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**Do the Bank of Japan's Unconventional Monetary Policies Decrease Real Interest
Rates under a Zero Lower Bound?**

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Do the Bank of Japan's unconventional monetary policies decrease real interest rates under a zero lower bound?*

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Abstract

To test Krugman's (1998) pioneering proposal for escaping from liquidity traps, this study examines whether unconventional monetary policies under a zero lower bound decrease real interest rates in Japan. We find a sizable decline in real interest rates under zero interest rate policy and Abenomics monetary policy. In addition, we find no significant decline in real interest rates under other unconventional monetary policies, such as the first quantitative easing and comprehensive monetary easing.

Keywords: Unconventional monetary policy; Real interest rate; Zero lower bound

JEL classification: E43; E58

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1 Introduction

Are unconventional monetary policies effective for an economy stuck at the zero lower bound of short-term nominal interest rates? The Bank of Japan (BOJ) was the world's first central bank to implement several unconventional measures, as shown in Figure 1, in order to tackle a liquidity trap in the latter half of the 1990s. The BOJ first introduced its zero interest rate (ZIR) policy from 1999 to 2000. Subsequently, the BOJ has designed and executed unconventional monetary policies in succession: quantitative easing (QE) from 2001 to 2006, comprehensive monetary easing (CE) from 2010 to 2013, and quantitative and qualitative easing (QQE or Abenomics monetary policy) from 2013. Most recently, a negative interest rate policy was introduced in January 2016, and the BOJ implemented yield curve control, a new policy framework, in September 2016.

[Insert Figure 1 around here]

The extant empirical literature explores the effects of those unconventional monetary policies and provides evidence on their effectiveness through various channels. For example, Okina and Shiratsuka (2004) investigate the commitment effect and find that it flattens the yield curve from March 1998 to February 2003. More recently, Honda (2014) finds positive effects of the first QE from 2001 to 2006 on investment and production through Tobin's q channel. Bowman *et al.* (2015) show that QE has only limited effects on bank lending. Regarding QQE after 2013, Matsuki *et al.* (2015) point out that quantitative easing leads to a decline in short-term interest rates and increase in prices, while qualitative easing stimulates economic activity. In addition, Miyao and Okimoto (2017) demonstrate that the introduction of QQE substantially raises real output and prices. Moreover, Michaelis and Watzka (2017) compare all the unconventional monetary policies (ZIR, QE, and QQE) and confirm a substantial effect on real output and prices only in Abenomics monetary policy (QQE).

However, while several channels of the BOJ's unconventional monetary policies have been studied up to now, surprisingly, there is no or little empirical evidence about whether those unconventional monetary policies lower real interest rates. Krugman (1998) developed a pioneering theory of unconventional monetary policy in a liquidity trap, suggesting that a radical regime change of monetary easing can boost an economy through an expected rise in inflation and a decline in real interest rates, even at a zero lower bound. The channel involving real interest rates has yet to be revealed.

In this study, we identify unconventional monetary policies (ZIR policy, QE, CE, and QQE) and examine whether they decrease real interest rates in Japan under a zero lower bound. To this end, we test the validity of the Fisher effect, that is, whether there is high

correlation between nominal interest rates and inflation.¹ If an unconventional monetary policy contributes to lowering real interest rates, then the Fisher effect does not hold in the period. Conversely, if real interest rates are not influenced by the expected changes in the inflation rate and remain constant in the period, then the Fisher effect should be validated.

We find a sizable decline in real interest rates under the ZIR policy and Abenomics monetary policy (QQE). On the contrary, a substantial decline in real interest rates cannot be confirmed under the other unconventional monetary policies (i.e., QE and CE).

The rest of the paper is organized as follows. In Section 2, we explain the data used in the analysis and our empirical strategy. In Section 3, we present the empirical results. Section 4 concludes.

2 Data and methodology

Our data are monthly observations in Japan and cover the time period from October 1997 to December 2015. Since our sample period is required to correspond to the zero lower bound period, the sample begins in the month in which the call rate (or short-term interest rate) falls below 50 basis points, following Iwata and Wu (2006) and Nakajima (2011). The end date of the sample corresponds to the end of the first QQE policy framework, and the sample ends before the negative interest rate policy is introduced. Nominal interest rates are long-term (10-year) government bond yields, which are obtained from the website of the St. Louis Fed's Federal Reserve Economic Data. The inflation rate is calculated as the year-on-year change rate of the core consumer price index. We use two types of core consumer price index: (1) all items less fresh food and energy and (2) all items less food (less alcoholic beverages) and energy. In the consumer price indexes, the effects of the tax hikes are excluded. These consumer price indexes can be retrieved from the website of Japan's Ministry of Internal Affairs and Communications.

[Insert Figure 2 around here]

Figure 2 displays the data. The nominal interest rate declines during the latter part of the sample period. On the contrary, the inflation rate rises after the beginning of the 2010s, especially under Abenomics monetary policy (QQE) from April 2013. Hence, it seems evident from Figure 2 that the Fisher effect does not hold throughout the entire sample period and the introduction of QQE at least yields a decline in the real interest rate.

¹While Ito (2009) examines the relationship between the validity of the Fisher effect and monetary policy regimes in Japan, unconventional monetary policies are not identified.

Following the literature on the Fisher effect (e.g., Mishkin, 1992), the basic model builds on the Fisher equation, as follows:

$$i_t = \alpha + \beta\pi_t + \varepsilon_t, \quad (1)$$

where i_t is the nominal interest rate in period t , π_t is the inflation rate in period t , and ε_t is the error term. Moreover, to verify the abovementioned visual inspection of Figure 2 formally, we incorporate slope dummy variables identifying the periods of Japanese unconventional monetary policies and estimate the following equation:

$$i_t = \alpha + \beta_1\pi_t + \beta_2\pi_tD_{ZIR} + \beta_3\pi_tD_{QE} + \beta_4\pi_tD_{CE} + \beta_5\pi_tD_{QQE} + \varepsilon_t, \quad (2)$$

where D_{ZIR} takes a value of unity in the ZIR policy period (from February 1999 to August 2000), D_{QE} does so in the QE period (from March 2001 to March 2006), D_{CE} does so in the CE period (from October 2010 to March 2013), and D_{QQE} does so in the QQE period (from April 2013 to December 2015).² If unconventional monetary policies act to decrease the real interest rate, then we should find that estimates of β_2, \dots , and β_5 are negative.

3 Empirical results

We now present our main results. In what follows, π_1 denotes the first inflation rate on all items less fresh food and energy, and π_2 denotes the second inflation rate on all items less food (less alcoholic beverages) and energy.³

[Insert Table 1 around here]

Prior to the estimation, we first check whether our variables are stationary. To do this, we perform two unit root tests: the augmented Dickey–Fuller (ADF) test by Dickey and Fuller (1979) and the refined Dickey–Fuller test by Elliott *et al.* (1996). The lag lengths are chosen based on the Schwarz information criterion (up to 10 lags). We assume that tests in levels include constants and linear trends (detrended tests) and tests in first differences include constants only (demeaned tests). Table 1 shows the results of unit root tests. Overall, the results indicate that the null hypothesis of the unit roots cannot

²In order to test the theoretical implications of Krugman (1998), we focus on the zero lower bound period and disregard the most recent period after January 2016, in which the negative interest rate policy is implemented.

³Note also that, in the following analysis, the time variable t is omitted when not needed for clarity.

be rejected in levels, but is strongly rejected in first differences. Hence, we treat all the variables as integrated of the order one.

[Insert Table 2 around here]

We next check whether there is a cointegrating relationship between i and π using Johansen's (1988) and Johansen and Juselius's (1990) maximal eigenvalue test. The lag lengths used in the tests are chosen based on the Schwarz information criterion and the Akaike information criterion (up to 10 lags). In both models (i, π_1) and (i, π_2) , the Schwarz information criterion indicates that there are no lags. The Akaike information criterion indicates two lags in model of (i, π_1) and four lags in model of (i, π_2) . The results reported in Table 2 indicate that the null of no cointegration is rejected overall, showing that there is cointegration in both models.

[Insert Table 3 around here]

Table 3 reports the estimation results of both (1) and (2), in which slope dummy variables are incorporated, because parameter shifts are suggested from a visual inspection of Figure 2, as already mentioned. We estimate the cointegrating vector using the fully modified ordinary least squares (FMOLS) and dynamic ordinary least squares (DOLS) methods. In the DOLS estimations, the lead and lag lengths are assumed to be unity.

In columns 1 and 2 of Table 3, the results of (1) are reported. In this case, all the estimated coefficients of π are negative, but not significant. Columns 3 and 4 of Table 3 add slope dummy variables of the unconventional monetary policies and display the estimation results. The estimated coefficients of π are affected and are positive values, but again are not significant.

The results of the slope dummy variables of (2) indicate that the ZIR and QQE variables are strongly negatively related to nominal interest rates in all the specifications and methods. This suggests that real interest rates decrease under the ZIR and QQE policies. On the contrary, the estimated coefficients of CE are rather positive and significant. Under the first QE period, no significant result can be confirmed.

[Insert Table 4 around here]

Table 4 further explores the robustness of the DOLS estimates, by increasing the lead and lag lengths. The table shows that the results presented above are mirrored by the additional analyses changing the lead and lag lengths. Our findings are consistent with QQE's positive effects suggested by previous researchers, such as Matsuki *et al.* (2015), Michaelis and Watzka (2017), and Miyao and Okimoto (2017).

4 Conclusion

While several channels of the BOJ's unconventional monetary policies have been studied in the existing literature, little is known about the channel involving real interest rates proposed by Krugman (1998). In this study, we attempted to fill this gap and investigated whether the BOJ's unconventional monetary policies decrease real interest rates. We found a sizable decline in real interest rates only under the ZIR policy and Abenomics monetary policy (QQE). The finding is useful for policymakers in considering which types of unconventional monetary policies are effective for cutting real interest rates, which are a crucial factor for real economic activities, such as private consumption and investment.

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Table 1: Unit root test statistics

	Dickey and Fuller (1979)	Elliot <i>et al.</i> (1996)
A. Detrended test in levels		
i	$-3.83(1)^{**}$	$-2.36(2)$
π_1	$-2.45(2)$	$-1.67(2)$
π_2	$-2.50(0)$	$-1.08(0)$
B. Demeaned test in first differences		
Δi	$-9.94(3)^{***}$	$-4.81(6)^{***}$
$\Delta \pi_1$	$-8.23(1)^{***}$	$-6.78(2)^{***}$
$\Delta \pi_2$	$-17.46(0)^{***}$	$-6.31(4)^{***}$

Notes: Panel A shows the results for variables in levels, including a constant and a linear trend (detrended tests). Panel B shows the results for variables in first differences, including a constant only (demeaned test). The lag lengths are chosen based on the Schwarz information criterion (up to ten lags) and shown in the parentheses. *, **, and *** represent the rejection of the null hypothesis at the 10, 5, and 1% significance levels, respectively.

Table 2: Cointegration test statistics

A. Model (i, π_1)	
	$13.98(0)^*$
	$14.47(2)^{**}$
B. Model (i, π_2)	
	$14.44(0)^{**}$
	$13.87(4)^*$

Notes: The statistics is on Johansen's maximal eigenvalue test. Panel A shows the results for model (i, π_1) . Panel B shows the results for model (i, π_2) . The lag lengths are chosen based on the Schwarz information criterion and the Akaike information criterion (up to ten lags) and shown in the parentheses. In both models, the Schwarz information criterion indicates that there are no lags. The Akaike information criterion indicates two lags in model of (i, π_1) and four lags in model of (i, π_2) . Critical values are from MacKinnon *et al.* (1999). * and ** represent the rejection of the null hypothesis at the 10 and 5% significance levels, respectively.

Table 3: Results of FMOLS and DOLS

	(1)	(2)	(3)	(4)
A. FMOLS				
π_1	-0.120 (0.094)		0.118 (0.096)	
$\pi_1 D_{ZIR}$			-0.832* (0.478)	
$\pi_1 D_{QE}$			0.118 (0.178)	
$\pi_1 D_{CE}$			0.537*** (0.188)	
$\pi_1 D_{QQE}$			-1.274*** (0.192)	
π_2		-0.127 (0.105)		0.147 (0.110)
$\pi_2 D_{ZIR}$				-1.801** (0.719)
$\pi_2 D_{QE}$				-0.023 (0.166)
$\pi_2 D_{CE}$				0.373** (0.169)
$\pi_2 D_{QQE}$				-1.636*** (0.254)
B. DOLS				
π_1	-0.107 (0.110)		0.105 (0.077)	
$\pi_1 D_{ZIR}$			-0.754*** (0.191)	
$\pi_1 D_{QE}$			0.140 (0.160)	
$\pi_1 D_{CE}$			0.517* (0.263)	
$\pi_1 D_{QQE}$			-1.250*** (0.179)	
π_2		-0.105 (0.136)		0.138 (0.102)
$\pi_2 D_{ZIR}$				-1.900*** (0.541)
$\pi_2 D_{QE}$				-0.015 (0.137)
$\pi_2 D_{CE}$				0.362* (0.210)
$\pi_2 D_{QQE}$				-1.585*** (0.293)

Notes: The values in parentheses are the standard errors. In the DOLS results, heteroscedasticity- and autocorrelation-consistent (Newey-West) robust standard errors are used. * and ** represent the rejection of the null hypothesis at the 10 and 5% significance levels, respectively.

Table 4: Robustness check of DOLS changing lead and lag lengths

	(1)	(2)	(3)	(4)
A. Two leads and lags				
π_1	-0.112 (0.113)		0.084 (0.086)	
$\pi_1 D_{ZIR}$			-0.979*** (0.207)	
$\pi_1 D_{QE}$			0.183 (0.165)	
$\pi_1 D_{CE}$			0.627** (0.288)	
$\pi_1 D_{QQE}$			-1.295*** (0.176)	
π_2		-0.111 (0.138)		0.127 (0.107)
$\pi_2 D_{ZIR}$				-1.972*** (0.521)
$\pi_2 D_{QE}$				0.009 (0.143)
$\pi_2 D_{CE}$				0.419* (0.229)
$\pi_2 D_{QQE}$				-1.660*** (0.294)
B. Three leads and lags				
π_1	-0.114 (0.118)		0.063 (0.100)	
$\pi_1 D_{ZIR}$			-1.113*** (0.255)	
$\pi_1 D_{QE}$			0.235 (0.171)	
$\pi_1 D_{CE}$			0.752** (0.290)	
$\pi_1 D_{QQE}$			-1.360*** (0.160)	
π_2		-0.114 (0.141)		0.140 (0.105)
$\pi_2 D_{ZIR}$				-1.907*** (0.537)
$\pi_2 D_{QE}$				0.034 (0.143)
$\pi_2 D_{CE}$				0.485** (0.233)
$\pi_2 D_{QQE}$				-1.822*** (0.270)

Notes: The values in parentheses are the standard errors. Heteroscedasticity- and autocorrelation-consistent (Newey-West) robust standard errors are used. * and ** represent the rejection of the null hypothesis at the 10 and 5% significance levels, respectively.

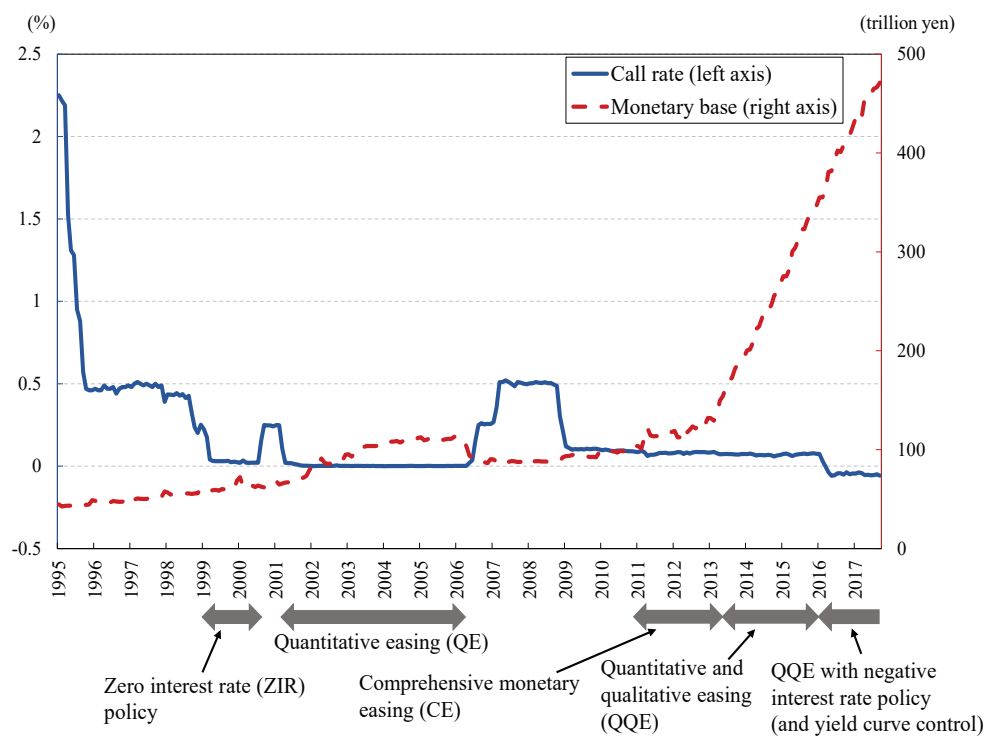


Figure 1: Unconventional Japanese monetary policies

Source: Bank of Japan

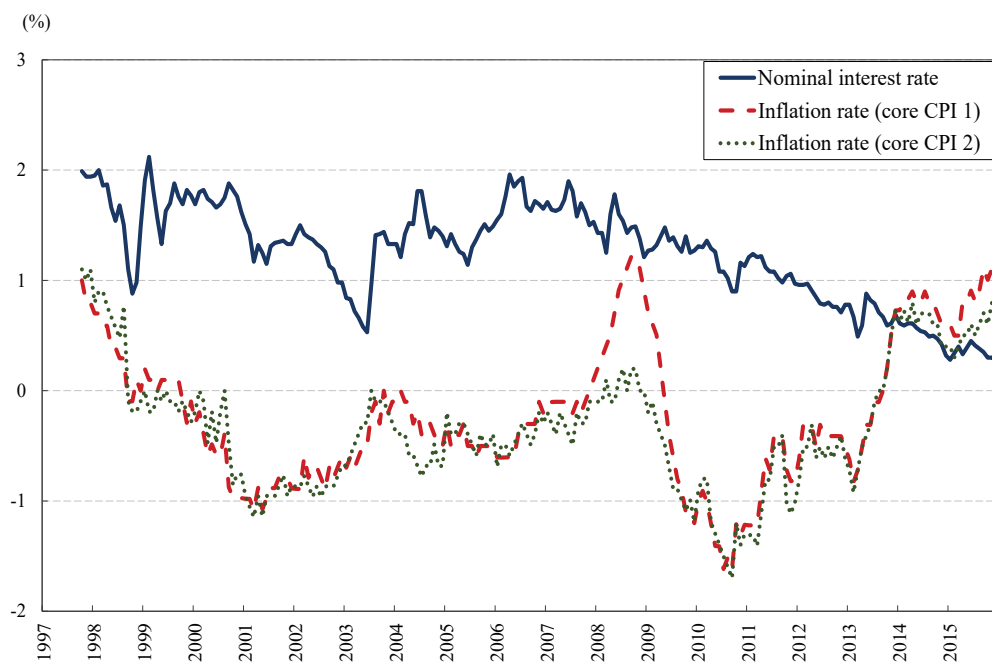


Figure 2: Data.