

Are monetary transmission channels effective under the quantitative and qualitative easing policy?

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ABSTRACT

This study measures the effectiveness of monetary transmission channels of the Bank of Japan's (BOJ) Quantitative and Qualitative Monetary Easing (QQE) policy in affecting Japan's inflation rate. The monetary transmission channels are interest rate, portfolio rebalancing and foreign exchange rate channels. Based on data from 1 August 2013 to 31 October 2019, the Granger's Causality Test showed that the interest rate channel was vital in transmitting the effect of monetary easing. Specifically, the interest rate channel transmitted the effect of QQE, QQE with a negative interest rate and QQE with yield curve control policy to the domestic price level. Portfolio rebalancing and foreign exchange rate channels did not influence Japan's inflation rate in all the QQE policy periods. The empirical results are robust against different estimation methods. Based on the findings, the study offers some imperative policy recommendations.

KEYWORDS

monetary transmission channels, quantitative and qualitative easing, inflation rate, interest rate channel, Japan

JEL CLASSIFICATIONS INDICES

E31, E52, E58

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1. INTRODUCTION

The Bank of Japan (BOJ) has implemented a series of Quantitative and Qualitative Monetary Easing (QQE) policies since April 4, 2013. In the first phase of the QQE policy, the BOJ targeted an annual increase of the monetary base in between 60 and 70 trillion yen through the purchase of Japanese government bonds (JGB), exchange-traded fund (ETF) and Japanese real estate investment trusts (J-REITs). The maturity of JGB purchases ranged from 6 to 8 years. Meanwhile, in the second phase of QQE, the QQE expansion targeted an annual increase of the monetary base to 80 trillion yen, and the maturity of JGB purchases expanded from 7 to 10 years.

In the QQE with the negative interest rate phase, the BOJ maintains the monetary base control at an annual increase of 80 trillion yen. At the same time, a *negative interest rate* of 0.1% is applied to the current accounts that financial institutions hold at the BOJ. As a result, the financial institutions are required to pay interest for parking excess reserves with the central bank. In other words, the central banks penalize the financial institutions for holding on to cash in the hope of prompting them to boost lending to businesses and consumers.

Lastly, in the QQE with the yield curve control phase, the BOJ introduced two new policy frameworks. First, yield curve control (controlling short-and long-term interest rates), and second, an inflation-overshooting commitment in which the BOJ commits itself to expand the monetary base until the inflation rate exceeds the price stability target of 2%. As a result, it abolished the guideline for Japanese government bond maturity purchase and is ready to purchase 20 years of Japanese government bonds to facilitate the long-term interest rate. [Table 1](#) summarizes the differences between the four QQE policies.

Through these QQE policies, the BOJ was confident of achieving an inflation rate of 2% with a time horizon of about two years. Under the QQE policy, three major transmission channels are essential for the BOJ to achieve its inflation target: interest rate, portfolio rebalancing and foreign exchange rate channel. They were expected to facilitate aggregate demand and raise the domestic inflation rate ([Shirai 2017a](#)).

However, the rate of inflation measured by the changes in the consumer price index (CPI) has been in a downward trend since the collapse of real estate and the stock price bubble in 1991. Historically, Japan's inflation rate exceeded 2%, mainly driven by a consumption tax hike from 3% to 5% (from April 1997 to March 1998) and a commodity price hike (mid-2008). Excluding these events, the inflation rate was always in the lower bound and even negative ([Shirai 2017a](#)). Hence, this raises the question of the effectiveness of the three major monetary transmission channels of QQE policy in stimulating the Japanese inflation rate.

Many empirical studies have shown the effectiveness of the monetary transmission channels of BOJ's Unconventional Monetary Policy (UMP) in facilitating Japan's inflation rate. However, most studies have examined the monetary transmission channels under the Quantitative Easing (QE) policy period from 2001 to 2006 ([Honda et al. 2007](#); [Harada –Masujima 2009](#); [Honda –Tachibana 2011](#); [Fasano-Filho et al. 2012](#); [Honda 2014](#); [Tsuji 2016](#)). Little attention has been given to the latest BOJ's UMP and the QQE policy. Since BOJ has adopted the QQE policy as the primary instrument in facilitating Japan's inflation rate since 2013, it is important to study which monetary transmission channel under the QQE policy effectively inflates the domestic price level. Subsequently, the BOJ could identify the correct channel, facilitating inflation effectively.



Table 1. Differences between the four QQE policies

QQE policy	Policy period	Policy targets
QQE	4 April 2013–30 October 2014	• An annual increase of the monetary base between 60 and 70 trillion yen. • The maturity of JGB purchases ranges from 6 to 8 years.
QQE expansion	31 October 2014–8 January 2016	• Annual increase of the monetary base to 80 trillion yen. • The maturity of JGB purchases expands to 7–10 years.
QQE with NIRP	29 January 2016–20 September 2016	• Maintain the monetary base control at an annual increase of 80 trillion yen. • Apply a negative interest rate of 0.1% to the financial institutions' accounts at the BOJ.
QQE with YCC	21 September 2016 Present	• Maintain the monetary base control at an annual increase of 80 trillion yen. • Maintain a negative interest rate of 0.1%. • Control short-and long-term interest rates. • The maturity of JGB purchases expands up to 20 years.

Notes: NIRP: Negative interest rate policy; YCC: Yield Curve Control; BOJ: Bank of Japan; JGB: Japanese Government Bond.

Source: Author's construction based on Shirai (2017a).

Despite limited evidence, a study by Miyao – Okimoto (2017) found that interest rate and portfolio rebalancing channels play an important role in stimulating domestic price levels under the QQE regime. As an extension, the study by Lau – Yip (2020) shed light on how monetary transmission channels of the QQE policy affect the inflation rate in the short-and long-run periods. Their study found that the foreign exchange rate and interest rate channels are essential in accelerating Japan's inflation rate in the long- and short-run periods during the sample period from 2013 to 2018. However, these studies have two limitations. First, the findings may suffer from an aggregation bias. In particular, both studies examine the effectiveness of monetary transmission channels without considering the *different* QQE policy regimes.

Given that each QQE policy has a different policy framework, forward guidance, amount and type of security purchase, it can be expected that the monetary transmission channels will work differently under each QQE policy regime. Moreover, as Brei^{tu}ß et al. (2017) and Iwasaki – Sudo (2017) pointed out, the nature of monetary transmission is subject to financial conditions or economic circumstances. Hence, the effectiveness of monetary transmission channels in affecting price levels may vary across different periods. Therefore, the findings by Miyao – Okimoto (2017) and Lau – Yip (2020), based on aggregate data from 2013 to 2015 and 2013 to 2018, respectively, may not be generalized to each QQE policy period.

The second limitation is in terms of measurement error. In particular, the above-mentioned studies employed monthly CPI data to proxy Japan's inflation rate. However, there is always a time lag between the survey period and the compilation of the CPI index. Therefore, the CPI value may not represent the current economic price level. As a result, a proper investigation of



the current state of the price level could not be made. Consequently, correct inferences on the effectiveness of monetary transmission channels in affecting price level cannot be made.

In line with the above reasons, our study aims to examine the effectiveness of monetary transmission channels of BOJ's four QQE policies. Our study differs from the previous literature in two ways:

- Our research considers the different policy frameworks of each QQE policy, and the effectiveness of each monetary transmission channel can be examined. Subsequently, this would minimize the aggregation bias.

- Contradicting the previous studies that use monthly or quarterly CPI data, we use the daily True price index (T-index) to proxy Japan's inflation rate.

The daily T-index is computed based on data collected from around 300 stores nationwide in Japan through the supermarket POS system. Moreover, the T-index covered more than 200,000 products sold in the stores in Japan. Hence, the T-index is highly accurate and quick compared to CPI, which is available once a month. In addition, the T-index has been used by the BOJ for discussion and policy decisions.¹ This idea motivates the study to employ the T-index to better gauge Japan's inflation rate. Subsequently, this would provide accurate inferences on the effectiveness of monetary transmission channels in affecting the domestic price level.

However, it is widely perceived that there is a time lag for monetary policy to affect the economic system. Hence, one may argue that using daily data to measure the effectiveness of monetary transmission channels is inappropriate in the context of this study. Despite that, the use of daily data is justifiable. Firstly, Hicks (1969) argues that central bank policy, particularly the central bank's announcement on a particular policy, would immediately impact the expectations of economic agents. This identification of the announcement effect is based on the expectations theory concerning long-term interest rates. In other words, he suggested that the forward-looking monetary policy would result in an immediate shift in the expectations of economic agents, and subsequently, affect the macroeconomic indicators.

Notably, the QQE policy by the BOJ is regarded as a forward-looking monetary policy, given that the QQE policy comprises forward guidance that informs the future course of monetary policy. The forward guidance provides a guidepost for the expected path of interest rates for the future. Therefore, it would immediately influence the inflation expectations of economic agents, thereby affecting the domestic price level. Secondly, the policy target of QQE is the monetary base, which differs from the previous monetary easing policies, which focused on the policy interest rate. Adopting the monetary base as the policy target makes it intuitively easier for the economic agents to grasp the scale of monetary easing. As such, the increase in the monetary base would quickly be connected to a large-scale supply of cash, thereby creating an image of inflation in the economy (Shirai 2017a). In line with the above reasons, it can be argued that the QQE policy would immediately impact inflation expectations, affecting the domestic inflation rate. Thus, the use of daily data is justifiable in the context of this study. Empirically, this paper is closely linked to the existing studies which employed daily data to quantify the effectiveness of the monetary transmission channels in influencing the macroeconomic indicators (Ehrmann – Fratzscher 2006; Ray – Prabu 2013; Lagos – Zhang 2020).

Based on the Vector Autoregressive (VAR) model, the Granger's Causality test result shows that: First, the interest rate channel plays an essential role in transmitting the effect of monetary

¹Detailed description for the daily T-index is available in <https://lp.nowcast.co.jp/nikkei/more>



easing to the domestic price level in the short-run period. In particular, the interest rate channel transmits the effect of QQE, QQE with a negative interest rate and QQE with yield curve control policy to Japan's inflation rate. Second, portfolio rebalancing and the foreign exchange rate channels have no short-run impact on Japan's inflation rate in all the QQE policy regimes. Third, the empirical results are robust against different estimation methods and model specifications.

In line with the empirical results, this study contributes to the existing literature on two fronts. 1) Our study proposes alternative measurements to examine the effectiveness of monetary transmission channels of the BOJ's QQE policy. Previous studies mainly used monthly data. This study shows that daily data such as daily monetary base, overnight call rate and daily T-index can capture the impact of monetary transmission channels. Likewise, using daily data allows the study to properly investigate the current price level, thereby improving the accuracy of the estimation results. Daily data provides more observations, which allows the study to examine the effectiveness of monetary transmission channels for different QQE policy regimes. Subsequently, this reduces the aggregation bias in the estimation results. 2) We found robust evidence of the interest rate channels affecting domestic price levels in the short run.

This paper unfolds as follows. *Section 2* reviews the monetary transmission channels of the BOJ's QQE policy, followed by a literature review. *Section 4* illustrates the data and methodology. *Section 5* presented the baseline results, followed by the robustness checks in *Section 6*. *Section 7* provides a discussion of empirical findings. *Section 8* concludes the study.

2. TRANSMISSION CHANNELS OF MONETARY POLICY TO INFLATION RATE

As Shirai (2017a) indicated, there are three major monetary transmission channels under the QQE policy. First, the traditional interest rate channel suggests that monetary policy would affect the general price level through changes in the short-term real interest rate. As such, an increase in the money supply would lead to a fall in the overnight call rate, given that the call rate is the predictor of the short-term interest rates among financial institutions. Therefore, this would lead to a reduction in the short-term real interest rates. This rate decreases the real cost of borrowing, leading to an increase in investment and consumer spending. Subsequently, aggregate demand increases, stimulating the price level (Mishkin 2016).

On the other hand, the inflation-stimulating effect of the interest rate channel would not be eased even with the zero lower bounds. The zero lower bounds refer to a condition where the short-term nominal interest rate is at or near zero. Mishkin (2016) pointed out that when the nominal interest rate is at a floor of zero, a commitment to future expansionary monetary policy can raise expected inflation. This policy would reduce the real interest rate, even when the nominal interest rate is fixed at zero.² Consequently, lower interest rates spur investment and consumer expenditure, increasing aggregate demand and stimulating inflation. Next, a similar argument is applied to a negative interest rate policy. In particular, Bernoth – Haas (2018) found that the interest rate channel remains important in stimulating domestic price level, even if the

²The formation of the real interest rate is based on the following formula:

$$r = i - \pi^e$$

where r is the real interest rate, i is the nominal interest rate and π^e is the inflation expectation.



nominal interest rate is in negative territory. However, the effect is weaker in a negative rate environment than in the regular times.

Second, the portfolio rebalancing channel suggests that the changes in the money supply would affect the portfolio decision of investors, thereby influencing economic activity (Tobin 1969; Andres et al. 2004; Mishkin 2016). An easing of monetary policy reduces the expected return of bonds, increasing the attractiveness of stocks. Subsequently, investors will sell bonds and the demand for stocks will increase, leading to higher stock prices. Higher stock prices increase the market value of firms, encouraging more investment spending and a higher degree of utilization of plants and equipment. Consequently, higher investment spending stimulates the aggregate demand and inflation rate.

Third, the foreign exchange rate channel indicates that expansionary monetary policy would increase the interest-rate differential among countries, thereby influencing the currency values and the export of goods and services of a particular country (Mishkin 2016; Shirai 2017a). An easing of monetary policy reduces the demand for domestic bonds, which exerts a depreciation pressure on the local currency. The lower value of the domestic currency makes domestic goods cheaper than foreign goods, leading to a rise in net exports and aggregate demand. Consequently, the price level has increased.

Table 2 shows the summary for each monetary transmission channel of the QQE policy. Moreover, this study uses several macroeconomic variables to illustrate each monetary transmission channel's working process. In particular, those macroeconomic variables would provide information on how the effect of monetary easing would transmit to the domestic price level. The monetary base, overnight call rate and inflation rate will illustrate the working process for the interest rate channel. The variables employed for the portfolio rebalancing channel are monetary base, overnight call rate, TOPIX stock price index of the Tokyo stock exchange and the inflation rate, as well.³ The use of the TOPIX stock price index to measure portfolio rebalancing channel is in line with the previous studies by Harada – Masujima (2009), Honda – Tachibana (2011), Honda (2014), Miyao – Okimoto (2017) and Lau – Yip (2020). Next, the USD to Japanese yen exchange rate is used to investigate the effectiveness of the foreign exchange rate channel in stimulating the inflation rate (Shirai 2017a; Lau – Yip 2020). This study defines the exchange rate as the Japanese yen per US Dollar. Hence, an increase in the exchange rate indicates a depreciation in the Japanese Yen.

Given that this study employs daily data, it is impossible to include all the relevant macroeconomic variables in the empirical model, as some variables are only available once a month or once a quarter. The selected macroeconomic indicators can still capture the effect of the monetary transmission channels on Japan's inflation rate despite the missing variables. In addition, a robustness check will be conducted to ensure the validity of the results.

3. LITERATURE REVIEW

In response to the Global Financial Crisis (GFC) of 2007–2009, central banks in the advanced economies have initiated the Unconventional Monetary Policy (UMP), such as zero lower

³Tokyo Stock Price Index commonly known as TOPIX, along with the Nikkei 225, is an important stock market index for the Tokyo Stock Exchange (TSE) in Japan.



Table 2. Summary of monetary transmission channels

Transmission channels	Information flow	Macroeconomic variables
Interest rate	Regular time	Monetary base Overnight call rate Inflation rate
	$MS \uparrow \Rightarrow Call \downarrow \Rightarrow r \downarrow \Rightarrow I \& C \uparrow \Rightarrow AD \uparrow \Rightarrow \pi \uparrow$	
	Zero lower bound or negative interest rate period	
	$MS \uparrow \Rightarrow Call \downarrow \Rightarrow \pi^e \uparrow \Rightarrow r \downarrow \Rightarrow I \& C \uparrow \Rightarrow AD \uparrow \Rightarrow \pi \uparrow$	
Portfolio rebalancing	$MS \uparrow \Rightarrow Call \downarrow \Rightarrow r \downarrow \Rightarrow Ps \uparrow \Rightarrow I \uparrow \Rightarrow AD \uparrow \Rightarrow \pi \uparrow$	Monetary base Overnight call rate TOPIX stock price index Inflation rate
Exchange rate	$MS \uparrow \Rightarrow Call \downarrow \Rightarrow r \downarrow \Rightarrow E \uparrow \Rightarrow NX \uparrow \Rightarrow AD \uparrow \Rightarrow \pi \uparrow$	Monetary base Overnight call rate USDJPY exchange rate Inflation rate

Notes: MS: money supply; Call: overnight call rate; r: real interest rate; I: investment spending; C: consumer spending; Ps: stock price; E: exchange rate; NX: net export; AD: aggregate demand; π^e : inflation expectation; π : inflation rate.

bound, quantitative easing, forward guidance and negative interest rate to stimulate economic activity. Consistent with the objective of central banks, empirical studies have found that UMP effectively stimulates domestic inflation rate and economic growth (Peersman 2011; Berkmen 2012; Gambacorta et al. 2012; Kapetanios et al. 2012; Weale – Wieladek 2016). The success of UMP is attributed to the presence of monetary transmission channels. As such, the monetary transmission channels transmit the effect of monetary easing into the economy, which stimulates domestic investment and consumption, leading to greater aggregate demand in the economy. Therefore, it is crucial to study the effectiveness of monetary transmission channels. It would guide the central bank on which channel to focus on to stimulate the economy. Given its importance, many studies examine the effectiveness of various monetary transmission channels of UMP in affecting domestic economic performance.

For the Euro area, a study by Wieladek – Pascual (2016) found that the QE policy by the European Central Bank (ECB) is imperative in stimulating the economic performance of the Euro area. Based on a Bayesian VAR approach, the estimation results show that QE improves real GDP and core inflation rate by 1.3 and 0.9%, respectively. The stimulating effect of QE is transmitted via portfolio rebalancing, signaling, credit easing and foreign exchange rate channels. However, the findings may suffer from an aggregation bias. This bias is because the study does not consider the country-specific effects in analyzing the effectiveness of monetary transmission channels. Given that different countries would have different economic structures, the findings based on the aggregate Euro area data may not be generalized to every country in the Euro area. Notably, a study by Elbourne et al. (2018) overcomes this limitation by examining the effectiveness of monetary transmission channels for several selected European countries.



As expected, the study found that the country-level models could provide greater insight into the UMP transmission channels. In particular, the estimation results based on the aggregate Euro area data show an insignificant impact of UMP on the economic performance.

For the United States, [Engen et al. \(2015\)](#) found that the signaling channel plays a vital role in transmitting the effect of quantitative easing into the economy. Moreover, the study found that the signaling channel would be more effective during the financial market impairment and economic uncertainty. In contrast, [Feldkircher and Huber \(2018\)](#) found that the US UMP works mainly via the wealth channel to stimulate aggregate demand in the economy, while the credit or bank lending channel has a limited role in affecting the macroeconomic performance. The mixed findings may be attributed to different sample periods, research methodologies and model specifications.

Likewise, Japan's unique, unconventional monetary policies have attracted much attention from researchers. In particular, many studies attempt to identify which channel of the UMP is vital in helping the BOJ achieve the inflation target of 2%. The study on the effectiveness of monetary transmission channels in stimulating the inflation rate can be traced back to [Honda et al. \(2007\)](#). Using a VAR model, the study found that the portfolio rebalancing channel is essential in increasing Japan's inflation rate during the Quantitative Monetary Easing Policy (QE) regime from 2001 to 2006. Moreover, the study suggests that further injection of money into the system can stimulate economic activities even when the short-term interest rates are zero.⁴ Next, by using more comprehensive historical data, [Schenkelberg and Watzka \(2013\)](#) found the presence of the interest rate channel in stimulating Japan's inflation rate. However, the stimulating effect is transitory and lasts for around ten months.

In another approach, [Honda \(2014\)](#) uses an operational model to demonstrate the effectiveness of QE adopted by the BOJ from March 2001 to March 2006. Results indicate that QE has a stimulating effect on investment and production. Specifically, an injection of money will lower the interest rate on bonds, thereby reducing the required rate of return from capital stock and the domestic currency depreciation. The depreciation in domestic currency increases the competitiveness of local goods, thereby increasing domestic production and facilitating the export sector. This study highlights the role of foreign exchange channels in helping the Japanese economy escape deflation. Conversely, using a different methodology, [Tsuji \(2016\)](#) found that the primary transmission channel of 2001–2006 Japanese QE policy is the expectations channel. The above studies examine the monetary transmission channels for QE policy from 2001 to 2006.

For the monetary transmission channels of QQE policy, the study by [Miyao – Okimoto \(2017\)](#) found that both interest rate and portfolio rebalancing channels are essential in transmitting the effect of monetary policy easing into the domestic economy. In contrast, [Shirai \(2017b\)](#) argues that the portfolio rebalancing channel has a limited role in accelerating the price level in Japan's economy. This finding is due to the risk aversion behaviour of the Japanese households and firms. Therefore, the QQE policy only moderately contributed to equity and investment fund share among the Japanese firms and households, and thus, reducing the effect

⁴Similar findings are observed in the study by [Harada – Masujima \(2009\)](#), [Honda – Tachibana \(2011\)](#) and [Fasano-Filho et al. \(2012\)](#), whereby the portfolio rebalancing channel plays a vital role in facilitating the aggregate demand and price level.



on aggregate demand. The interest rate channel is essential in stimulating Japan's short- and long-term inflation rates.

As observed from the above-mentioned studies, there is limited study on the effectiveness of monetary transmission channels of the BOJ's QQE policy. Given that the QQE policy is the latest development of UMP in Japan and has been used by the BOJ as the primary instrument in stimulating Japan's inflation rate since 2013, it is vital to understand which channel of the QQE policy effectively influences the domestic price level. Subsequently, this allows the BOJ to identify the correct channel and facilitates inflation effectively. Apart from the limited empirical evidence, findings from the existing studies may suffer from the aggregation bias. As such, existing studies examine the monetary transmission channels of QQE policy without considering different regimes of the QQE policy.

Given that the effectiveness of the monetary transmission channels is subjected to economic circumstances that vary across different periods, the findings based on aggregate data may not be generalized to each QQE regime. Likewise, the existing studies that employ monthly or quarterly inflation rate data may result in the measurement errors. This measurement error is due to the time lag in compiling the CPI index.

Accordingly, this study aims to fill the gap by examining the effectiveness of three major transmission channels of the QQE policy. The channels are interest rate, portfolio rebalancing and foreign exchange rate channels. They would affect Japan's inflation rate during QQE (4 April 2013 to 30 October 2014), QQE expansion (31 October 2014 to 28 January 2016), QQE with a negative interest rate (29 January 2016 to 20 September 2016) and QQE with yield curve control (21 September 2016 until present).

4. DATA AND METHODOLOGY

Our study uses data from 1 August 2013 to 31 October 2019. The sample period selection was based on the availability of monetary base and T-index data. In particular, the daily monetary base data has been available since 1 August 2013. Meanwhile, the daily True price index was retrieved until 31 October 2019 due to the limited access to the NOWCAST database. Next, the sample period was divided into the QQE regime (1 August 2013 to 30 October 2014), QQE expansion regime (31 October 2014 to 28 January 2016), QQE with negative interest rate regime (29 January 2016 to 20 September 2016) and QQE with yield curve control regime (21 September 2016 to 31 October 2019).

Next, the daily return for the stock price index and the exchange rate is computed based on the following formula:

$$Return_t = \log(X_t) - \log(X_{t-1}) \quad (1)$$

Table 3 shows the list of the variables used in this study. Furthermore, Figure 1 compares the weekly movement between the daily T-index and the Hitotsubashi consumer purchase price index.⁵ By and large, both price indices shared a similar movement throughout the sample period.

⁵The Hitotsubashi consumer purchase price index is available in weekly basis.



Table 3. List of variables

Variables	Description	Unit of measurement	Source
Variables for the baseline model			
Inflation	Daily T-index (7 days average)	% YoY	NOWCAST
MB	Daily monetary base	Japanese yen	BOJ
Call	Daily uncollateralized overnight call rate	%	BOJ
Topix	Daily return for TOPIX	%	TSE
USDJPY	Daily return for USDJPY	%	BOJ
Variables for robustness check			
REER	Daily return for real effective exchange rate	%	JP Morgan

Notes: TSE: Tokyo Stock Exchange; NOWCAST website: <https://lp.nowcast.co.jp/en>

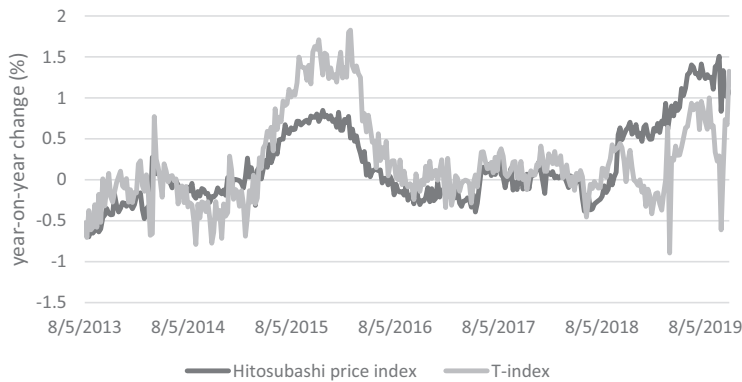


Fig. 1. End of the week inflation rate

Source: for Hitosubashi price index: <https://risk.ier.hit-u.ac.jp/English/nei/poscpi.html>; for T-index: <https://lp.nowcast.co.jp/en>

We employ the VAR model to examine the effectiveness of monetary transmission channels of the QQE policy. In particular, we utilize Granger’s Causality test to identify the working process for each of the channels of monetary transmission, as mentioned in Table 1. The lag length for the VAR model may be determined by using information criteria. However, the method may not be adequate in the presence of autocorrelation in the error term (Cheung – Lai 1993). Therefore, we follow the suggestion by Hall (1989) in specifying the lag length such that the VAR residuals are serially uncorrelated.

Next, a robustness check is conducted to ensure the validity of the baseline Granger’s Causality test results. It is widely perceived that the unit root tests have low power, which will lead to an incorrect conclusion on a series’s stationary properties. Subsequently, suppose a non-stationary series is applied to a VAR model and tested for the causality test. In that case, there will be an asymptotic



problem in the Wald test statistics. Therefore, the causality test results will be invalid (Sims et al. 1990; Toda – Phillips 1993). Hence, the Toda – Yamamoto (1995) procedure will be estimated to confirm the causality test results obtained from the baseline VAR model. This method is useful because it bypasses the need for potentially biased pre-tests for the unit roots.

5. ESTIMATION RESULTS

5.1. Descriptive statistics

Table 4 shows the descriptive statistics for all the variables. As observed, the average inflation rate during the QQE period was in the negative territory. However, the inflation rate turns positive in the QQE expansion, QQE with a negative interest rate, and QQE with a yield curve control period. This result implies that the BOJ's QQE policy effectively inflates Japan's inflation rate. The monetary base shows an increasing trend in line with the improved inflation rate. In contrast, the overnight call rate has been reduced to negative territory. Notably, the monetary base and overnight call rate movement align with the BOJ's effort to stimulate Japan's inflation rate.

5.2. Unit root test results

Unit root tests for all variables across the four QQE regimes are conducted. Before the unit root test is conducted, the monetary base (MB) is transformed into a natural logarithm. Overall, there is a mixture of integration among the stationary variables at the level, and some require first differencing. Subsequently, the VAR model with the first difference term is estimated for all four QQE regimes.⁶

5.3. Baseline Granger's causality test results based on VAR

Tables 5–8 show the baseline Granger's Causality test results for QQE, QQE expansion, QQE with negative interest rate and QQE with yield curve control. By focusing on the QQE period, it can be observed that there is a strong unidirectional causality from the monetary base (MB) to the overnight call rate (Call) and overnight call rate (Call) to the inflation rate (Inflation). The causality test result validates the working process of the interest rate channel, as outlined in Table 2 above. Hence, this indicates the presence of an interest rate channel in influencing the inflation rate during the QQE period. On the other hand, there is no evidence of the portfolio rebalancing and foreign exchange rate channels in the QQE period. In particular, TOPIX stock price return (TOPIX) and USD to Japanese yen exchange rate (USDJPY) do not impact the inflation rate.

Next, for the QQE expansion period, Table 6 shows that none of the channels influences the inflation rate. Meanwhile, the interest rate channel prevails in both the period of QQE with a negative interest rate (Table 7) and QQE with yield curve control (Table 8). In particular, there is a strong causality from monetary base to overnight call rate and overnight call rate to inflation rate. Similarly, there is no causal relationship between TOPIX, USDJPY and inflation rate. This result indicates that the portfolio rebalancing and foreign exchange rate channels do not affect Japan's inflation rate during both QQE regimes.

⁶Due to limited space, the results of ADF and KPSS can be obtained from the authors directly.



Table 4. Descriptive statistics

Variables	Mean	Std.Dev	Skewness	Kurtosis	Obs.
QQE: 8/1/2013–30/10/2014					
Inflation	−0.1951	0.266	0.149	3.200	326
MB	2132559	259857	0.100	1.707	326
Call	0.0690	0.006	−0.611	11.565	326
Topix	0.0004	0.011	−0.287	4.751	326
USDJPY	0.0004	0.004	−0.268	3.813	326
Large	0.0003	0.011	−0.212	4.350	326
Middle	0.0004	0.012	−0.333	4.839	326
Small	0.0005	0.011	−0.499	5.913	326
REER	−0.0002	0.004	0.083	4.093	326
QQE expansion: 31/10/2014–28/1/2016					
Inflation	0.6026	0.742	−0.206	1.536	325
MB	3091322	306778	−0.159	1.719	325
Call	0.0718	0.009	−3.411	22.289	325
Topix	0.0003	0.013	−0.119	6.876	325
USDJPY	0.0003	0.005	0.029	4.717	325
Large	0.0002	0.014	−0.020	6.684	325
Middle	0.0004	0.013	−0.233	6.6202	325
Small	0.0003	0.012	−0.437	7.689	325
REER	0.0001	0.005	0.246	8.006	325
QQE with negative interest rate: 29/1/2016–20/9/2016					
Inflation	0.6309	0.546	0.573	2.066	168
MB	3841952	179299	−0.423	1.856	168
Call	−0.0311	0.036	1.375	4.563	168
Topix	−0.0003	0.017	−0.372	7.829	168
USDJPY	−0.0009	0.008	−0.531	3.665	168
Large	−0.0003	0.018	−0.283	7.612	168
Middle	−0.0004	0.016	−0.409	7.873	168
Small	−0.0003	0.015	−0.736	7.376	168
REER	0.0008	0.008	0.924	8.106	168

(continued)



Table 4. Continued

Variables	Mean	Std.Dev	Skewness	Kurtosis	Obs.
QQE with yield curve control: 21/9/2016-31/10/2019					
Inflation	0.1452	0.312	0.710	4.182	812
MB	4787235	298860	-0.683	2.534	812
Call	-0.0534	0.015	0.583	2.761	812
Topix	0.0003	0.009	-0.297	8.719	812
USDJPY	0.0001	0.005	0.031	5.856	812
Large	0.0003	0.009	-0.175	9.048	812
Middle	0.0003	0.009	-0.367	7.777	812
Small	0.0004	0.010	-0.569	8.935	812
REER	-0.0001	0.004	0.130	4.115	812

Notes: All statistics are based on original data values.

Table 5. Granger's causality test results (QQE: 1/8/2013-30/10/2014)

Dependent variables	Independent variables				
	Δ Inflation	LnMB	Call	Topix	USDJPY
Δ Inflation		18.245** (0.011)	20.434*** (0.005)	5.902 (0.551)	8.132 (0.321)
LnMB	10.899 (0.143)		2.158 (0.951)	14.485** (0.043)	10.799 (0.148)
Call	7.052 (0.424)	27.711*** (0.000)		3.967 (0.784)	10.956 (0.141)
Topix	7.446 (0.384)	4.144 (0.763)	4.449 (0.727)		10.077 (0.184)
USDJPY	2.672 (0.914)	4.052 (0.774)	6.952 (0.434)	9.406 (0.225)	

Notes: ***, ** and *: statistical significance at 1, 5 and 10%, respectively. Optimal lag length of the VAR model: 7. All estimates are asymptotic Granger Chi-squared statistics. Values in parentheses are *P*-values. Δ : first difference. Ln: natural logarithm.

The Granger's Causality test reveals the short-run dynamics between the macroeconomic variables. Hence, based on the results, it can be argued that the interest rate channel plays a vital role in affecting Japan's inflation rate in the short-run period. At the same time, the portfolio rebalancing and foreign exchange rate channels have no short-run impact on the domestic price levels across all four QQE policy regimes.



6. ROBUSTNESS CHECK

To ensure the robustness of the baseline VAR results, four different VAR models at level form are estimated using the procedure developed by [Toda – Yamamoto \(1995\)](#). Tables 9–12 outline

Table 6. Granger’s Causality Test Results (QQE expansion: 31/10/2014–28/1/2016)

Dependent variables	Independent variables				
	Δ Inflation	Δ LnMB	Call	Topix	USDJPY
Δ Inflation		0.776 (0.678)	1.341 (0.512)	0.109 (0.947)	2.382 (0.304)
Δ LnMB	5.422* (0.067)		3.155 (0.207)	1.820 (0.403)	1.625 (0.444)
Call	1.533 (0.465)	0.617 (0.735)		6.131** (0.047)	2.216 (0.330)
Topix	1.059 (0.589)	0.222 (0.894)	1.388 (0.500)		5.433* (0.066)
USDJPY	3.136 (0.208)	0.711 (0.701)	1.646 (0.439)	4.024 (0.134)	

Notes: ***, ** and *: statistical significance at 1, 5 and 10%, respectively. Optimal lag length of the VAR model: 2. All estimates are asymptotic Granger Chi-squared statistics. Values in parentheses are *P*-values. Δ : first difference. Ln: natural logarithm.

Table 7. Granger’s causality test results (QQE with NIRP: 29/1/2016–0/9/2016)

Dependent variables	Independent variables				
	Δ Inflation	Δ LnMB	Δ Call	Topix	USDJPY
Δ Inflation		1.443 (0.919)	15.800*** (0.007)	6.379 (0.271)	4.353 (0.500)
Δ LnMB	5.035 (0.412)		9.576* (0.088)	6.082 (0.298)	5.333 (0.377)
Δ Call	3.429 (0.634)	26.515*** (0.000)		11.391** (0.044)	2.763 (0.736)
Topix	5.270 (0.384)	2.693 (0.743)	4.346 (0.501)		3.956 (0.556)
USDJPY	5.631 (0.344)	2.099 (0.835)	2.301 (0.806)	3.467 (0.628)	

Notes: ***, ** and *: statistical significance at 1, 5 and 10%, respectively. Optimal lag length of the VAR model: 5. All estimates are asymptotic Granger Chi-squared statistics. Values in parentheses are *P*-values. Δ : first difference. Ln: natural logarithm. NIRP: negative interest rate policy.



Table 8. Granger's causality test results (QQE with YCC: 21/9/2016–31/10/2019)

Dependent variables	Independent variables				
	Δ Inflation	Δ LnMB	Δ Call	Topix	USDJPY
Δ Inflation		4.134 (0.127)	8.817** (0.012)	2.214 (0.331)	0.697 (0.706)
Δ LnMB	2.527 (0.283)		0.203 (0.904)	0.126 (0.939)	5.142* (0.077)
Δ Call	1.423 (0.491)	61.436*** (0.000)		2.574 (0.276)	1.979 (0.372)
Topix	1.776 (0.416)	4.916* (0.086)	2.309 (0.315)		7.670** (0.021)
USDJPY	0.200 (0.905)	0.243 (0.885)	1.430 (0.489)	6.812** (0.033)	

Notes: ***, ** and * statistical significance at 1%, 5% and 10% levels, respectively. Optimal lag length of the VAR model: 2. All estimates are asymptotic Granger Chi-squared statistics. Values in parentheses are *P*-values.
 Δ : first difference. Ln: natural logarithm. YCC: yield curve control.

Table 9. Granger's causality test results (QQE: 1/8/2013–30/10/2014)

Dependent variables	Independent variables				
	Inflation	LnMB	Call	Topix	USDJPY
Inflation		15.219** (0.033)	16.163** (0.024)	6.332 (0.502)	6.439 (0.489)
LnMB	11.545 (0.117)		1.356 (0.987)	14.449** (0.044)	10.939 (0.141)
Call	6.977 (0.431)	36.727*** (0.000)		5.237 (0.631)	11.132 (0.133)
Topix	7.526 (0.378)	4.799 (0.684)	3.730 (0.810)		8.978 (0.254)
USDJPY	5.826 (0.560)	3.940 (0.786)	5.886 (0.553)	8.949 (0.256)	

Notes: ***, ** and *: statistical significance at 1%, 5% and 10% levels, respectively. The optimal lag length of the Toda-Yamamoto Augmented VAR model is 8 [$k + d(\max)$]. All estimates are asymptotic Granger Chi-squared statistics. Ln: natural logarithm. Values in parentheses are *P*-values.

the respective Granger's Causality test results. Notably, the results are consistent with the baseline Granger's causality test results, in which the interest rate channel is imperative in affecting the short-run inflation rate. As such, the results show that there is a causality from



monetary base to overnight call rate and overnight call rate to inflation rate during QQE (Table 9), QQE with negative interest rate policy (Table 11) and QQE with yield curve control periods (Table 12). Similarly, both TOPIX and USDJPY do not influence the inflation rate. This

Table 10. Granger’s Causality Test Results (QQE expansion: 31/10/2014–28/1/2016)

Dependent variables	Independent variables				
	Inflation	LnMB	Call	Topix	USDJPY
Inflation		1.416 (0.492)	0.837 (0.658)	0.675 (0.714)	4.309 (0.116)
LnMB	6.264** (0.044)		2.625 (0.269)	2.698 (0.259)	1.938 (0.379)
Call	3.876 (0.144)	1.457 (0.483)		7.549** (0.023)	2.155 (0.340)
Topix	1.111 (0.574)	0.338 (0.845)	0.429 (0.807)		4.839* (0.089)
USDJPY	2.961 (0.228)	0.820 (0.664)	1.103 (0.576)	4.916* (0.086)	

Notes: ***, ** and *: statistical significance at 1, 5 and 10% levels, respectively. The optimal lag length of the Toda-Yamamoto Augmented VAR model is 3 $[k + d(\max)]$. All estimates are asymptotic Granger Chi-squared statistics. Ln: natural logarithm. Values in parentheses are *P*-values.

Table 11. Granger’s causality test results (QQE with NIRP: 29/1/2016 – 20/9/2016)

Dependent variables	Independent variables				
	Inflation	LnMB	Call	Topix	USDJPY
Inflation		1.198 (0.945)	11.054* (0.050)	6.695 (0.244)	5.660 (0.341)
LnMB	4.189 (0.523)		10.120* (0.072)	5.489 (0.359)	4.626 (0.463)
Call	5.985 (0.308)	28.762*** (0.000)		11.008* (0.051)	3.098 (0.685)
Topix	5.959 (0.310)	3.055 (0.692)	7.310 (0.199)		3.867 (0.569)
USDJPY	5.928 (0.313)	2.777 (0.734)	4.574 (0.470)	4.012 (0.548)	

Notes: ***, ** and *: statistical significance at 1, 5 and 10%, respectively. The optimal lag length of the Toda-Yamamoto Augmented VAR model is 6 $[k + d(\max)]$. All estimates are asymptotic Granger Chi-squared statistics. Ln: natural logarithm. Values in parentheses are *P*-values. NIRP: negative interest rate policy.



Table 12. Granger's causality test results (QQE with YCC: 21/9/2016–31/10/2019)

Dependent variables	Independent variables				
	Inflation	LnMB	Call	Topix	USDJPY
Inflation		3.044 (0.218)	10.664*** (0.005)	2.042 (0.360)	0.733 (0.693)
LnMB	2.149 (0.341)		1.030 (0.597)	0.062 (0.969)	4.855* (0.088)
Call	0.013 (0.994)	57.833*** (0.000)		2.286 (0.319)	3.589 (0.166)
Topix	1.805 (0.406)	4.425 (0.109)	2.032 (0.362)		7.569** (0.023)
USDJPY	0.438 (0.803)	0.288 (0.866)	2.123 (0.346)	6.346** (0.042)	

Notes: ***, ** and *: statistical significance at 1, 5 and 10%, respectively. The optimal lag length of the Toda-Yamamoto Augmented VAR model is 3 [$k + d(\max)$]. All estimates are asymptotic Granger Chi-squared statistics. Ln: natural logarithm. Values in parentheses are *P*-values. YCC: yield curve control.

finding indicates the absence of the portfolio rebalancing and foreign exchange rate channels in affecting Japan's inflation rate in all four QQE policy regimes. By and large, the baseline results are not spurious and robust against different estimation methods.

7. CONCLUSION

Our study examined the effectiveness of monetary transmission channels of the BOJ's QQE policy in affecting the Japanese inflation rate from 1 August 2013 to 31 October 2019. The Granger's Causality test results indicate that:

1. The interest rate channel is vital in transmitting the effect of monetary easing to Japan's inflation rate in the short-run period. Specifically, the interest rate channel transmits the effect of QQE, QQE with a negative interest rate and QQE with yield curve control policy to Japan's inflation rate.
2. Portfolio rebalancing and foreign exchange rate channels have no short-run impact on Japan's inflation rate in all the QQE policy regimes.
3. The empirical results are robust against different estimation methods and model specifications.

These empirical findings highlight the interest rate channel's importance in inflating Japan's inflation rate in the short-run period. As a policy suggestion, the BOJ may further strengthen the interest rate channel by changing the policy rates, thereby influencing the domestic price level. Meanwhile, little attention should pay to the portfolio rebalancing and foreign exchange rate channels. As such, the inflation-stimulating effect of the portfolio rebalancing channel is limited



by the risk-averse behaviour of the Japanese society. In contrast, the effect of the foreign exchange rate channel on price level prevails only in the long-run period.

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