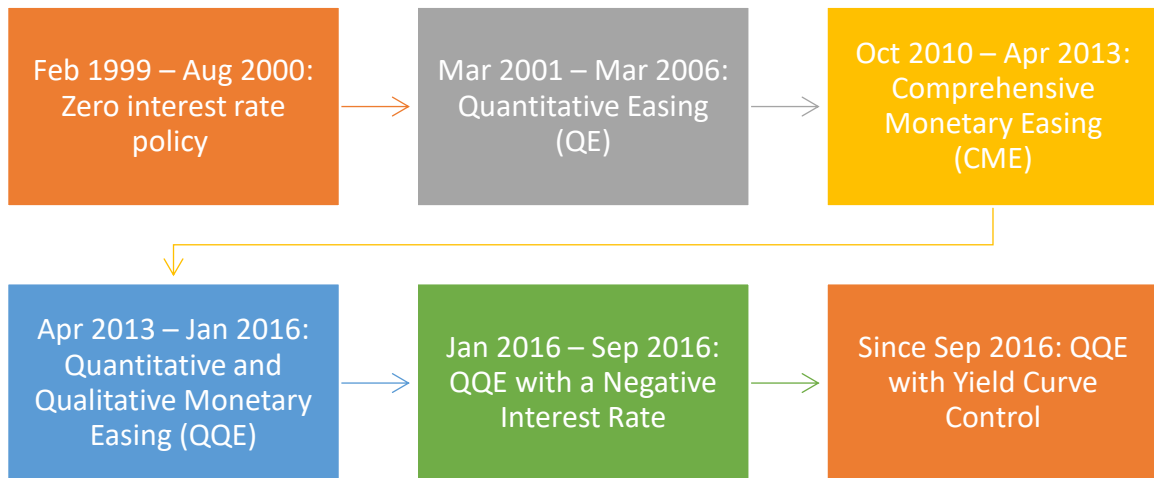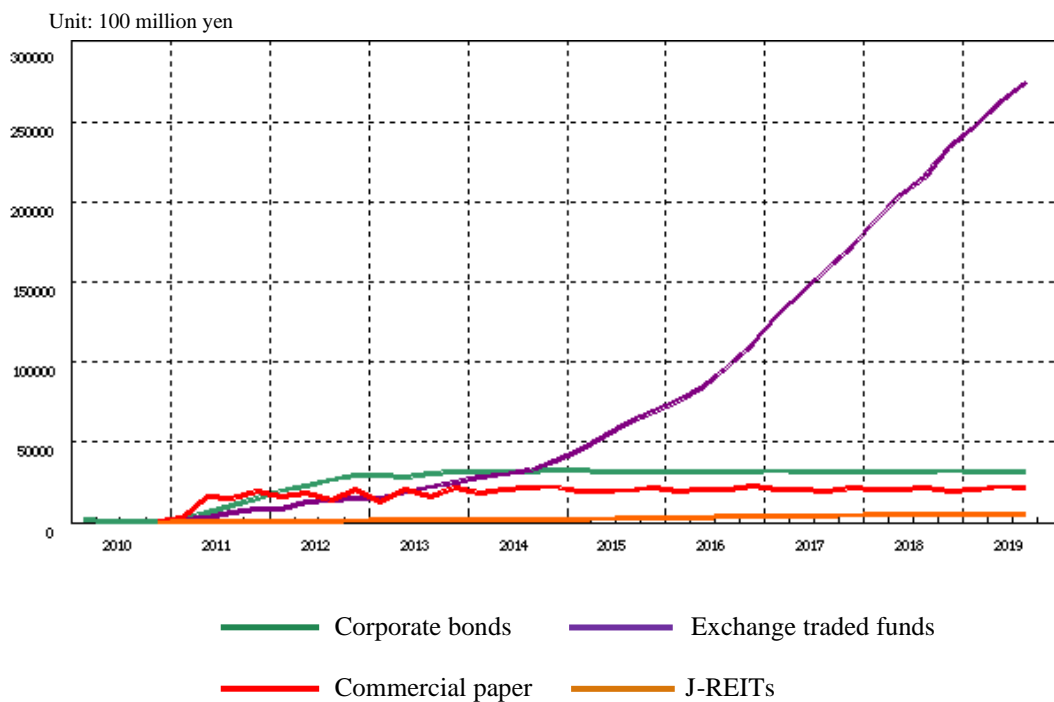## Figure 1. Unconventional monetary policy in Japan

Feb 1999 – Aug 2000: Zero interest rate policy	Mar 2001 – Mar 2006: Quantitative Easing (QE)	Oct 2010 – Apr 2013: Comprehensive Monetary Easing (CME)
Apr 2013 – Jan 2016: Quantitative and Qualitative Monetary Easing (QQE)	Jan 2016 – Sep 2016: QQE with a Negative Interest Rate	Since Sep 2016: QQE with Yield Curve Control

Figure 2. Total outstanding amount of BOJ's risk asset holdings

Source: Based on data from the Bank of Japan
(https://www.boj.or.jp/en/statistics/boj/other/acmai/release/index.htm/).

Figure 3. Nikkei 225 Stock Average and BOJ ETF purchases
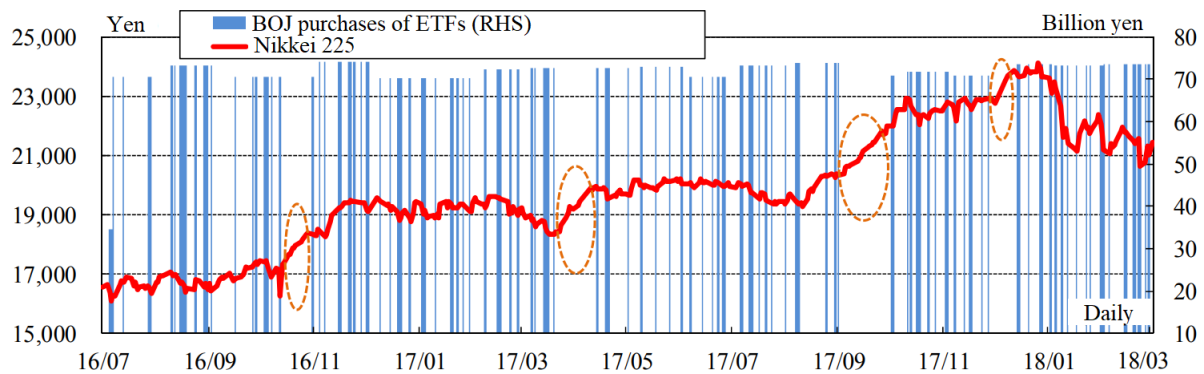
Notes: 1. The data exclude purchases of ETFs consisting of stocks issued by firms that proactively invest in physical and human capital.

2. Daily data up to and including March 30, 2018.

Source: Samikawa and Takano (2018: 8).

**Figure 4. BOJ ETF purchases: Changes in purchasing amount allocation**

September 21, 2016

July 31, 2018
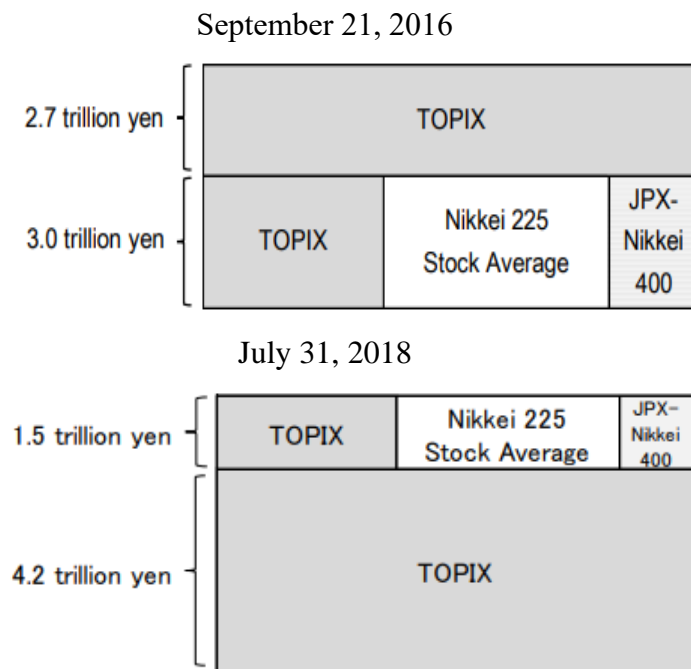
Source: Bank of Japan, "The Maximum Amount of Each ETF to be Purchased"
(https://www.boj.or.jp/en/announcements/release_2016/rel160921c.pdf),
and "Outline of Purchases of ETFs" (https://www.boj.or.jp/en/announcements/release_2018/rel180731h.pdf).

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Figure 5. Testing for parallel trend (DID key assumption)
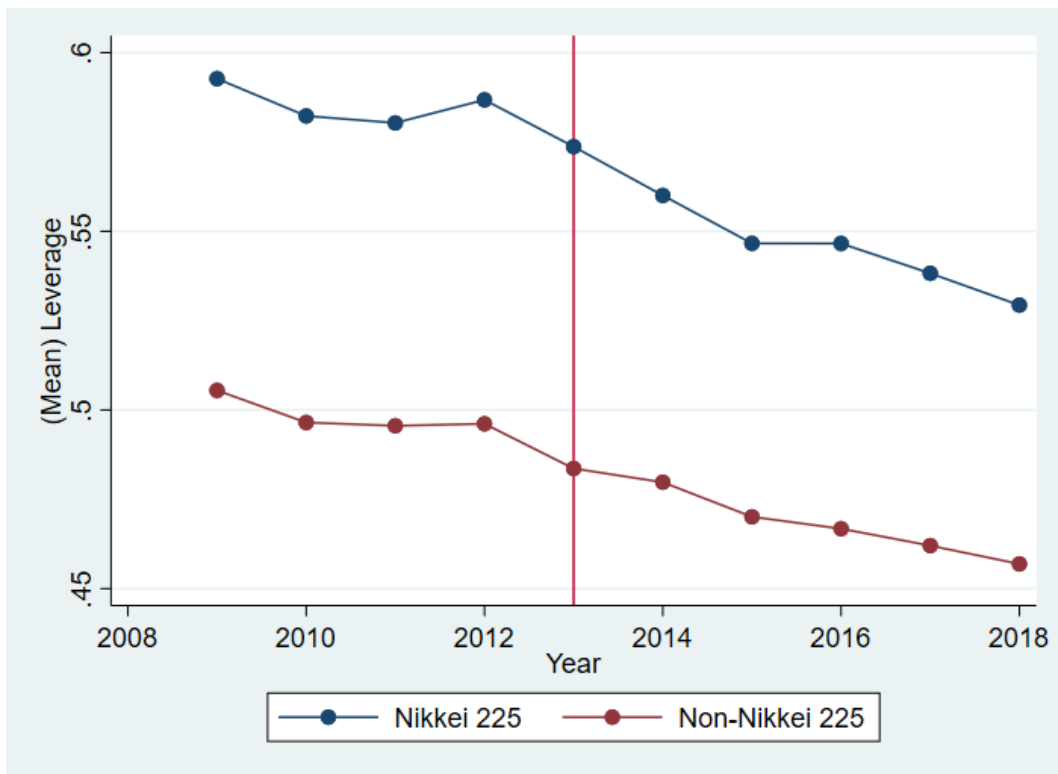
Appendix

This appendix presents the methodology used by Gunji et al. (2019) to calculate the BOJ's indirect shareholding ratio of TOPIX component firms and of Nikkei 225 firms.

The BOJ's indirect shareholding ratio of TOPIX component firms

Let ρ_{it} denote the BOJ's (indirect) shareholding ratio of TOPIX component firm i in year t, which is defined as the number of stocks of firm i purchased by the BOJ in year t (q_{it}^*) divided by the number of outstanding shares of firm i in year t (q_{it}):

$$\rho_{it} \equiv \frac{q_{it}^*}{q_{it}}.$$

The TOPIX is calculated as the sum of the market capitalization of listed stocks on the First Section of the Tokyo Stock Exchange, with a base date of January 4, 1968, and a base value of 100.[8] That is:

$$TOPIX_t = \frac{\sum_{i=1}^N p_{it} q_{it} w_{it}}{\sum_{i=1}^N p_{i,1968} q_{i,1968}} \cdot 100$$

where w_{it} is the free float ratio of firm i in year t and p_{it} is the stock price of firm i in year t.

When the BOJ spends X_t^{TOPIX} trillion yen to purchase Q_t^{TOPIX} units of TOPIX ETFs in period t, we have:

$$X_t^{TOPIX} = TOPIX_t \cdot Q_t^{TOPIX} = \frac{\sum_{i=1}^N p_{it} q_{it} w_{it}}{\sum_{i=1}^N p_{i,1968} q_{i,1968}} \cdot 100 \cdot Q_t^{TOPIX}.$$

Therefore, the amount of stock of firm i purchased by the BOJ is

$$\frac{p_{it} q_{it} w_{it}}{\sum_{i=1}^N p_{i,1968} q_{i,1968}} \cdot 100 \cdot Q_t^{TOPIX}.$$

By dividing this by the stock price p_{it}, we obtain the number of stocks of firm i purchased by the BOJ,

$$q_{it}^* = \frac{q_{it} w_{it}}{\sum_{i=1}^N p_{i,1968} q_{i,1968}} \cdot 100 \cdot Q_t^{TOPIX}.$$

Dividing q_{it}^* by the outstanding shares q_{it} yields the BOJ's (indirect) shareholding ratio of TOPIX component firm i, which is:

$$\rho_{it} = \frac{q_{it}^*}{q_{it}} = \frac{w_{it}}{\sum_{i=1}^N p_{i,1968} q_{i,1968}} \cdot 100 \cdot \frac{X_t^{TOPIX}}{TOPIX_t}$$

where we use $Q_t^{TOPIX} = X_t^{TOPIX}/TOPIX_t$.

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[8] See https://www.jpx.co.jp/english/markets/indices/topix/tvdivq00000030ne-att/e_cal_3_topix.pdf, pages 5–6.

Assuming, for simplicity, that w_{it} is constant with respect to i, and using the definition of the TOPIX, yields

$$\rho_{it} = \frac{w_{it}}{\sum_{i=1}^{N} p_{i,1968} q_{i,1968}} \cdot 100 \cdot \frac{X_t^{TOPIX}}{\frac{\sum_{i=1}^{N} p_{it} q_{it} w_{it}}{\sum_{i=1}^{N} p_{i,1968} q_{i,1968}} \cdot 100} = \frac{X_t^{TOPIX}}{\sum_{i=1}^{N} p_{it} q_{it}}.$$

Thus, for all TOPIX component firms, the BOJ's indirect shareholding ratio in year t is:

$$\rho_t = \frac{X_t^{TOPIX}}{\sum_{i=1}^{N} p_{it} q_{it}}.$$

The BOJ's indirect shareholding ratio of Nikkei 225 firms

Let θ_{it} denote the BOJ's (indirect) shareholding ratio of Nikkei 225 component firm i in year t, which is defined as the number of stocks of firm i purchased by the BOJ in year t (q_{it}^*) divided by the number of outstanding shares of firm i in year t (q_{it}):

$$\theta_{it} \equiv \frac{q_{it}^*}{q_{it}}.$$

The Nikkei 225 is calculated as a weighted price average where the sum of the constituent stock prices adjusted by the presumed par value is divided by the divisor.[9] Thus, we have:

$$N225_t = \frac{\sum_{i=1}^{N} s_{it}}{d_t}$$

where d_t is the Nikkei 225 divisor in year t, s_{it} is the adjusted stock price of firm i in year t, and

$$s_{it} = p_{it} \cdot \frac{50}{\bar{p}_{it}}$$

where $\bar{p}_{it}$ is the presumed par value of firm i in year t and p_{it} is the stock price of firm i in year t.

When the BOJ spends X_t^{N225} trillion yen to purchase Q_t^{N225} units of Nikkei 225 ETFs in period t, we have:

$$X_t^{N225} = N225_t \cdot Q_t^{N225} = \frac{\sum_{i=1}^{N} s_{it}}{d_t} \cdot Q_t^{N225}.$$

Therefore, the amount of stock of firm i purchased by the BOJ is:

$$\frac{s_{it}}{d_t} \cdot Q_t^{N225}$$

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[9] See https://indexes.nikkei.co.jp/nkave/archives/file/nikkei_stock_average_guidebook_en.pdf , pages 7–8.

Dividing this by the stock price p_{it}, we obtain the number of stocks of firm i purchased by the BOJ,

$$q_{it}^* = \frac{s_{it} Q_t^{N225}}{p_{it} d_t}.$$

Moreover, by dividing this by the number of outstanding shares q_{it}, we obtain the BOJ's indirect shareholding ratio of Nikkei 225 firms:

$$\theta_{it} = \frac{q_{it}^*}{q_{it}} = \frac{s_{it} Q_t^{N225}}{p_{it} q_{it} d_t}.$$

Alternatively, from the definition of s_{it} and because $Q_t^{N225} = X_t^{N225}/N225_t$, we have

$$\theta_{it} = p_{it} \cdot \frac{50}{\bar{p}_{it}} \cdot \frac{X_t^{N225}}{N225_t} \cdot \frac{1}{p_{it} q_{it} d_t} = \frac{50 X_t^{N225}}{\bar{p}_{it} q_{it} d_t N225_t}.$$