



The Cointegration Analysis of the Long-term Bond Rates in Japan under the Zero Lower Bound Problems

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Abstract

In April of 2013, Bank of Japan introduced Qualitative and Quantitative Easing (QQE). And the unexpected announcement of additional QQE in October of 2014 surprised many market participants. Just after both announcements stock prices of Japanese market rose rapidly. BOJ had introduced non-traditional monetary policies not only QQE, but Zero Interest Rate Policy (ZIRP) and Quantitative Easing (QE) for about 15 years. Not only Japan but U.S. Federal Reserve, Bank of England of U.K. (BOE) and Sveriges Riksbank of Sweden have also introduced QE. Especially, Federal Reserve Board of U.S. had executed the non-traditional monetary policies of QE1, QE2 and QE3 since November of 2008 till October of 2014 by the chairmen, Bernanke and Yellen. It continues another non-traditional monetary policy, ZIRP under the slowly recovering economy. Meanwhile ECB announced their introduction of QE on January 22 of 2015 and began buying government bonds on March 9, when Europe's fragile recovery is lagging the rest of the world and a drop in prices is threatening to make things worse. However none of them had not brought adequate result by the non-traditional monetary policies yet. In this thesis we analyze the relationship between Japanese long-term interest rates and its non-traditional monetary policies under persistent and serious deflation. We investigate the extent to which change rates of monetary base and amounts of loan outstanding of banks and other proxy variables affect both the nominal and real interest rates of 10 year JGBs. We used a fundamental bond rate model based on [Sargent \(1969\)](#) and test the cointegrating relationship among the variables. Then we estimate the model with cointegrating relationship by Dynamic OLS and Error Correction model by GMM.


Keywords: Zero interest rate policy, Quantitative and qualitative easing, Cointegration analysis, Carlson Parkin method, Dynamic OLS, Error correction model.

JEL Classification: E52, E58.

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1. Introduction

Since the inauguration of the governor of Bank of Japan (hereinafter written as BOJ), Haruhiko Kuroda, “Quantitative and Qualitative Monetary Easing” (QQE) released in April, 2014 has been aimed at achieving the price stability target of 2% without “gradualism” for the easing. However, when economic downturn became so apparent that the goal became hard to be achieved, additional QQE were released on 31st of October, 2014 with great surprises of financial markets. The concrete measures of original QQE is to double the monetary base and the amounts outstanding of Japanese Government Bonds (JGBs) BOJ holds for 2 years, to lengthen the durations of JGBs BOJ purchases and to purchase Exchange Trade Funds (ETFs) and Japan-Real Estate Investment Trust (J-REITs). Meanwhile, those of the additional QQE are to increase the amount to purchase from 60-70 trillion yen to 80 trillion yen a year.¹ Just after both announcements of the QQEs, the stock prices increased dramatically. The announcement effects for the financial markets by the additional QQE were mostly caused by the positive attitudes toward the QQE and the denial of “gradualism” for the easing by Mr. Kuroda.

QQE is not the first trial of the non-traditional monetary policy by BOJ. BOJ had little room for further reductions in interest rates already in 1995. The economy are said to have been in a liquidity trap since then and fell in deflation in 1997 at last. Then BOJ lowered the overnight call rate to virtually zero percent in February and March of 1999. This is the so-called zero interest rate policy (ZIRP) which has been the core of the BOJ’s monetary policy since 1999. BOJ announced in April 1999 that the Bank would continue the zero interest rate “until deflationary concerns were dispelled”. ZIRP was removed twice in 2000 and in 2006 judging from the economic condition in recovery at that time. However just after both removals, the economy became deteriorated.

Then BOJ adopted Quantitative Easing (QE) policy in March 2001 by the governor, Toshiro Fukui. BOJ maintained an ample liquidity supply by using the current account balances at BOJ as the operating policy target and committed itself to maintaining the provision of ample liquidity until the rate of change of the core CPI becomes zero percent or higher on a sustained basis to purchase JGBs from time to time as a tool for liquidity injection. BOJ increased the current account balance from ¥5 trillion to ¥35 trillion and tripled the quantity of long-term Japan government bonds it could purchase on a monthly basis. Owing to the QE in Japan in this period, to some extent the economy recovered, while aggregate domestic loans outstanding and money stock by financial institutions did not increase much and fail to escape from deflation at last. The QE came to a sudden halt in March 2006 and the monetary base turned into drop though subprime loan problem which would cause global depression were surfacing in U.S. See [Graph-1](#) and [2](#) which describe the movement of the interest rates of 10 year JGB, real call rates, monetary base and monetary stock in the periods under the non-traditional monetary policies in Japan.

Not only Japan but U.S. Federal Reserve, Bank of England of U.K. (BOE) and Sveriges Riksbank of Sweden have also introduced QE. Especially, Federal Reserve Board of U.S. had executed the non-traditional monetary policies of QE1, QE2 and QE3 since November of 2008 till October of 2014 by the chairmen, Bernanke and Yellen. And at last ECB announced their introduction of QE on January 22 of 2015 and began buying government bonds on March 9, when Europe’s fragile recovery is lagging the rest of the world and a drop in prices is threatening to make things worse. President Mario Draghi overcame German-led opposition on the bank’s Governing Council and pledged an asset-purchase program worth about 1.1 trillion euros. The ECB finally turned to bond buying after cutting one of its main interest rates below zero in 2014.²

It is sometimes pointed out that the economies of those areas and countries are in liquidity traps: private demand is so weak that even near or at a zero short-term interest rates. Whether QE policy has effects to the real economy or not has been a very controversial issue. The concept of “Liquidity Trap” which [Hicks \(1937\)](#) point out that further monetary easing do not have much stimulus effects on the real economy when interest rates fall around the lower bound, is referred for supporting the skeptical view against the effect of QE.

Meanwhile [Bernanke et al. \(2004\)](#) discuss some possible effects³ of QE for real economies: (a) the portfolio rebalancing effect, whereby increases in the monetary base would lead the private sector to rebalance its portfolios, lowering yields on alternative, non-monetary assets; (b) the signal effect (time axis effect by BOJ), altering expectations of the future path of policy rates by a visible act of setting and meeting a high reserve target;

Both (a) and (b) above are also referred at a news conference in April 2013 by the Governor of BOJ, Kuroda on his own non-traditional monetary policy, QQE. Such effects are also emphasized by the previous non-traditional monetary policy, QE with time axis policy. However, in QQE with the higher inflation target of 2%, monetary easing entered a new phase both quantitatively and qualitatively with BOJ’s more stubborn faith denying an incremental approach or gradualism. Such attitude influences the expectation for inflation of the people. And higher expected inflation means a lower real interest rate which would lead to stronger economy. Furthermore, the word “Qualitative” of QQE shows, BOJ try to prolong the average remaining maturity of JGB purchases to lower the long-term interest rates. Therefore in QQE especially expectation of people and long-term bond rates are key points. The former is thought to be influenced by the attitude of adamancy of the governor of BOJ and affect real interest rates much. The latter is considered to be important in stimulating the real economy over fears of deteriorating fiscal condition.

For the non-traditional monetary policies in Japan, both the nominal and real JGB interest rates are very important and delicate index. In the period from 1999 until 2012, the previous non-traditional monetary policies which failed to overcome deflation at last had had effect on the nominal 10 year JGB rate within the narrow range from 0.5% to 2%. It could be appreciated as long-term interest rates had been kept low. Before the introduction of QQE, mainly, insurance companies and banks of Japan have purchased huge amounts of newly issued JGBs, owing to difficult fund management environment with extremely low interest rate and their attitude of risk-aversion,

¹ The amount BOJ’s will purchase a year is 30 trillion yen of long-term JGBs, 3 trillion yen of ETFs and 90 billion yen of J-REITs yen which is three times as previous amount. Magic number for the amounts is 3 for additional QQE, while that was 2 for original QQE.

² ECB had also introduced minus interest rates that made private banks pay 0.1 % commissions to ECB instead of their receipt of the interest rates on the current accounts of ECB.

³ Exactly they pointed out three possible effects. The other (c) is the expansionary fiscal effect, whereby the central bank replaces public holdings of interest-bearing government debt with non-interest-bearing currency or reserves, thus replacing the expected future tax liability for the public with an inflation tax.

regardless of the growth in the debt-to-GDP ratio has accelerated as [Graph-3](#) shows. And since the introduction of QQE in April of 2013, BOJ had increased so rapidly its purchase amount of JGB that the yields of nominal 10 year JGB have been kept lower. However, the real JGB rates might have fluctuated much more to function to stimulate consumption and business investments. In this thesis we analyze the relationship between the non-traditional monetary policies and the JGB rates introducing cointegration analysis.

This thesis is organized in 5 sections and 6 sub-sections. Section 2 presents an overview of theoretical and empirical contributions. Section 3 is divided into 2 subsections; subsection 3-1 presents the theoretical models and subsection 3-2 presents the data, definition of the proxy variables and adapted model to empirical work. Section 4 is divided into 4 subsections from 4-1 to 4-4. They present the results of estimation, the results of unit root tests, cointegration test, the Dynamic OLS Estimation and Error Correction Model regression respectively. Section 5 concludes. Finally Appendix show how to estimate the expected inflation rates based on Carlson-Parkin method.

2. Literature

[Mehra \(1994\)](#) employed fundamental bond rate model based on [Sargent \(1969\)](#) substituting the variables for real federal funds rates into those for money supply in the original model and estimates the cointegrating relationship among the variables in the bond rate models. [Mehra \(1994\)](#) concluded that changes in the real federal funds rate have substantially short-run effects on the bond rate, even though long-run stochastic movement in the bond rate are unrelated to the real federal funds rate. And the bond rate rises if inflation edge up. We adopted this model to adjust under the zero lower bound problem of interest rate in Japan.

As Classical literature, [Hicks \(1937\)](#) describes “Liquidity Trap” in which the zero lower bound problem of interest rate is difficult obstacles against traditional monetary policies. It is also the beginning of the continuing controversy on the non-traditional monetary policy, such as quantitative easing policy. However, [Bernanke et al. \(2004\)](#) shows that central bank communications can help to shape public expectations of future policy actions (signal effect) and that asset purchases in large volume by a central bank would be able to affect the price or yield of the targeted asset (portfolio-rebalancing effect) even though money market rate is zero

We can find much literature on the controversy whether non-traditional monetary policies by BOJ, such as de facto zero interest rate policy and quantitative easing has definite policy effect or not in diverse way. However, they are less conclusive totally about what kind of effects on the prices and productions such non-traditional monetary policies had.

[Miyao \(2002\)](#) finds cointegrating relationship in the stability of an equilibrium money, or M1, demand in Japan even after 1995 when nominal rates were lowered to de facto zero percent and concluded that Japanese economy really had not trapped at the zero interest rate bound at that time. And [Fujiwara \(2006\)](#) employing an identified Markov switching VAR framework, points out that there exists a structural break when ZIRP was resumed, suggesting that the effectiveness of monetary policy is seen weaker since then and ZIRP had not fulfilled its role enough.

However, [Honda et al. \(2007\)](#) concludes that quantitative easing policy has definite policy effects, analyzing the effect of the quantitative easing policy by BOJ from 2001 until 2006 by introducing VAR models by 3 variables, interest rates, stock prices and foreign exchange rates. [Honda et al. \(2007\)](#) finds a transmission effect to the real economy via the portfolio-rebalancing especially on equities which is caused by investor’s using the supplied money by operation of BOJ for the purchase of the financial assets.

[Iida and Yasushi \(2004\)](#) points out that even in phase of recovery after the introduction of the re-inflationary policy by Korekiyo Takahashi in 1931 as the Finance Minister at the time, banks’ aggregate balances of loans did not increase very much. Takahashi conducted the policy mix corresponding to Keynes’ macroeconomics theory, which contains firstly depreciation of yen (exchange rate policy), secondly increase in government expenditure associated with the underwriting of deficit-covering bonds by the BOJ (fiscal policy), and finally interest rate cut (monetary policy). It has enough effect to recover Japanese economy from the predicament by Showa depression, however the increase of lending was delayed to begin about three years to that of production and to rise in stock prices because in the three years corporate enterprises expand their investment by their surplus funds stocked under deflation.

[Harada and Suzuki-Loeffelholz \(2007\)](#) shows growth of fixed assets are not correlated with increase of bank loans but however are correlated with increases in equity or corporate bonds strongly in the period of the recovery during the Showa depression and concludes that the recovery of corporate enterprises then are supported by capital markets.

3. Model and Methods

3.1. Models

We introduce the model which has the determinants of the nominal long bond rate from [Sargent \(1969\)](#). This model shows us that nominal interest rate is assumed to be determined by the three kinds of real determinants. One is the expected inflation rates and related ones. The others are the ones which are concerned with operating or intermediate targets of monetary policies and fiscal policy. The equation expressed in [Sargent \(1969\)](#) is as follows;

$$Rn_t = \delta_0 + \delta_1 E\pi_t + \alpha_2 RFB_t - \delta_3 RGDP_t - \delta_4 \Delta rM_t^s + \delta_5 \Delta RGDP_t \quad (1)$$

Where Rn_t is the nominal interest rate, $E\pi_t$ is the anticipated inflation rate, RFB is the real government fiscal balance, RGDP is real income or real GDP, and rM_t^s is the real supply of money. [Equation \(1\)](#) means that nominal bond rates are affected by anticipated inflation, the government deficit, changes in real money supply and real income.

[Sargent \(1969\)](#) estimates equation like (1) for one-year and ten-year bond yields using annual data from 1902 to 1940. However the bond rate equation applied in this work are under the some kinds of non-traditional monetary policies from February of 1999 in Japan when despite of extremely low interest rates the change rates of money supply had stayed low or negative. In the non-traditional monetary policy period, it is more appropriate to employ the other proxy variables instead of those for real money supply because BOJ had not been able to control it. We

substitute two kinds of proxy variables for money supply in this work. One is change rates of monetary base which is the operating target of BOJ since April in 2013 and the other is the change rate of aggregate loan amount of banks in Japan. They could substitute the change in amounts of real money supply.

And we omit the variable RFB because Japanese long-terms bond rates which have stayed low in very narrow range seems to be uncorrelated with real government fiscal balance continuing to worsen as Graph-3 shows. The correlation coefficient of the two variable are 0.077 and the P-value for the correlation of them is 0.320.

And in the bond rate equation the impact of monetary policy action on the real rate need to be included to introduce cointegration analysis and error-correction model based on it, which is better adapted to both short-run and long-run determinants on the bond rates. Now we show the long-term bond rate model as follows;

$$Rn_t = \alpha_0 + \alpha_1 E\pi_t + \alpha_2 CRMB_t + \alpha_3 CRLOAN_t + \alpha_4 \ln RGDP_t + \alpha_5 \Delta \ln RGDP_t + U_t \quad (2)$$

,where CRMB is the change rate of monetary base and CRLOAN is the change rate in the aggregate amount of financial institutions in Japan instead of the variable of. Equation (2) describes the long-run responses of the bond rate to anticipated inflation and monetary policies. If some among above variables of Equation (2) are nonstationary but cointegrated as in Engle and Granger (1987) the coefficients of the other variables may all be zero.

We need another equation which describes short-run effects of fundamentals as Mehra (1994) shows. Long-run bond rate Equation (2) ignores short-run effects and short-run dynamics. Short-run equation is as follows;

$$\Delta Rn_t = \beta_0 + \beta_1 \Delta E\pi_t + \beta_2 \Delta CRMB_t + \beta_3 \Delta CRLOAN_t + \beta_4 \Delta RGDP_t + \beta_5 \Delta^2 RGDP_t + \beta_6 U_{t-1} + \varepsilon_t \quad (3)$$

Where is the lagged residual from the long-run bond Equation (2), and is the second-difference operator. Then, as Mehra (1994) did, we produce the error correction model of the bond rate to as follows;

$$Rn_t = \alpha_0 + \alpha_1 E\pi_t + \alpha_2 CRMB_t + \alpha_3 CRLOAN_t + \alpha_4 RGDP_t + \alpha_5 \Delta RGDP_t + \sum_{s=-k}^k \beta_{5s} \Delta E\pi_{t-s} + \sum_{s=-k}^k \beta_{6s} \Delta CRMB_{t-s} + \sum_{s=-k}^k \beta_{7s} \Delta CRLOAN_{t-s} + \sum_{s=-k}^k \beta_{8s} \Delta RGDP_{t-s} + \sum_{s=-k}^k \beta_{9s} \Delta^2 RGDP_{t-s} + \varepsilon_t \quad (4)$$

The 5 variables whose coefficients' numbers are from 1 to 5 are respectively the proxy variables for economic determinants. And the variables whose coefficients' numbers are from 5s to 9s (s=1 to n) are the proxy variables for short-run dynamics. This equation is in an error-correction form, indicating that the bond rate will adjust in the short run if the actual bond rate differs from its long-run value determined in (2). The lagged error correction residual in (4) whose coefficient number is 5s to 9s (s=1 to n) reflects the short-run influence of long-run dynamics on the bond rate.

3.2. Data and Definition of Variables

It is important problem that the proxy variable for anticipated inflation is unobservable to estimate Equations (2), (3) and (4). For the empirical work here, we use the proxy variable for the actual inflation rate, and that for the anticipated inflation rates which is estimated by the modified Carlson-Parkin methods as shown in Appendix.

We adopted the monthly data for three kinds of periods. One is the period from January of 1999 till December of 2012. Another is that from January of 1999 till December of 2013. And the other is that from January of 1999 till December 2014. We name them period A, B and C respectively. Period B includes the 9 months and Period C does more 12 months under QQE.

The bond rates are the nominal yield of 10-year JGBs at the end of the months respectively. Inflation is measured by the changes of consumer price index in Japan released by Statistics Bureau of Japan. And anticipated inflation is measured by the modified Carlson-Parkin methods. See Appendix. The monthly real call rate, overnight and without collateral, is the nominal call rate minus the anticipated inflation rate at each end of the month. Both the change rates of real monetary bases and the outstanding lending by financial institutions in Japan are year-on-year basis according to Bank of Japan Time-Series Data Search. The data of real monthly fiscal balances are adopted from the Ministry of Finance of Japan. We adjusted them seasonally by the X-ARIMA-13-seats. And we changed the row numbers of the real monthly fiscal balances into the ratio forms scaled by real GDPs which was seasonally adjusted as Mehra (1994) did, setting the restriction that the coefficients of and , or and , in equation (2) are equal in magnitude but opposite in sign. The data of seasonally adjusted monthly Real GDPs are estimated by Japan Center Economic Research. Thus we induce Equation (5)-a, (5)-b, (6)-a and (6)-b. Equation (5)-a and (5)-b are long-run bond rate equations and Equation (6)-a and (6)-b are short-run bond rate equations for empirical work as follows;

$$JGB10_t = a_0 + a_1 \pi_t + a_2 CRMB_t + a_3 CRLOAN_t + a_4 RGDP_t + a_5 \Delta RGDP_t + U_t^a \quad (5)-a$$

$$JGB10_t = b_0 + b_1 E\pi_t + b_2 CRMB_t + b_3 CRLOAN_t + b_4 RGDP_t + b_5 \Delta RGDP_t + U_t^b \quad (5)-b$$

$$\Delta JGB10_t = e_0 + e_1 \Delta \pi_t + e_2 \Delta CRMB_t + e_3 \Delta CRLOAN_t + e_4 \Delta RGDP_t + e_5 \Delta^2 RGDP_t + e_6 U_{t-1} + \varepsilon_t^e \quad (6)-a$$

$$\Delta JGB10_t = f_0 + f_1 \Delta E\pi_t + f_2 \Delta CRMB_t + f_3 \Delta CRLOAN_t + f_4 \Delta RGDP_t + f_5 \Delta^2 RGDP_t + f_6 U_{t-1} + \varepsilon_t^f \quad (6)-b$$

Where JGB10 stands for the nominal Japan Government Bond rates. are actual inflation rates and are anticipated inflation rates. We set another restriction that the coefficients on JGB10 and $\pi(E\pi)$ sum to zero. This restriction is effective in the case of a complete Fisher-effect. In that case Equation (5)-a and (5)-b could be changed into (5)-c and (5)-d respectively as follows;

$$RJGB10_t = c_0 + c_1 CRMB_t + c_2 CRLOAN_t + c_3 RGDP_t + c_4 \Delta RGDP_t + U_t^c \quad (5)\text{-c}$$

$$RJGB10E_t = d_0 + d_1 CRMB_t + d_2 CRLOAN_t + d_3 RGDP_t + d_5 \Delta RGDP_t + U_t^d \quad (5)\text{-d}$$

Where RJGB10 is the real rates of 10 years JGBs which equal JGB rates minus actual inflation rates and RJGB10E is also the real rates of that which equal JGB rates minus anticipated inflation rates. And (6)-a and (6)-b could be transformed as well into (6)-c and (6)-d respectively as follows;

$$\Delta RJGB10_t = g_0 + g_1 \Delta CRMB_t + g_2 \Delta CRLOAN_t + g_3 \Delta RGDP_t + g_4 \Delta^2 RGDP_t + g_5 U_{t-1} + \varepsilon_t^g \quad (6)\text{-c}$$

$$\Delta RJGB10E_t = h_0 + h_1 \Delta CRMB_t + h_2 \Delta CRLOAN_t + h_3 \Delta RGDP_t + h_4 \Delta^2 RGDP_t + h_5 U_{t-1} + \varepsilon_t^h \quad (6)\text{-d}$$

Now we induce the 8 kinds of long-run and short-run bond rate equations.

4. Estimation Results

4.1. Unit Root Tests Results

First of all we need to test for the presence of a unit root to verify whether the variables making up the of long-term bond rate Equations, (5)-a, (5)-b, (5)-c and (5)-d are nonstationary. We employed three kinds of unit root tests to test whether each variable has a unit root and is I(1) variable. They are Augmented Dickey-Fuller Test (ADF test), Dickey-Fuller GLS test (DF-GLS test) and Perron unit root test. The null hypothesis of ADF test and DF-GLS test are that each series contains a unit root. And that of Perron unit root test is that each series contains a unit root with a structural break. The lag lengths are chosen based on Akaike Information Criteria.

ADF test and DF-GLS test are built on the Dickey-Fuller test. ADF is improved in that the lag terms of the endogenous variables were added in the regressions for test to remove the serial correlation of error term. And DF-GLS were improved in that the data are detrended applied by Generalized Least Squares (GLS). The power of DF-GLS is known to be strong. And Perron unit root test is developed by Perron (1997) allowing for structural change like a break in the trend function at an unknown time. This test could redeem the weakness of the Dickey-Fuller style unit-root test.

Table 1, 2 and 3 show the results of unit root tests for the all periods respectively. Judging from the statistics of the three kinds of tests, all variables except for $E\pi$ for period A are considered as non-stationary variables in all three periods. For these variables we cannot reject the null hypotheses of unit root when their forms are levels. However, when their forms are 1st difference, we can reject the null hypotheses of unit root. Therefore as for three periods, we cannot find cointegrating relationships in the equation b. As for Perron unit root test, RGDP for both periods are not I(1) to be exact owing to their structural changes for such as Lehman's Shock. However, we consider it as I(1) variable because other two tests accepts them so definitely.

4.2. Cointegration Tests Results

Then we employed three kinds of cointegration tests to find cointegrating relationship among the variables which are considered to have unit roots. Firstly, Augmented Dickey Fuller (ADF) test on the residuals whose null hypothesis is that the residuals of the models composed of the variables have unit roots. Secondly, Johansen cointegration test developed by Johansen and Juselius (1990) whose null hypothesis is that there are no cointegrating vectors in the system. And finally Engle-Granger (EG) test, a method of single-equation cointegration tests based on the Dynamic OLS (DOLS). The null hypothesis of EG test is that there are no cointegrating relationships in the single equation. In the all tests above the lag lengths were selected using Schwarz Information Criteria to determine them.

Table 4, 5 and 6 present the results of the cointegration tests, only showing the systems we found cointegrating relationships. They are (RJGB10, CRLOAN), (RJGB10, RGDP), (RJGB10, CRMB, RGDP), (RJGB10, CRLOAN, RGDP), (RJGB10E, CRLOAN), (RJGB10E, RGDP), (RJGB10E, CRMB, CRLOAN), (RJGB10E, CRMB, RGDP), (RJGB10E, CRMB, CRLOAN, RGDP) in period A, (JGB10, $E\pi$, CRMB, RGDP), (RJGB10, RGDP), (RJGB10, CRMB, RGDP), (RJGB10, CRMB, CRLOAN, RGDP), (RJGB10E, CRMB, RGDP) and (RJGB10E, CRMB, CRLOAN, RGDP) in period B and (RJGB10E, CRMB) and (RJGB10E, CRMB, RGDP) in period C.

Our criterion of the cointegration tests is that all five kinds of test results should be significant at less than 5% levels.

4.3. Dynamic OLS Estimation

Table-7, 8 and 9 show the dynamic OLS (DOLS) estimates of the cointegrating relationships among the bond rates and other I(1) variables in Equation (5)-b, (5)-c and (5)-d respectively in the three kinds of periods. The estimation result of the system (JGB10, $E\pi$, CRMB, RGDP) in period B as Table 7 shows is the only one extracted from Equation (5)-b.

Table-8 shows the estimation results for systems of (RJGB10, CRLOAN), (RJGB10, RGDP), (RJGB10, CRMB, RGDP) and (RJGB10, CRLOAN, RGDP) for period A and, (RJGB10, CRMB, RGDP), (RJGB10, CRMB, CRLOAN, RGDP) for period B.

Table 9 shows the estimation results for systems of (RJGB10E, CRLOAN), (RJGB10E, RGDP), (RJGB10E, CRMB, CRLOAN), (RJGB10E, CRMB, RGDP) and (RJGB10E, CRMB, CRLOAN, RGDP) for period A, (RJGB10E, RGDP) and (RJGB10E, CRMB, CRLOAN, RGDP) for period B and (RJGB10E, CRMB) and (RJGB10E, CRMB, RGDP) for period C.

As Table 7 shows for Equation (5)-b, only for Period B, both coefficients of CRMB and RGDP are negative significantly while that of $E\pi$ is negative insignificantly. It means that the growths of monetary base and Japanese

economy made long-term interest rates lower from 1999 till 2013, for period B. And we cannot say that expected inflation rates have negative effect on long-term interest rates.

And as Table 8 shows for Equation (5)-c, only for period A and B, twos of respective three coefficients of CRMB and CRLOAN and all coefficients of RGDP are negative significantly. It also means that the growths of monetary base, loan amounts and Japanese economy made long-term interest rates lower for both period A and B.

Finally as Table 9 shows for Equation (5)-d, all coefficients of CRMB and most coefficients of CRLOAN and RGDP are negative significantly. It also means that the growths of monetary base, loan amounts and Japanese economy made long-term interest rates lower for all three periods.

Comparing the coefficients of the variables in Period A, B and C, in all three Equations, only insignificant coefficient for CRMB is found only in Period A, CRMB of (RJGB10, CRMB, RGDP) in Equation (5)-c.

Moreover, in Equation (5)-d where complete Fisher effect are assumed, the absolute values of the coefficients of CRMB in Period A which do not include the period under QQE are totally larger than those in Period B and C which include it. And comparing those coefficients of CRMB between Period B and C, those in Period C is larger. These differences could be owing to an effect of QQE introduced in April of 2013. After introducing QQE in 2013, the lowering effect for long-term interest rates are reduced. This is the restrictive effect of QQE in 2013 which need time to take. However, after QQE effect are reduced and economy slowed in later 2013, such effect also seemed to be reduced.

4.4. Error Correction Model Regression

Then we substitute the long-run Equations, (5)-a, (5)-b, (5)-c and (5)-d to short-run Equations (6)-a, (6)-b, (6)-c and (6)-d respectively to estimate the Error Correction Model, hereinafter referred to as “ECM, with instrument variables like equation (4). To begin with, long-run equations are lagged for one period. Then solve them for the disturbance term, u_{t-1} . And finally we substitute them into short-term equations respectively. We induce the short-run bond Equation (7)-a, (7)-b, (7)-c and (7)-d which are jointed with the long-run part as follows;

$$\begin{aligned} \Delta JGB10_t &= (e_0 - e_6 a_0) + e_1 \Delta \pi_t + e_2 \Delta CRMB_t + e_3 \Delta CRLOAN_t + e_4 \Delta RGDP_t + e_5 \Delta^2 RGDP_t \\ &\quad - e_6 a_1 \pi_{t-1} - e_6 a_2 CRMB_{t-1} - e_6 a_3 CRLOAN_{t-1} - e_6 a_4 RGDP_{t-1} - e_6 a_5 \Delta RGDP_{t-1} \\ &\quad + e_6 JGB10_{t-1} + \varepsilon_t^e \end{aligned} \tag{7-a}$$

$$\begin{aligned} \Delta JGB10_t &= (f_0 - f_6 b_0) + f_1 \Delta \pi_t + f_2 \Delta CRMB_t + f_3 \Delta CRLOAN_t + f_4 \Delta RGDP_t + f_5 \Delta^2 RGDP_t \\ &\quad - f_6 b_1 E \pi_{t-1} - f_6 b_2 CRMB_{t-1} - f_6 b_3 CRLOAN_{t-1} - f_6 b_4 RGDP_{t-1} - f_6 b_5 \Delta RGDP_{t-1} \\ &\quad + f_6 JGB10_{t-1} + \varepsilon_t^f \end{aligned} \tag{7-b}$$

$$\begin{aligned} \Delta RJGB10_t &= (g_0 - g_5 c_0) + g_1 \Delta CRMB_t + g_2 \Delta CRLOAN_t + g_3 \Delta RGDP_t + g_4 \Delta^2 RGDP_t \\ &\quad - g_5 c_1 CRMB_{t-1} - g_5 c_2 CRLOAN_{t-1} - g_5 c_3 RGDP_{t-1} - g_5 c_4 \Delta RGDP_{t-1} \\ &\quad + g_5 RJGB10_{t-1} + \varepsilon_t^g \end{aligned} \tag{7-c}$$

$$\begin{aligned} \Delta RJGB10E_t &= (h_0 - h_5 d_0) + h_1 \Delta CRMB_t + h_2 \Delta CRLOAN_t + h_3 \Delta RGDP_t + h_4 \Delta^2 RGDP_t \\ &\quad - h_5 d_1 CRMB_{t-1} - h_5 d_2 CRLOAN_{t-1} - h_5 d_3 RGDP_{t-1} - h_5 d_4 \Delta RGDP_{t-1} \\ &\quad + h_5 RJGB10E_{t-1} + \varepsilon_t^h \end{aligned} \tag{7-d}$$

We regress four kinds of models, Equation (7)-a, (7)-b, (7)-c and (7)-d by Generalized Method of Moments (GMM) estimation with instrumental variables. Two of them, Equation (7)-c and (7)-d are with the restriction to assume the complete Fischer-effect works. And Equation (7)-a and (7)-c have in common that they include the variable for actual inflation.

Instrumental variables we employ, for example in Equation (7)-a, are as follows;

$$JGB10_{t-1}, \pi_{t-1}, RCALL_{t-1}, CRMB_{t-1}, CRLOAN_{t-1}, RGDP_{t-1}, \Delta RGDP_{t-1}, \Delta \pi_{t-1}, \Delta CRMB_{t-1}, \Delta CRLOAN_{t-1}, \Delta RGDP_{t-1}, \Delta^2 RGDP_{t-1}, \Delta \pi_{t-2}, \Delta CRMB_{t-2}, \Delta CRLOAN_{t-2}, \Delta RGDP_{t-2}, \Delta^2 RGDP_{t-2}, \Delta JGB10_{t-1}, \Delta JGB10_{t-2}$$

Table 10, 11 and 12 show the result of the regression of the four kinds of ECM in period A, B and C respectively. Although not many coefficients are significant, the sign conditions are as we had expected. All the coefficients of $CRMB_{t-1}$, and most coefficients of $RGDP_{t-1}$ and $CRLOAN_{t-1}$ are negative.

In Period B and C, in Equation (7)-c and (7)-d with restriction for assumption of complete Fisher effect, three coefficients of $CRMB_{t-1}$ and $RGDP_{t-1}$ are negative with the exception that that of $RGDP_{t-1}$ in Equation (7)-d is negative insignificantly as well. Meanwhile, in Period A, only one coefficient for $RGDP_{t-1}$ in Equation (7)-c is negative significantly with the restriction above.

5. Conclusion

The results of Dynamic OLS Estimation show that in long-term Equations (5)-b, (5)-c and (5)-d, most sign conditions of the coefficients for the proxy variables of monetary base and change rates of loans are negative significantly. It means that the more both the monetary base and loan outstanding increase, the lower real bond rates decline with cointegrating relationships under the zero-interest boundary.

And the results of ECMs show that on the assumption that complete Fischer effect works increases and the rises of increase rate of loans outstanding by financial institutions also lower the nominal and real interest rates in the short run paradoxically.

Even under the non-traditional monetary policy in Japan from 1999, it has been very difficult of Japanese economy to escape from the swamp of deflation and it has not been realized yet. Even though monetary base and lending increase more, the nominal and real long-term bond rates will decline in the long-run through the cointegrating relationship. After longer duration of the unusual economic condition with non-traditional monetary easing than we had expected, real economy would recover and escape from the stagnant deflation.

Judging from the estimation results of DOLS, we can conclude in three points as follows. Firstly, only by the increase of monetary base, real interest rates could not be lowered. Secondly by the combination of the increase of monetary base, the loans outstanding real and the recovery of real economy, especially real interest rates could be lowered after some interval or cointegration process. Thirdly, even by non-traditional monetary policies it takes even more time than had been expected to recover the economy because the increase of loans outstanding and recovery of real economy is the first step before the decline of real interest rates.

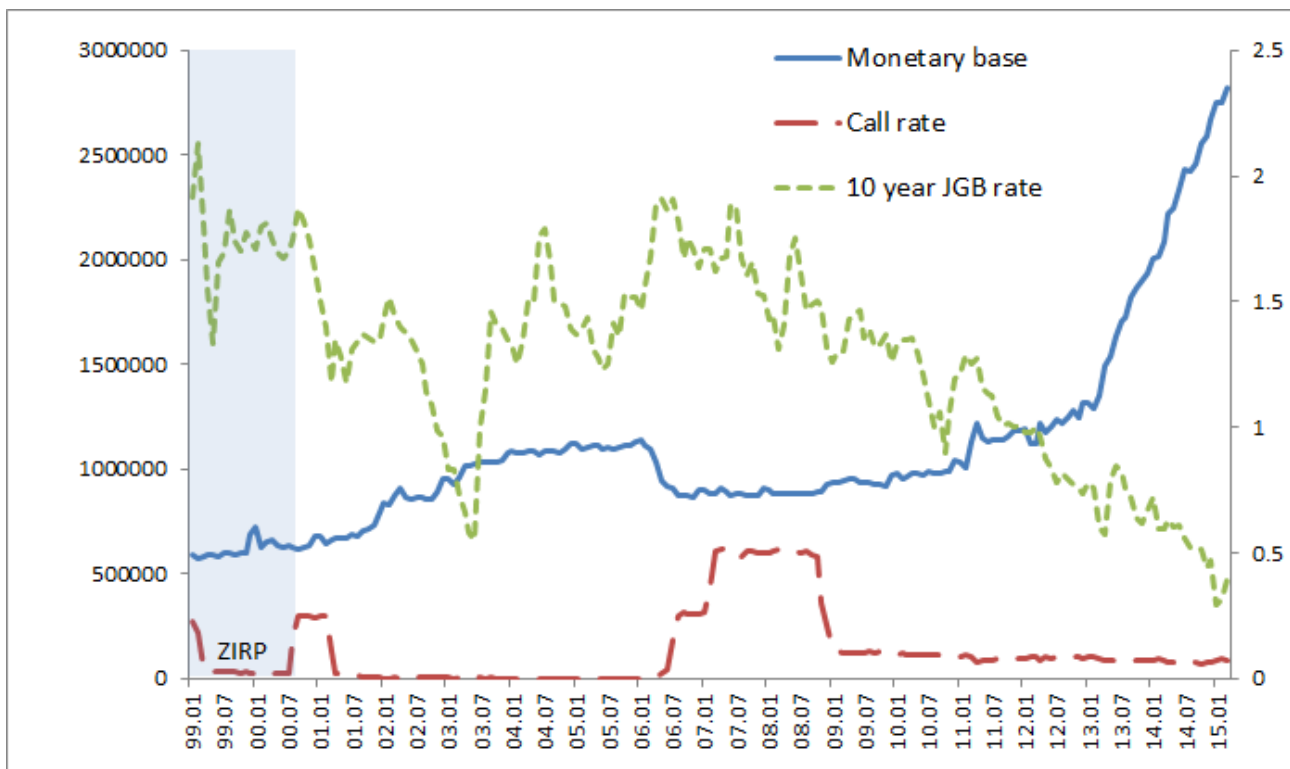
As Iida and Yasushi (2004) pointed out, even in phase of recovery from Showa Depression in 1930s, banks' aggregate balances of loans did not increase very much because corporate enterprises expand their investment firstly by their surplus funds stocked under deflation. It take time of the corporate enterprise in our age to increase their loan outstanding.

In QQE and additional QQE, as a portfolio rebalancing effect, it is expected many investors and financial institutions allocate their funds to risk assets such as stocks, foreign bonds and loans as a result that BOJ purchased long-term JGB in large quantities. It is the ideal transmission mechanism by such asset allocations that lead to the recovery of capital investments by the lowered interest rates and the expansion of exports by the weaker yen successfully. However our results indicate that even after allocation to loans by the financial institutions in Japan both the nominal and real interest rates of JGBs still be lowered in the previous non-traditional monetary policies. Lowered interest rates are favorable step to recover the economy. Therefore whether QQE supplying much more monetary base than in previous policies is enough or not should be judged carefully.

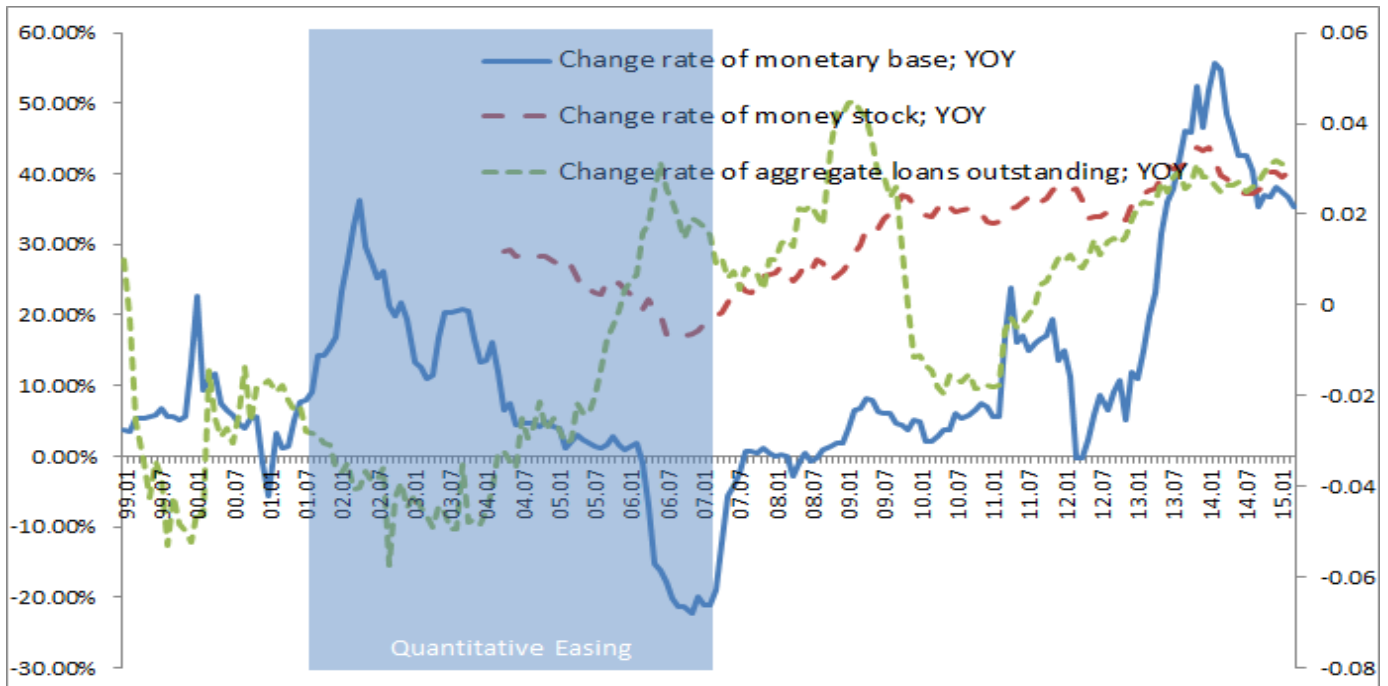
And as signal effect (time axis effect by BOJ), it is expected setting a high reserve target in an adamant attitude by the governor of BOJ alter our expectations and raise the anticipated inflation. The sudden announcement of unexpected expansion of QQE program on 31st of October 2014 are thought of as a very effective signal for an adamant attitude of BOJ. According to our estimation results of Equation (5)-c and (5)-d, real interest rates are also lowered by both increases of monetary base and aggregate amount of loan outstanding on the assumption that complete Fisher effect works. However there is a limit in this paper to find whether the complete Fisher effect works or not and signal effect works on Japanese real economy under the zero-interest boundary especially in 2013.

In the previous non-traditional monetary policies, interest rates were lowered having cointegrating relationship with increase rates of monetary base and loans. However it failed to rise in the long-run accompanied by the economic recoveries at last. It is important to perform in more adamant attitudes for the governor of BOJ to succeed in QQE than in the previous non-traditional monetary policies. Mr. Kuroda the present governor of BOJ emphasized in his inauguration speech that they should do whatever is necessary to overcome deflation and make all-out efforts to utilize every possible resource rather than to adopt an incremental approach or to adopt gradualism. It is very ideal attitude as a governor of BOJ to convey a strong and clear commitment. However it is also important in the long-run they could continue with the quantitative and qualitative monetary easing. He stated that aiming to achieve the price stability target of 2 percent, as long as it is necessary for maintaining that target in a stable manner, they will not hesitate to make adjustments as appropriate. They also have time horizon of 2 years which was set to convince many people including those who are rather skeptical that BOJ will continue with enough monetary easing to achieve the target of 2 percent of inflation rate.

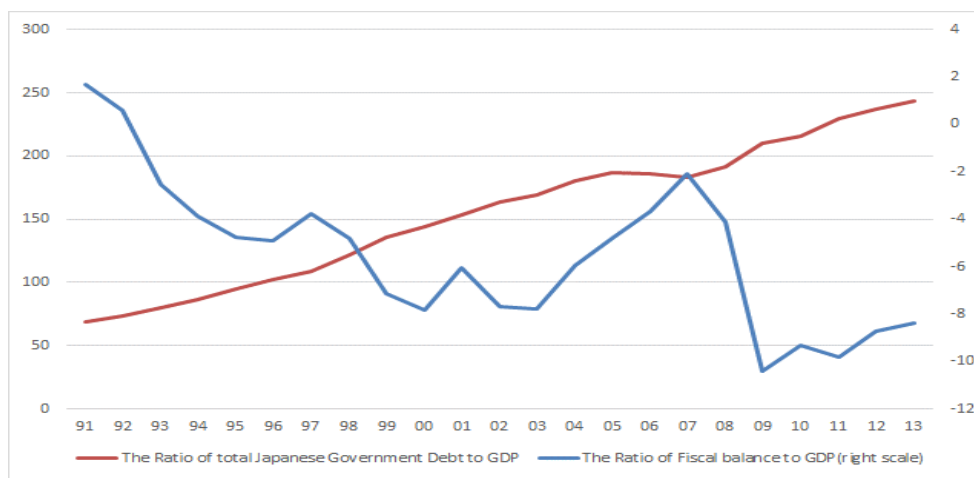
In QQE, BOJ implement the non-traditional monetary policy with unflinching purpose, numerical target and time horizon. However, it may take much time to achieve 2% inflation rate escaping from deflation. If things go wrong, QQE may end up with no result and effect. It is appropriate to conclude that QQE needs its continuity at least.



Graph-1. Monetary base, call rate and bond rate from January, 1999 till 2014



Graph-2. Change rates of Monetary base, Money Stock and Loan outstanding from 1999 till 2014



Graph-3. Japanese Government's Fiscal Situation from 1999 till 2013

Table-1. Unit Root tests results (Period A)

Period A: January 1999 – December 2012

	Variables	Augmented Dickey-Fuller test t-statistics	Lag length		DF GLS t statistic	Lag length		Perron unit root test t-statistic	Lag length	
				*			*			*
Level of Variables	JGB10	-2.92	0		-2.35	0		-4.57	0	
	RJGB10	-2.84	12		-2.81	12	*	-4.58	1	
	RJGB10E	-3.16	13	*	-2.98	13	*	-4.27	2	
	π	-2.21	12		-1.91	12	*	-5.15	1	
	$E\pi$	-4.00	11	***	-2.33	13	**	-4.83	4	
	CRMB	-1.31	12		-1.32	12		-3.88	3	
	CRLOAN	-1.19	13		-1.24	13		-3.85	3	
	RGDP	-1.61	0		-0.50	0		-5.47	0	**
1 st difference of Variables	Δ JGB10	-13.04	0	***	-8.32	1	***			
	Δ RJGB10	-6.17	11	***	-5.62	11	***			
	Δ RJGB10E	-4.28	12	***	-4.08	12	***			
	$\Delta\pi$	-6.43	11	***	-2.91	12	***			
	$\Delta E\pi$	-4.12	12	***	-2.64	12	***			
	Δ CRMB	-4.27	13	***	-4.28	13	***			
	Δ CRLOAN	-5.17	12	***	-3.56	13	***			
	Δ RGDP	-13.70	0	***	-13.23	0	***	-14.33	0	***

As for Table 1, 2, and 3, "****", "***" and "*" denote statistical significance at the 1%, 5% and 10% levels, respectively. The base models of JGB10 and RJGB10 and RJGB10E include their constant terms and trend lines, while the others include only their constant terms. The lag length employed in those unit root tests are selected by the Akaike Information Criterion. Perron unit root test is developed by Perron (1997) with a break in the trend function at an unknown time. The critical values of Perron unit root test we adopted are as follows; 10% 5% 1% Perron test -4.92 -5.23 -5.92.

Table-2. Unit Root tests results (Period B)

Period B: January 1999 – December 2013

	Variables	Augmented Dickey-Fuller test t-statistics	Lag length		DF GLS t-statistic	Lag length		Perron unit root test t-statistic	Lag length	
Level of Variables	JGB10	-2.91	0		-2.44	0		-4.82	0	
	RJGB10	-2.24	12		-2.19	12		-4.08	12	
	RJGB10E	-2.81	13		-2.56	13		-4.88	13	
	π	-1.64	12		-1.70	12	*	-4.80	12	
	$E\pi$	-2.74	13	*	-2.23	13	**	-4.72	9	
	CRMB	-0.62	13		-0.65	13		-3.15	12	
	CRLOAN	-1.07	13		-1.26	13		-3.81	13	
	RGDP	-1.41	0		-0.17	0		-5.70	0	**
1 st difference of Variables	Δ JGB10	-13.35	0	***	-12.60	0	***			
	Δ RJGB10	-6.25	11	***	-5.85	11	***			
	Δ RJGB10E	-4.39	12	***	-4.24	12	***			
	$\Delta\pi$	-6.48	11	***	-2.71	12	***			
	$\Delta E\pi$	-4.16	12	***	-2.37	12	**			
	Δ CRMB	-4.99	12	***	-4.48	12	***			
	Δ CRLOAN	-5.33	12	***	-2.52	13	**			
	Δ RGDP	-14.27	0	***	-13.46	0	***	-16.01	0	***

Table-3. Unit Root tests results (Period C)

Period C: January 1999 – December 2014

	Variables	Augmented Dickey-Fuller test t-statistics	Lag length		DF GLS t-statistic	Lag length		Perron unit root test t-statistic	Lag length	
Level of Variables	JGB10	-2.58	0		-2.35	0		-4.82	0	
	RJGB10	-1.88	12		-1.89	12		-4.08	12	
	RJGB10E	-2.40	13		-2.18	13		-4.88	13	
	π	-1.43	12		-1.63	12	*	-4.80	12	
	$E\pi$	-2.19	13		-2.09	13	**	-4.72	9	
	CRMB	-0.11	13		-0.02	13		-3.15	12	
	CRLOAN	-0.72	13		-1.17	13		-3.81	13	
	RGDP	-1.37	1		-0.01	1		-6.03	0	***
1 st difference of Variables	Δ JGB10	-13.90	0	***	-13.14	0	***			
	Δ RJGB10	-5.89	11	***	-5.58	11	***			
	Δ RJGB10E	-4.53	12	***	-4.42	12	***			
	$\Delta\pi$	-5.89	11	***	-3.30	11	***			
	$\Delta E\pi$	-4.28	12	***	-2.65	12	***			
	Δ CRMB	-5.36	12	***	-5.10	12	***			
	Δ CRLOAN	-5.34	12	***	-0.78	14				
	Δ RGDP	-15.63	0	***	-14.84	0	***	-17.13	0	***

Table-4. Cointegration Tests results (Period A)

Period A: January 1999 – December 2012

system	ADF Test		Johansen Test				Engle-Granger Test				Equation
	t-statistics (p-value)		Lag	Trace Test (p-value)	Maximum Eigenvalue Test (p-value)	Lag	Tau statistics (p-value)		Z statistics (p-value)		
(RJGB10, RLOAN)	4	(0.01) **	1	29.41 (0.00) **	24.51 (0.00) **	1	-3.51 (0.04) **	-25.00 (0.02) **	(4)-c		
(RJGB10, RGDP)	1	(0.00) ***	2	25.93 (0.00) *	22.07 (0.00) *	1	-3.94 (0.01) **	-31.29 (0.00) **	(4)-c		
(RJGB10, CRMB, RGDP)	1	(0.00) ***	3	40.15 (0.00) **	27.91 (0.00) **	1	-3.99 (0.03) **	-31.97 (0.01) **	(4)-c		
(RJGB10, CRLOAN, RGDP)	1	(0.00) ***	4	51.57 (0.00) **	28.63 (0.00) **	1	-3.93 (0.04) **	-31.07 (0.02) **	(4)-c		
(RJGB10E, CRLOAN)	9	(0.03) **	1	22.88 (0.00) *	19.28 (0.01) *	3	-3.52 (0.04) **	-30.59 (0.00) **	(4)-d		
(RJGB10E, RGDP)	2	(0.01) **	4	19.39 (0.01) **	14.39 (0.05) **	3	-3.63 (0.03) **	-32.12 (0.00) **	(4)-d		
(RJGB10E, CRMB, CRLOAN)	9	(0.00) ***	1	35.91 (0.01) **	24.99 (0.01) **	3	-4.15 (0.02) **	-45.05 (0.00) **	(4)-d		
(RJGB10E, CRMB, RGDP)	3	(0.00) ***	4	36.18 (0.01) **	25.26 (0.01) **	0	-5.78 (0.00) **	-55.63 (0.00) **	(4)-d		
(RJGB10E, CRMB, CRLOAN, RGDP)	3	(0.00) ***	4	61.14 (0.00) **	32.75 (0.01) **	0	-5.80 (0.00) **	-56.06 (0.00) **	(4)-d		
				**	**		**	**	**		
				*	*		*	*	*		
				**	**		**	**	**		
				*	*		*	*	*		

As for Table 4, 5, and 6, "***", "**" and "*" denote statistical significance at the 1%, 5% and 10% levels, respectively. The lag length employed in those unit root tests are selected by the Akaike Information Criterion. In any test, The base models of all variables include only their constant terms.

Table-5. Cointegration Tests results (Period B)

Period B: January 1999 – December 2013

system	ADF Test		Johansen Test				Engle-Granger Test				Equation		
	t-statistics (p-value)		Lag	Trace Test (p-value)		Maximum Eigenvalue Test (p-value)		Lag	Tau statistics (p-value)			Z statistics (p-value)	
	Lag												
(JGB10, Eπ, CRMB, RGDP)	0	(0.01)***	2	51.41 (0.02)**		28.41 (0.04)**		0	-3.82 (0.11)**		-25.66 (0.12)**		(4)-b
(RJGB10, RGDP)	1	(0.00)***	2	23.20 (0.00)**		19.42 (0.01)**		1	-3.60 (0.03)**		-29.80 (0.01)**		(4)-c
(RJGB10, CRMB, RGDP)	1	(0.00)***	2	36.79 (0.01)*		30.89 (0.00)*		2	-4.47 (0.01)**		-48.32 (0.00)**		(4)-c
(RJGB10, CRMB, CRLOAN, RGDP)	1	(0.00)***	4	54.26 (0.01)**		31.12 (0.02)**		2	-4.48 (0.02)**		-48.45 (0.00)**		(4)-c
(RJGB10E, CRMB, RGDP)	0	(0.00)***	4	32.25 (0.03)**		25.82 (0.01)**		3	-4.65 (0.00)**		-56.94 (0.00)**		(4)-d
(RJGB10E, CRMB, CRLOAN, RGDP)	0	(0.00)***	4	51.70 (0.02)**		27.97 (0.04)**		3	-4.67 (0.01)**		-57.66 (0.00)**		(4)-d
													**
													*
													**
													*

Table-6. Cointegration Tests results (Period C)

Period C: January 1999 – December 2014

system	ADF Test		Johansen Test				Engle-Granger Test				Equation		
	t-statistics (p-value)		Lag	Trace Test (p-value)		Maximum Eigenvalue Test (p-value)		Lag	Tau statistics (p-value)			Z statistics (p-value)	
	Lag												
(RJGB10E, CRMB)	3	(0.00)***	1	18.06 (0.02)**		17.37 (0.02)**		3	-3.86 (0.01)**		-39.43 (0.00)**		(4)-d
(RJGB10E, CRMB, RGDP)	0	(0.00)***	1	36.27 (0.01)**		31.90 (0.00)**		0	-5.73 (0.00)**		-56.32 (0.00)**		(4)-d
													**
													*
													**
													*

Table-7. Dynamic OLS Estimation results (Equation (5)-b)

Period B: January 1999 – December 2013

System	(JGB10, Eπ, CRMB, RGDP)		
Variables	Coefficient	t-Value	
C	4.63	(4.30)	***
Eπ	-0.01	(-0.23)	
CRMB	-1.66	(-5.00)	***
CRLOAN			
RGDP	-6.41	(-3.03)	***
Lead	0		
Lag	0		
Adjusted R-squared	0.43		

As for Table-7, 8, and 9, "****", "***" and "*" denote statistical significance at the 1%, 5% and 10% levels, respectively

Table-8. Dynamic OLS Estimation results (Equation (5)-c)

Period A: January 1999 – December 2012

System	(RJGB10, CRLOAN)			(RJGB10, RGDP)		
Variables	Coefficient	t-Value		Coefficient	t-Value	
C	1.44	(9.86)	***	12.48	(4.37)	***
Eπ						
CRMB						
CRLOAN	-12.82	(-3.12)	***			
RGDP				-21.88	(-3.81)	***
Lead	5			7		
Lag	0			2		
Adjusted R-squared	0.40			0.51		

Period B: January 1999 – December 2013

System	(RJGB10, CRMB, RGDP)			(RJGB10, CRLOAN, RGDP)		
Variables	Coefficient	t-Value		Coefficient	t-Value	
C	16.48	(4.87)	***	21.34	(6.16)	***
$E\pi$						
CRMB	-0.69	(-0.53)				
CRLOAN				12.34	(2.60)	**
RGDP	-29.69	(-4.41)	***	-39.00	(-5.70)	***
Lead	0			0		
Lag	0			3		
Adjusted R-squared	0.51			0.48		

Period B: January 1999 – December 2013

System	(RJGB10, CRMB, RGDP)			(RJGB10, CRMB, CRLOAN, RGDP)		
Variables	Coefficient	t-Value		Coefficient	t-Value	
C	21.64	(7.65)	***	23.92	(6.61)	***
$E\pi$						
CRMB	-3.01	(-3.09)	***	-2.72	(-2.87)	***
CRLOAN				6.54	(1.36)	
RGDP	-39.91	(-7.08)	***	-44.24	(-6.20)	***
Lead	0			0		
Lag	3			3		
Adjusted R-squared	0.51			0.53		

Table-9. Dynamic OLS Estimation results (Equation (5)-d)

Period A: January 1999 – December 2012

System	(RJGB10E, CRLOAN)			(RJGB10E, RGDP)		
Variables	Coefficient	t-Value		Coefficient	t-Value	
C	2.34	(9.58)	***	11.32	(2.44)	**
$E\pi$						
CRMB						
CRLOAN	-3.00	(-0.45)				
RGDP				-17.96	(-1.92)	*
Lead	0			0		
Lag	0			0		
Adjusted R-squared	0.02			0.07		

Period A: January 1999 – December 2012

System	(RJGB10E, CRMB, CRLOAN)			(RJGB10E, CRMB, RGDP)			(RJGB10E, CRMB, CRLOAN, RGDP)		
Variables	Coefficient	t-Value		Coefficient	t-Value		Coefficient	t-Value	
C	2.31	(11.55)	***	18.16	(6.16)	***	17.67	(3.36)	***
$E\pi$									
CRMB	-9.94	(-4.38)	***	-5.19	(-2.88)	***	-5.23	(-2.68)	***
CRLOAN	-28.00	(-3.51)	***				-0.85	(-0.12)	
RGDP				-31.22	(-3.31)	***	-30.26	(-2.91)	***
Lead	5			0			0		
Lag	5			0			0		
Adjusted R-squared	0.30			0.19			0.19		

Period B: January 1999 – December 2013

System	(RJGB10E, RGDP)			(RJGB10E, CRMB, CRLOAN, RGDP)		
Variables	Coefficient	t-Value		Coefficient	t-Value	
C	13.97	(3.13)	***	16.81	(3.41)	***
$E\pi$						
CRMB				-4.43	(-3.54)	***
CRLOAN				1.22	(0.19)	
RGDP	-23.42	(-2.62)	***	-28.46	(-2.94)	***
Lead	0			0		
Lag	0			0		
Adjusted R-squared	0.12			0.27		

Period C: January 1999 – December 2014

System	(RJGB10E, CRMB)			(RJGB10E, CRMB, RGDP)		
	Coefficient	t-Value		Coefficient	t-Value	
C	2.64	(11.77)	***	20.36	(5.56)	***
CRMB	-6.81	(-5.26)	***	-6.46	(-6.55)	***
RGDP				-35.54	(-4.86)	***
Lead	1			1		
Lag	1			1		
Adjusted R-squared	0.34			0.53		

Table-10. Error Correction Model (Period A)

Period A: January 1999 – December 2012

Variable	(7)-a			(7)-b		(7)-c			(7)-d		
	Based on Actual Inflation			Based on Anticipated Inflation		Based on Actual Inflation			Based on Anticipated Inflation		
	No restriction			With Restriction		With Restriction			With Restriction		
	Co-efficient	t-value		t-value	Co-efficient	t-value	Co-efficient	t-value	Co-efficient	t-value	
C	1.88	(1.77)	*	0.73	(1.08)	3.77	(2.89)	**	4.74	(1.29)	
JGB10 _{t-1}	-0.22)	*	-0.13	(-1.38)			*			
RJGB10 _{t-1}		(-				-0.18	(-3.15)				
RJGB10E _{t-1}		1.84)						**	-0.31	(-2.27)	**
π_{t-1}	0.02							*			
$E\pi_{t-1}$				-0.00	(-0.06)						
CRMB _{t-1}	-0.74	(0.48)		-0.40	(-1.41)	-0.68	(-1.09)		-2.46	(-1.09)	
CRLOAN _{t-1}	-0.91			-0.61	(-0.82)	-1.24	(-0.37)		-5.59	(-0.73)	
RGDP _{t-1}	-3.11	(-1.52)	*	-1.11	(-0.97)	-6.94	(-2.69)		-7.99	(0.28)	
Δ RGDP _{t-1}	-2.90	(-0.72)		-1.35	(-0.30)	-0.73	(-0.07)		4.81	(0.20)	
$\Delta\pi_t$	0.17	(-1.71)						**			
$\Delta E\pi_t$		(-0.56)		-0.02	(-0.19)			*			
Δ CRMB _t	-0.79	(1.05)		-0.24	(-0.18)	-0.90	(-0.19)		-6.01	(-0.38)	
Δ CRLOAN _t	-2.91			-0.70	(-0.09)	-13.02	(-1.19)		-53.79	(-1.38)	
Δ RGDP _t	-27.66	(-0.40)		-11.86	(-0.86)	-51.37	(-1.34)		-60.36	(-0.64)	
Δ JGB10 _{t-1}	0.11	(-0.53)		-0.02	(-0.09)						
Δ JGB10 _{t-2}	0.07	(-1.33)		0.11	(0.55)						
Δ RJGB10 _{t-1}		(0.67)				0.20	(2.56)				
Δ RJGB10 _{t-2}		(0.44)				0.01	(0.10)				
Δ RJGB10E _{t-1}									-0.08	(-0.70)	
Δ RJGB10E _{t-2}								**	-0.18	(-1.63)	
DW	1.94			1.89		2.02			1.98		
Hansen's J Statistics (p-value)	1.05 (0.79)			4.93 (0.18)		2.56 (0.28)			0.68 (0.71)		

As for Table-10, 11, and 12, "****", "***" and "*" denote statistical significance at the 1%, 5% and 10% levels, respectively. Hansen's J statistics are the most common test statistics in GMM and used to see whether the instruments are uncorrelated with the errors to satisfy the orthogonality condition. The test statistic has a χ^2 distribution under the null hypothesis that the instruments are valid.

Table-11. Error Correction Model (Period B)

Period B: January 1999 – December 2013

Variable	(7)-a			(7)-b		(7)-c			(7)-d		
	Based on Actual Inflation			Based on Anticipated Inflation		Based on Actual Inflation			Based on Anticipated Inflation		
	No restriction			With Restriction		With Restriction			With Restriction		
	Co-efficient	t-value		t-value	Co-efficient	t-value	Co-efficient	t-value	Co-efficient	t-value	
C	1.31	(1.48)		0.22	(0.39)	4.83	(3.06)	**	4.80	(1.42)	
JGB10 _{t-1}	-0.16)		-0.07	(-0.94)			*			
RJGB10 _{t-1}		(-				-0.19	(-3.36)				
RJGB10E _{t-1}		1.54)						**	-0.26	(-2.38)	**
π_{t-1}	0.03							*			
$E\pi_{t-1}$				0.01	(0.26)						
CRMB _{t-1}	-0.37	(0.30)	*	-0.16	(-0.94)	-0.70	(-2.42)		-1.39	(-2.04)	**
CRLOAN _{t-1}	-0.29			-0.57	(-0.87)	0.41	(0.16)		-2.20	(-0.45)	
RGDP _{t-1}	-2.14	(-1.67)		-0.25	(-0.25)	-9.00	(-2.90)	**	-8.32	(-1.21)	
Δ RGDP _{t-1}	-0.51	(-0.38)		0.80	(0.20)	9.75	(1.03)		14.32	(0.74)	
$\Delta\pi_t$	0.16	(-1.38)						**			
$\Delta E\pi_t$		(-0.16)		0.03	(0.31)			*			
Δ CRMB _t	0.24	(1.14)		0.88	(0.63)	3.65	(0.78)		2.55	(0.23)	
Δ CRLOAN _t	-4.27			-5.88	(-0.72)	-13.73	(-1.24)		-46.15	(-1.27)	

Δ RGDP _t	-15.83	(0.14)		-5.44	(-0.48)	-21.04	(-0.56)		-38.84	(-0.52)	
Δ JGB10 _{t-1}	0.09	(-1.00)		0.05	(0.21)						
Δ JGB10 _{t-2}	-0.02	(-1.18)		-0.04	(-0.20)						
Δ RJGB10 _{t-1}		(0.67)				0.24	(2.74)				
Δ RJGB10 _{t-2}		(-0.16)				-0.01	(-0.10)				
Δ RJGB10E _{t-1}								**	-0.08	(-0.66)	**
Δ RJGB10E _{t-2}								*	-0.20	(-2.17)	**
DW	1.98			1.95		2.06			1.98		
Hansen's J Statistics (p-value)	2.88 (0.41)			5.54 (0.14)		1.31 (0.52)			1.04 (0.52)		

Table-12. Error Correction Model (Period C)

Period C: January 1999 – December 2014

Variable	(7)-a		(7)-b		(7)-c		(7)-d	
	Based on Actual Inflation		Based on Anticipated Inflation		Based on Actual Inflation		Based on Anticipated Inflation	
	No restriction				With Restriction			
	Co-efficient	t-value	Co-efficient	t-value	Co-efficient	t-value	Co-efficient	t-value
C	1.46	(1.45)	0.11	(0.18)	4.83	(2.73)	4.98	(1.35)
JGB10 _{t-1}	-0.16)	-0.05	(-0.59)				
RJGB10 _{t-1}		(-			-0.18	(-3.62)		
RJGB10E _{t-1}		1.35)					-0.23	(-2.64)
π_{t-1}	0.03							
E π_{t-1}			-0.00	(-0.07)				
CRMB _{t-1}	-0.38	(0.83)	-0.04	(-0.21)	-0.81	(-3.13)	-1.31	(-1.89)
CRLOAN _{t-1}	-0.36		-0.50	(-0.77)	-0.14	(-0.05)	-2.85	(-0.56)
RGDP _{t-1}	-2.46	(-1.63)	-0.11	(-0.10)	-9.06	(-2.58)	-8.94	(-1.20)
Δ RGDP _{t-1}	-0.77	(-0.40)	-0.86	(-0.23)	5.40	(0.58)	9.96	(0.52)
$\Delta\pi_t$	0.18	(-1.32)						
$\Delta E\pi_t$		(-0.22)	-0.01	(-0.06)				
Δ CRMB _t	0.98	(1.06)	1.45	(0.80)	5.77	(0.92)	7.56	(0.63)
Δ CRLOAN _t	-4.68		-2.68	(-0.35)	-18.07	(-1.45)	-45.08	(-1.36)
Δ RGDP _t	-19.42	(0.33)	-11.74	(-0.99)	-24.38	(-0.59)	-60.00	(-0.77)
Δ JGB10 _{t-1}	0.07	(-0.81)	-0.04	(-0.19)				
Δ JGB10 _{t-2}	-0.05	(-1.30)	-0.06	(-0.29)				
Δ RJGB10 _{t-1}		(0.49)			0.21	(2.26)		
Δ RJGB10 _{t-2}		(-0.23)			-0.04	(-0.31)		
Δ RJGB10E _{t-1}							-0.10	(-0.94)
Δ RJGB10E _{t-2}							-0.23	(-2.60)
DW	2.01		1.92		2.12		1.98	
Hansen's J Statistics (p-value)	2.06 (0.56)		5.01 (0.17)		1.69 (0.43)		1.57 (0.46)	

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Appendix

How to estimate expected inflation rates in Japan by the Carlson-Parkin method is as follows.

1. Assumption and variables

- (1) There could be the threshold value, δ_t in the change of the actual inflation rate π_t . The respondents of surveys for expected inflation rates could perceive the symptom of the changes of inflation rates touching the threshold values correctly.
- (2) The respondents of surveys would answer, "go up", when the expected inflation rates, $E\pi_t$ is higher than $\pi_t + \delta_t$.
- (3) The respondents of surveys would answer, "go down", when $E\pi_t$ is lower than $\pi_t - \delta_t$.
- (4) The respondents of surveys would answer, "stay the same", when $E\pi_t$ is higher than or equal to $\pi_t - \delta_t$ while $E\pi_t$ is lower than or equal to $\pi_t + \delta_t$.

The table bellow shows these assumptions (2), (3) and (4).

answers by respondents	"go up"	"go down"	"stay the same"
Relation expression between the expected inflation rate and the actual inflation rates	$E\pi_t > \pi_t + \delta_t$	$E\pi_t < \pi_t - \delta_t$	$\pi_t - \delta_t \leq E\pi_t \leq \pi_t + \delta_t$

- (5) It is assumed that the answers by the respondents of surveys are normally distributed which is expressed by $N(\mu_t, \sigma_t^2)$.

Therefore we can express the two kinds of distributions as follows;

$$A_t = \Pr(E\pi_t > \pi_t + \delta_t) = \Pr\left(\frac{E\pi_t - \mu_t}{\sigma_t} > a_t\right) \quad (1)$$

where A_t is the ratio of the respondents who answered "go up" and a_t is $\frac{\pi_t + \delta_t - \mu_t}{\sigma_t}$.

$$B_t = \Pr(E\pi_t > \pi_t - \delta_t) = \Pr\left(\frac{E\pi_t - \mu_t}{\sigma_t} > b_t\right) \quad (2)$$

where B_t is the ratio of the respondents who answered "go down" and b_t is $\frac{\pi_t - \delta_t - \mu_t}{\sigma_t}$.

2. The estimation of the expected inflation by regression analysis

Equation (1) could be expressed by cumulative normal distribution as follows;

$$A_t = \Pr\left(\frac{E\pi_t - \mu_t}{\sigma_t} > a_t\right) = 1 - \Phi(a_t) \quad (3)$$

In the same way.

$$B_t = \Pr\left(\frac{E\pi_t - \mu_t}{\sigma_t} < b_t\right) = \Phi(b_t) \quad (4)$$

Where $\Phi(\bullet)$ is the cumulative normal distribution function.

The relation between the mean values and the standard deviations of expected inflation rates with a_t and b_t could be expressed as follows;

$$\mu_t = -\delta_t \frac{a_t + b_t}{a_t - b_t} \quad (5)$$

With the estimation of δ_t in the Equation (5), we could get the anticipated inflation rate for each period.

3. Application to the Japanese data

In Original Carlson-Parkin method, threshold δ which is common throughout the whole periods is applied in the Equation (6) as follows with the condition that $\sum_{t=1}^T \pi_t = \sum_{t=1}^T \mu_t$.

$$\delta = -\frac{\sum_{t=1}^T \pi_t}{\sum_{t=1}^T \left(\frac{a_t + b_t}{a_t - b_t}\right)} \quad (6)$$

And the expected value of anticipated inflation rate μ could be expressed by the Equation (5) above.

However, we use the diffusion index called "prediction for prices" of the consumer behavior forecasting survey by Cabinet Office, Government of Japan as reference index for the Japanese people's anticipation for inflation, in

which whether the inflation rate instead of the level of prices as of then “go up” or “go down” are inquired. Therefore equation (5) is not appropriate to use here. Horii and Terai (2004) introduce the modified Carlson-Parkin method adjusted for Japanese statistics. According to it, equation (5) is modified into Equation (5)’ as follows;

$$\mu_t = \pi_t - \delta_t \frac{a_t + b_t}{a_t - b_t} \quad (5)'$$

where π is the actual inflation rate. But now there is another problem. In the original Carlson-Parkin method, δ is calculated on the assumption that the average values of anticipated inflation rates throughout the observing period equal that of the actual inflation rates then. Without another modification, left-side and right-side of Equation (5)’ or μ would be zero and it means that the anticipated inflation rate always equals the actual inflation rate in each period. It makes no sense.

The modified Carlson-Parkin method assumes that anticipated inflation rates equal the average rate of forward inflation rates for the next one year. In this thesis we need the monthly anticipated inflation rates, that is

$$\frac{\sum_{t=1}^T \pi_{t+1} + \pi_{t+2} + \dots + \pi_{t+12}}{12}$$

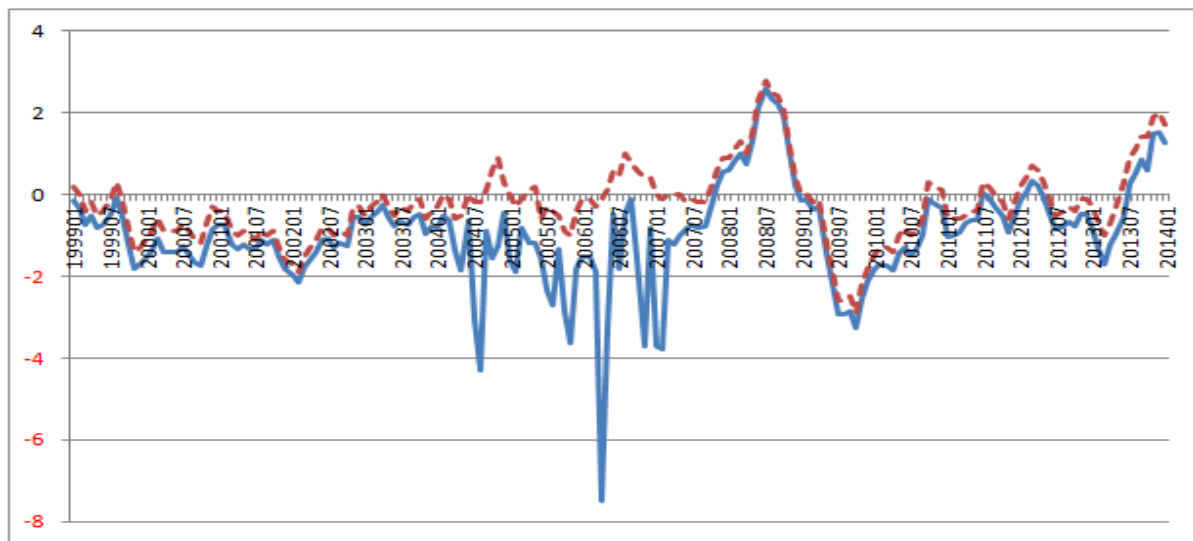
Therefore Equation (6) for modified Carlson-Parkin method is expressed as follows;

$$\sum_{t=1}^T \pi_t = \sum_{t=1}^T \mu_t - \delta \sum_{t=1}^T \frac{a_t + b_t}{a_t - b_t} = \sum_{t=1}^T \pi_t^* = \sum_{t=1}^T \frac{\pi_{t+1} + \pi_{t+2} + \dots + \pi_{t+12}}{12} \quad (6)$$

Therefore,

$$\delta = \frac{\pi_{12} + 2\pi_{11} + \dots + 12\pi - 12\pi_{T+1} - 11\pi_{T+2} - \dots - \pi_{T+4}}{12 \sum_{t=1}^T \left(\frac{a_t + b_t}{a_t - b_t} \right)} \quad (7)$$

Substituting the δ above to Equation (5), we can estimate the anticipated inflation rates. Graph-4 shows the movement of anticipated inflation rate, solid line, and the actual inflation rate, the dot line from January of 1999 until December of 2012.



Graph-4. Anticipated inflation rate estimated by Carlson-Parkin method

Owing to the temporary run-up of the resource and other prices by speculation in the commodities markets, from 2004 until 2007 there are much gap between them. During that period actual inflation rate is much higher than estimated anticipated inflation rates.