Working Paper No. 906

The Dynamics of Japanese Government Bonds' Nominal Yields

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May 2018

Acknowledgements: The authors thank participants at various workshops and conferences for their valuable comments and suggestions. The authors also thank Ms. Elizabeth Dunn for her copyediting.

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ISSN 1547-366X

ABSTRACT

This paper employs a Keynesian perspective to explain why Japanese government bonds' (JGBs) nominal yields have been low for more than two decades. It deploys several vector error correction (VEC) models to estimate long-term government bond yields. It shows that the low short-term interest rate, induced by the Bank of Japan's (BoJ) accommodative monetary policy, is mainly responsible for keeping long-term JGBs' nominal yields exceptionally low for a protracted period. The results also demonstrate that higher government debt and deficit ratios do not exert upward pressure on JGBs' nominal yields. These findings are relevant to ongoing policy debates in Japan and other advanced countries about government bond yields, fiscal sustainability, fiscal policy, functional finance, monetary policy, and financial stability.

KEYWORDS: Japanese Government Bonds; Long-Term Interest Rate; Nominal Bond Yields; Monetary Policy; Bank of Japan; John Maynard Keynes

JEL CLASSIFICATIONS: E43; E50; E58; E60; G10; G12

I. INTRODUCTION

Japanese government bonds' (JGBs) nominal yields have been chronically quite low for decades. JGBs' yields have been near zero or negative since the beginning of 2016. The country's economic stagnation since the early 1990s has resulted in the large deficits in its primary/fiscal balance. This in turn has led to the rise in the ratios of government debt to nominal GDP (nGDP). Why have JGBs' nominal yields stayed low for so long in the midst of the deterioration of the government of Japan's fiscal condition? This paper addresses this question from a Keynesian viewpoint. It builds on and extends Akram and Das's (2014a, 2014b) earlier analysis from a similar perspective. Whereas Akram and Das's (2014a, 2014b) empirical studies rely on the generalized method of moments for their empirical modeling, this paper deploys a vector error correction (VEC) framework to model the dynamics of long-term government bond yields. This paper also uses a longer period for the study, includes more recent observations, and incorporates data on nominal yields of government bonds of wider range of tenors than in Akram and Das's (2014a, 2014b) studies.

This paper shows that the low short-term interest rate, induced by the Bank of Japan's (BoJ) accommodative monetary policy, has kept JGBs' nominal yields exceptionally low for a protracted period. It discerns the effects other variables, including government fiscal variables—such as the ratios of the primary/fiscal balance and government's gross and net debt to nGDP—on JGBs' nominal yields. This paper also reinvigorates and enhances the Keynesian perspective on the determinants of the long-term interest rate.

There is a substantial theoretical and empirical literature on the determinants of government bond yields. There are two strands in the literature. First, the conventional view is that higher ratios of the primary/fiscal deficit and government debt to nGDP increases government bond yields. Baldacci and Kumar (2010), Doi, Hoshi, and Okimoto (2011), Gruber and Kamin (2012), Horoka, Nomoto, and Terada-Hagiwara (2014), Hoshi and Ito (2012, 2013, 2014), Lam and Tokuoka (2011), Poghosayn (2014), Reinhart and Rogoff (2009), and Tokuoka (2012) represent this point of view. Second, the Keynesian view is that the central bank's actions affect government bond yields mainly through the influence of the central bank's policy rate on the short-term interest rate. This view, derived from Keynes (1930, 2007 [1936]), is represented in several empirical studies, such as Akram (2014), Akram and Das (2014a, 2014b, 2015, 2017), and Akram and Li (2016, 2017a, 2017b), as well as theoretical analysis, such as Fullwiler (2008, 2016), Kregel (2011), Lavoie (2014), and Wray ([1998] 2003, 2012). The Keynesian views about the drivers of government bond yields are derived from several conceptual foundations: (1) ontological uncertainty about the future (Davidson 2015); (2) animal spirits and herd behavior among investors in financial assets (Akerlof and Shiller 2009; Kregel 2011); and (3) liquidity preference (Keynes [1936] 2007). This paper bolsters the Keynesian view with empirical evidence from the Japanese case.

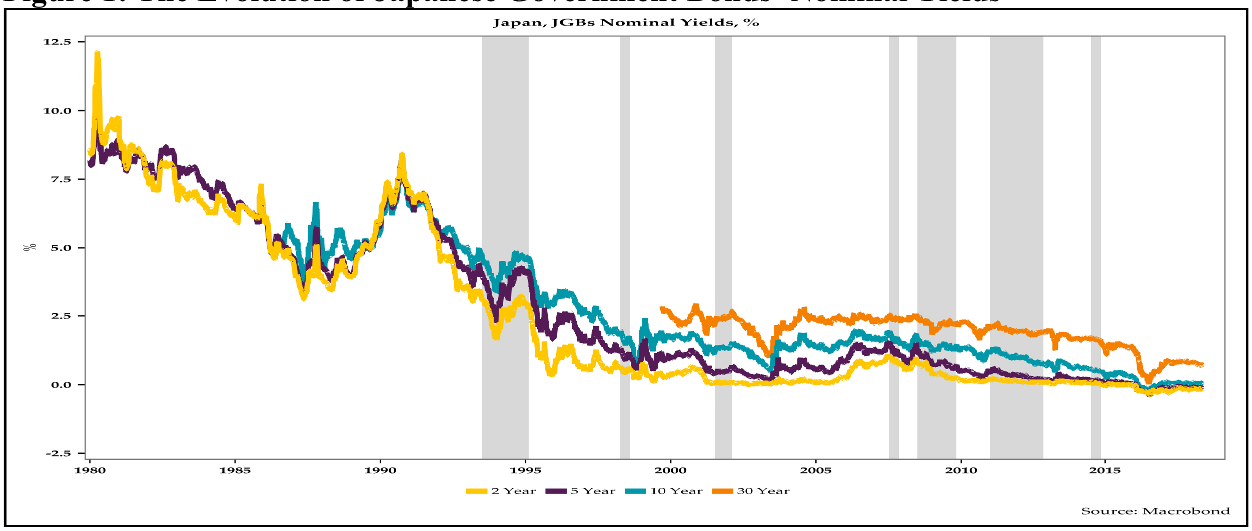
The paper is organized as follows. Section II describes important stylized facts about the evolution of JGBs' nominal yields and fundamental macroeconomic and financial variables that are key drivers of JGBs' nominal yields, such as the short-term interest rate, the rate of core inflation, and the government fiscal ratio. Section III describes the data and its sources. Section IV presents the econometric framework applied in this paper. This section undertakes unit root tests, cointegration tests, and the estimation of various VEC models. It reports and interprets the findings from the estimated models. Section V conveys the implications of the empirical analysis for macroeconomic theory and policy from a Keynesian perspective. Section VI concludes. The appendix is comprised of several tables. These tables present additional findings that reinforce the main empirical results of the paper.

II. THE EVOLUTION AND MACRODYNAMICS OF JGBs' NOMINAL YIELDS

For more than two decades the Japanese economy has been entrapped in economic stagnation. This stagnation has been characterized by slow economic growth and low inflation or even deflation. In recent years Japan has experienced a decline in both its labor force and total population, mainly due to the aging of its population.

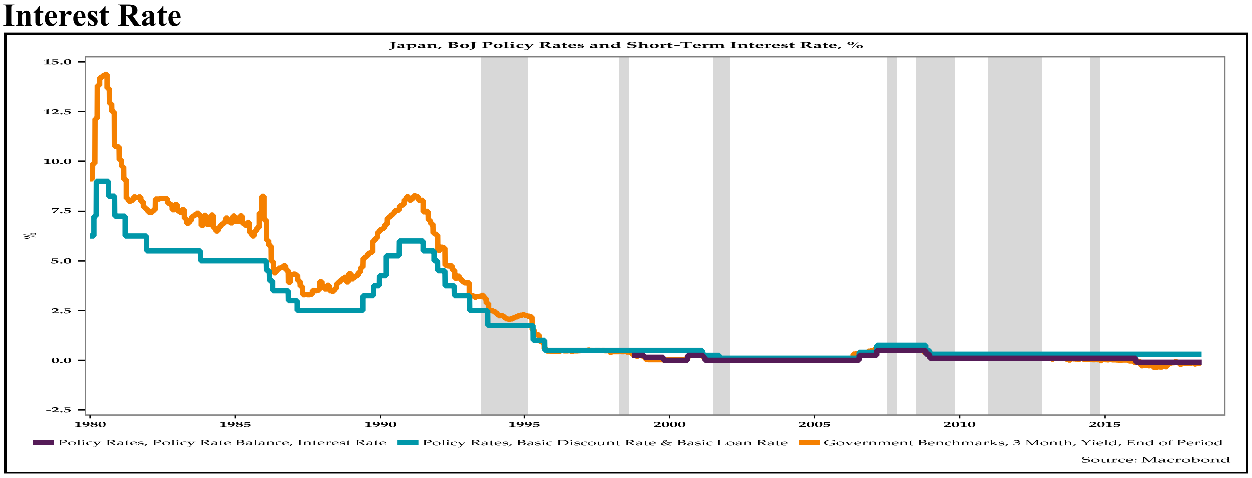
The evolution of JGBs' nominal yields since 1980 reveals that nominal yields on JGBs fell sharply in the early 1990s and have stayed low since then (figure 1). Since the turn of the twentyfirst century, the yields on JGBs have remained extremely low. JGBs' yields declined in the aftermath of the recessions of the global financial crisis, Tohoku earthquake, and the launch of the BoJ's quantitative and qualitative monetary easing (QQME) program. Nominal yields on JGBs crossed into negative territory in early 2016, as the BoJ's policy shifted to QQME with yield curve control.

Figure 1: The Evolution of Japanese Government Bonds' Nominal Yields



The BoJ's policy rates and the short-term interest rate fell in the mid-1990s and have stayed low (figure 2). While there have been some changes and important innovations in monetary policy from time to time, overall the central bank's monetary policy has been highly accommodative.

Figure 2: The Evolution of the Bank of Japan's (BoJ) Policy Rate and the Short-Term Interest Rate



Japan's economy is characterized by low inflation and deflationary dynamics. Core inflation has been low (figure 3A). The deflationary dynamics are well reflected in the deflators for real GDP and various expenditure components (figure 3B).

Figure 3A: Evolution of the Rate of Core Inflation in Japan

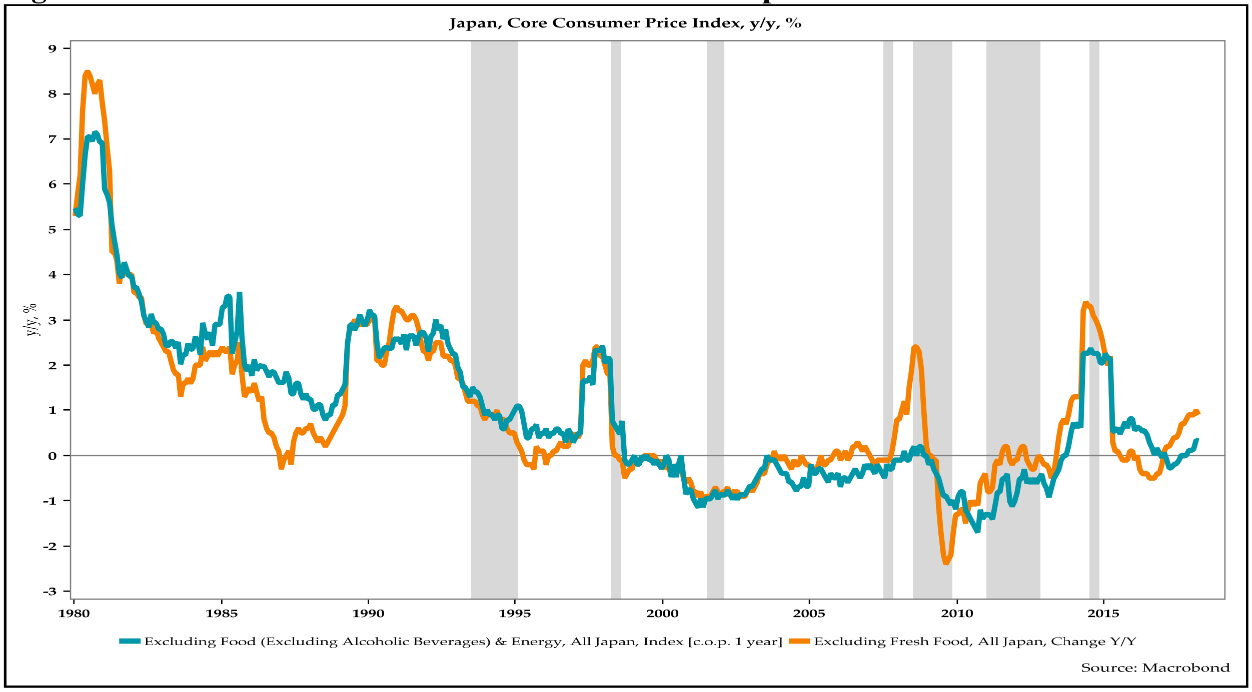
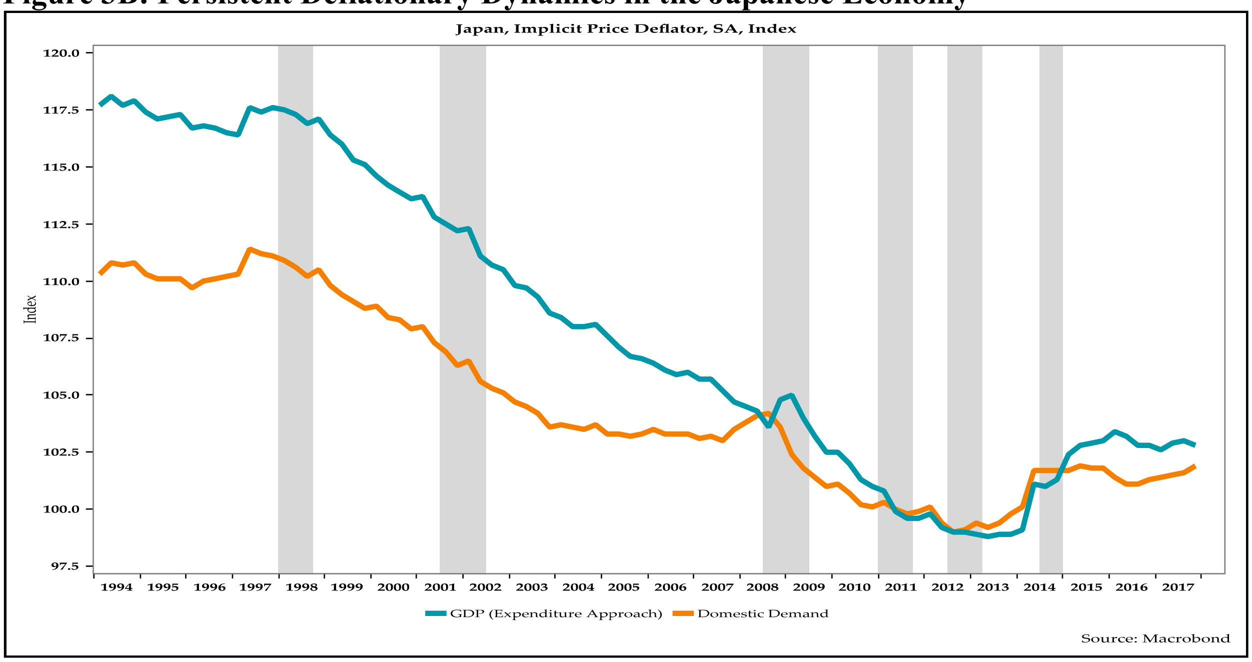
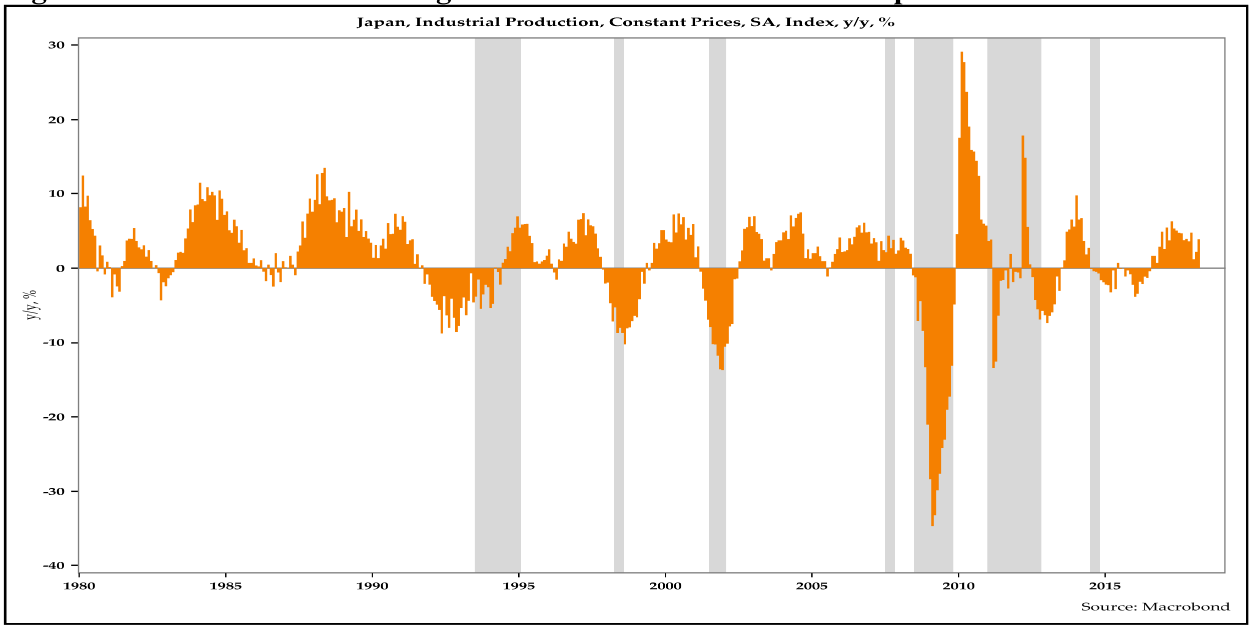


Figure 3B: Persistent Deflationary Dynamics in the Japanese Economy



The growth and the contraction of industrial production in Japan is a useful indicator of the country's business cycles (figure 4).

Figure 4: Year-over-Year Changes in Industrial Production in Japan



There is a tight correlation between the growth of industrial production and the growth of real GDP when both series are measured as a year-over-year percentage change (figure 5A). There is also a positive correlation between the growth of industrial production and the growth of real GDP when both series are measured as a quarter-over-quarter percentage change (figure 5B). However, the correlation between the industrial growth and the growth of real GDP is weaker when measured on a quarter-over-quarter basis as opposed to a year-over-year basis.

Figure 5A: The Strong Correlation between the Year-over-Year Changes in Industrial Production and the Pace of Economic Activity, as Measured by Real GDP Growth

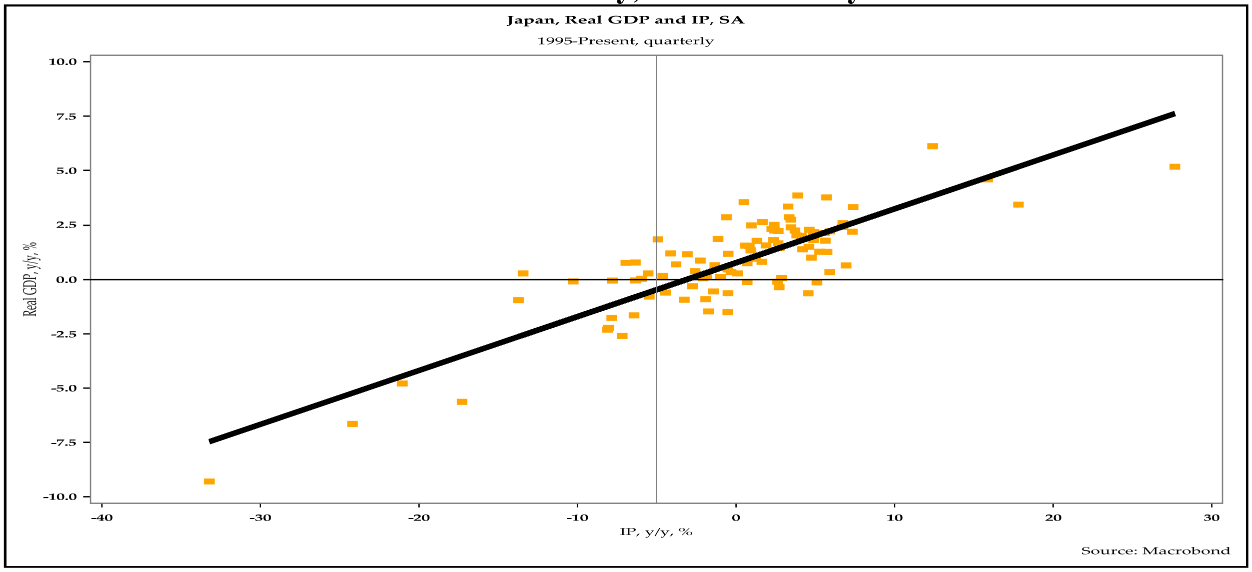
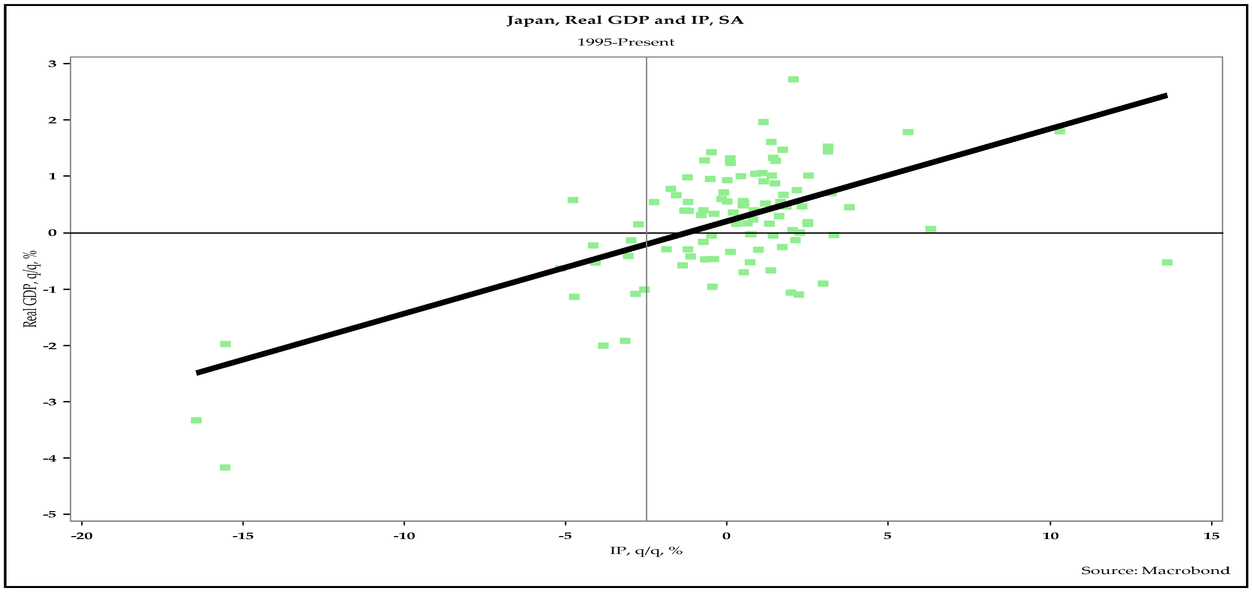
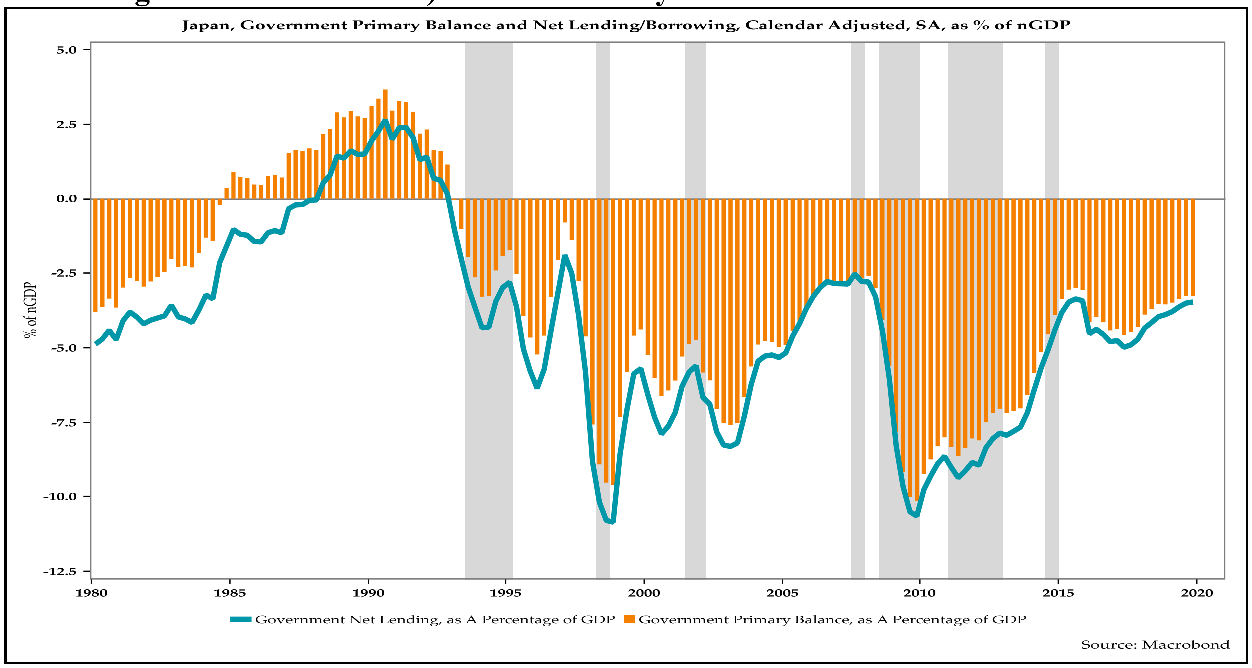


Figure 5B: The Positive Correlation between the Quarter-over-Quarter Growth in Industrial Production and the Pace of Economic Activity, as Measured by Real GDP Growth



Japan's primary/fiscal balance (net government lending/borrowing) ratios have been negative since the mid-1990s (figure 6). A negative primary/fiscal balance indicates a primary/fiscal deficit, while a positive fiscal balance indicates a primary/fiscal surplus. Japan's fiscal deficit and primary deficit ratios have widened as its economy experienced slower growth in the late 1990s. The recession in the later 1990s caused fiscal deficits to widen sharply. After the 2001 recession was over, the country's fiscal deficits began to narrow. However, with the global financial crisis, fiscal deficits widened sharply and remained high for several years. In the past couple of years, the fiscal deficit ratios have narrowed again. In recent years, Japan's fiscal deficit ratios have been in the range of 3 percent to 4 percent of nGDP.

Figure 6: Evolution of the Ratios of the Fiscal Balance (Government Net Lending/ Borrowing as a Share of nGDP) and the Primary Fiscal Balance



Japan has experienced chronic and large primary/fiscal deficits due to slower growth, fiscal stimulus, and increased transfers instituted by demographic changes resulting from the rapid aging of its population. The Japanese government generally runs a primary/fiscal deficit. This implies that usually the government of Japan is a net borrower from the nongovernment sectors. The slower growth and demographic changes have resulted in the widening of primary/fiscal deficit ratios because of automatic stabilizers and the use of fiscal stimulus to counter the slowdown of the economy.

Japan's government debt ratios are elevated. Gross debt and net debt ratios have risen since the mid-1990s (figure 7), and the rise in these debt ratios has continued since the turn of the century due to several factors. First, the country has experienced persistent primary/fiscal deficits. Second, nGDP has been stagnant due to slow growth, low inflation, and deflation. Third, the rapid aging of the population requires substantial fiscal transfers. Fourth, the authorities have often undertaken fiscal stimulus in response to the weakness of effective demand.

JGBs are primarily held by domestic investors, particularly by domestic financial institutions (figure 8). The share of JGBs held by overseas investors is miniscule. Figure 9 provides more details about the holdings of JGBs by investor class, including the BoJ and various government agencies. The BoJ's share of JGB holdings has increased markedly since 2012, during which time the BoJ's balance sheet has risen spectacularly (figure 10), mainly due to substantial purchases of JGBs under the QQME program.

Figure 7: Rise in the Ratios of Japanese Government Debt as a Share of nGDP

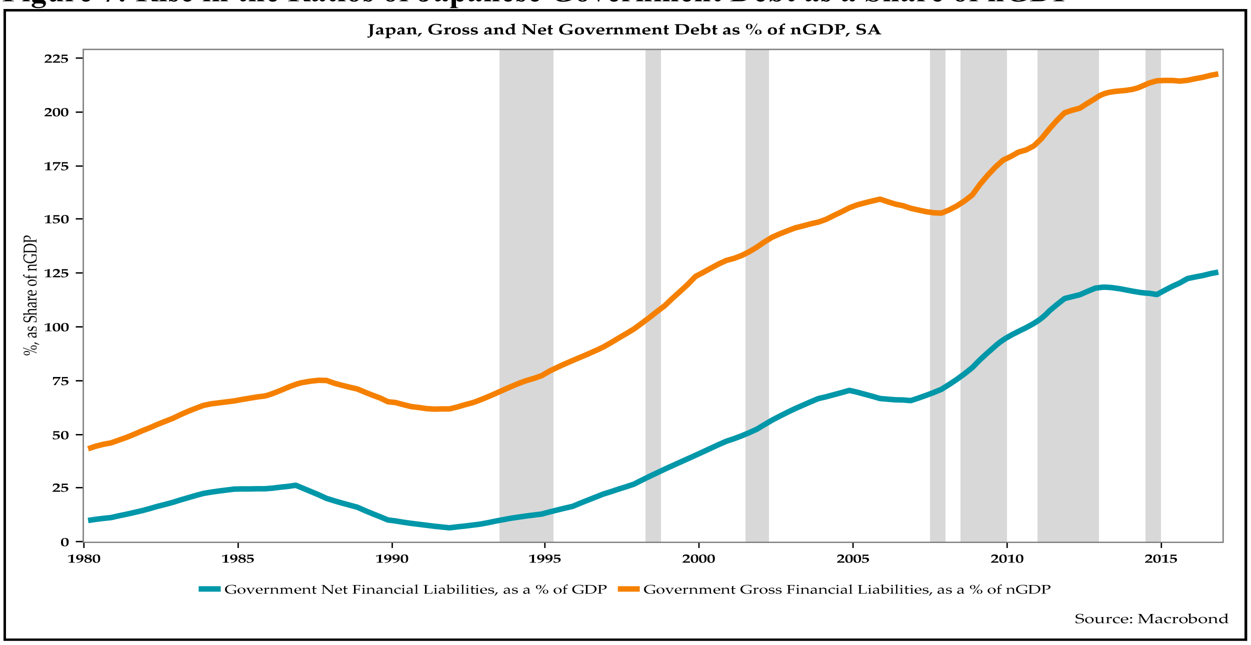


Figure 8: JGBs Are Primarily Held by Domestic Investors, Particularly Domestic Financial Institutions

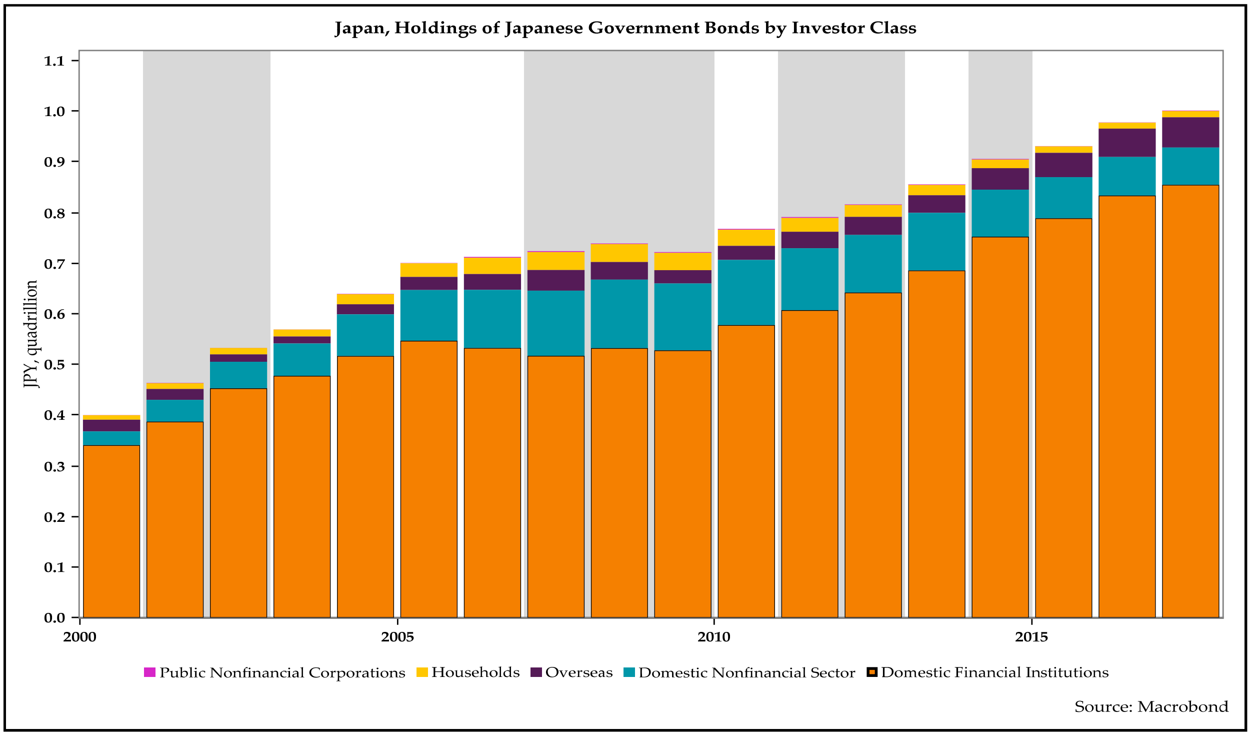


Figure 9: Holding of JGBs by Investor Class, Including the BoJ and Other Government Agencies

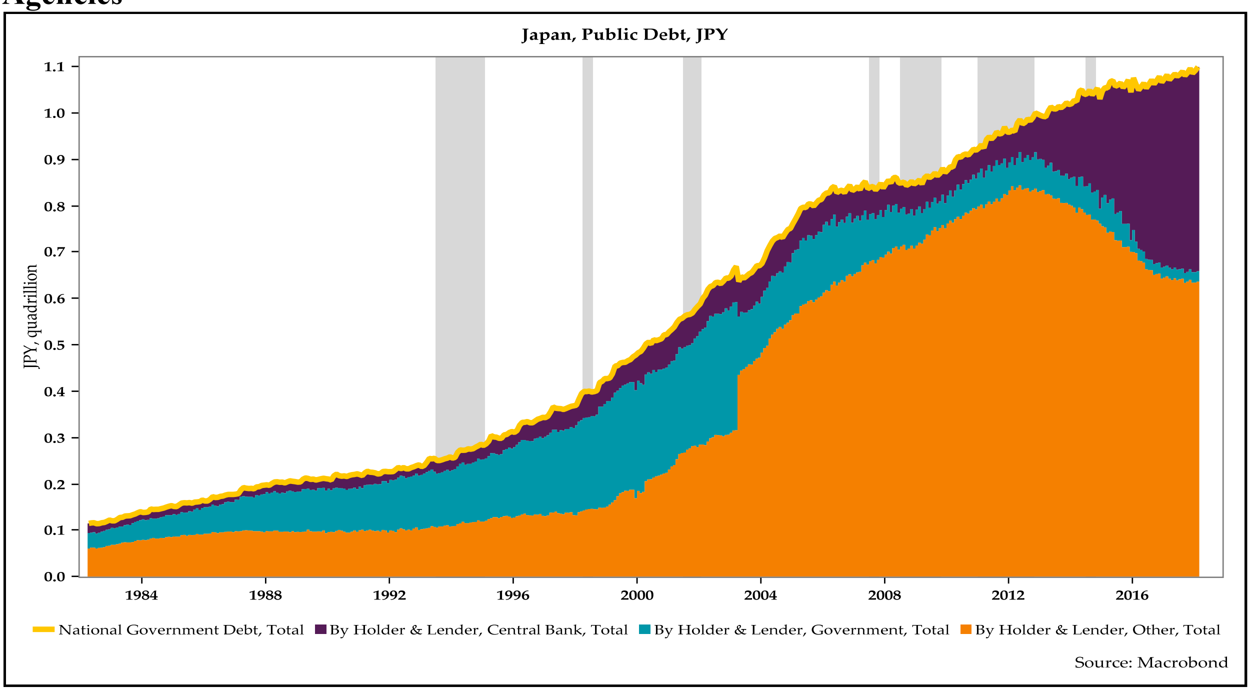
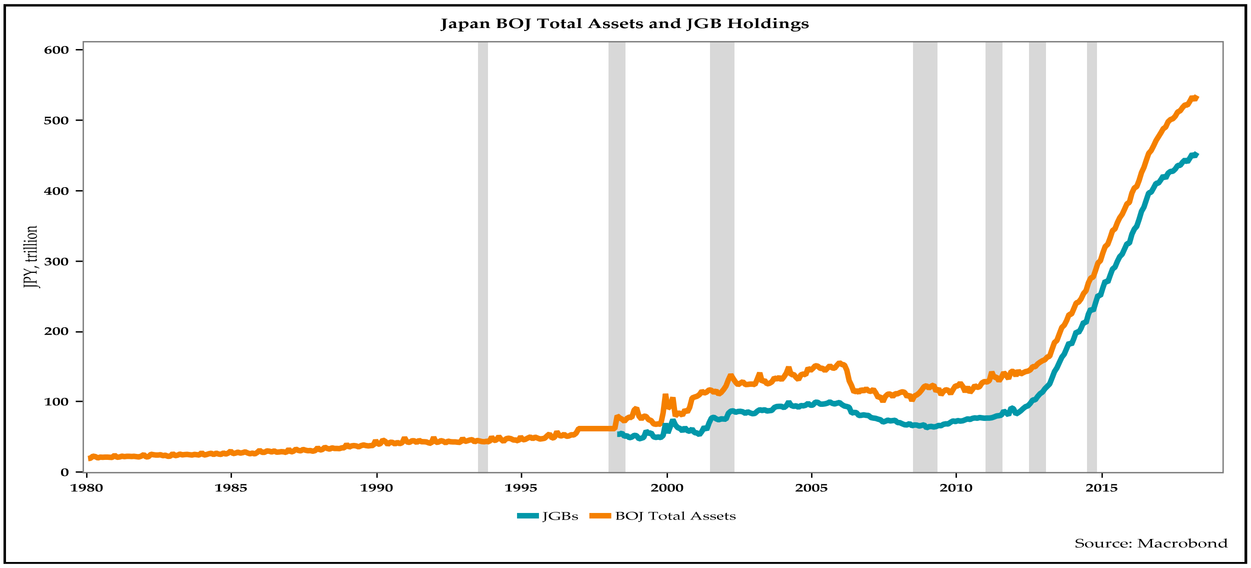
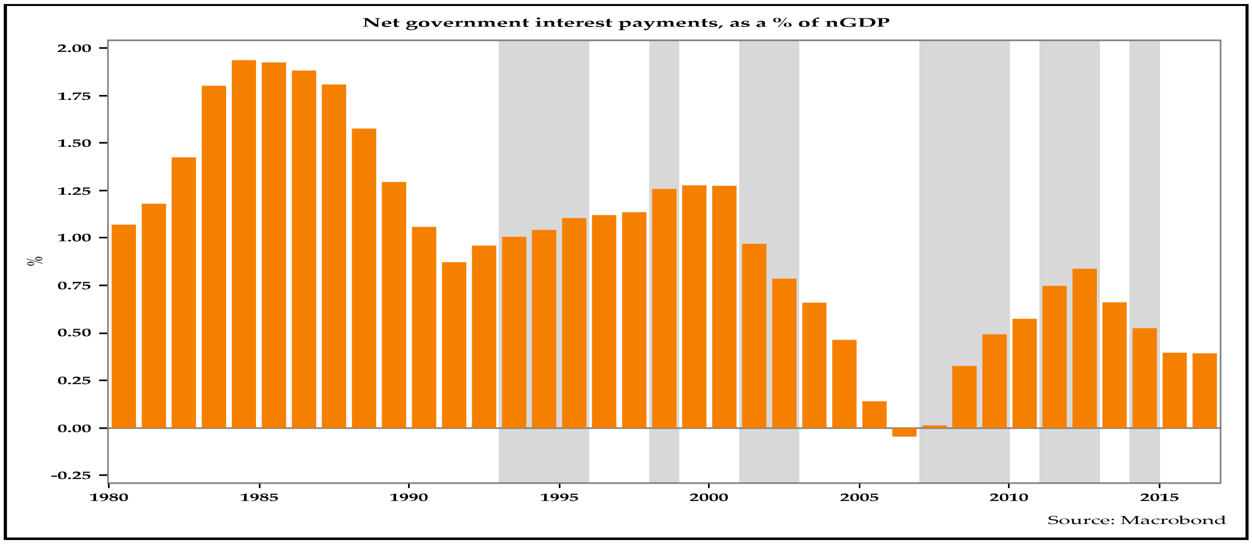


Figure 10: The BoJ's Holdings of JGBs Have Risen Sharply Due to the Rapid Expansion of its Balance Sheet



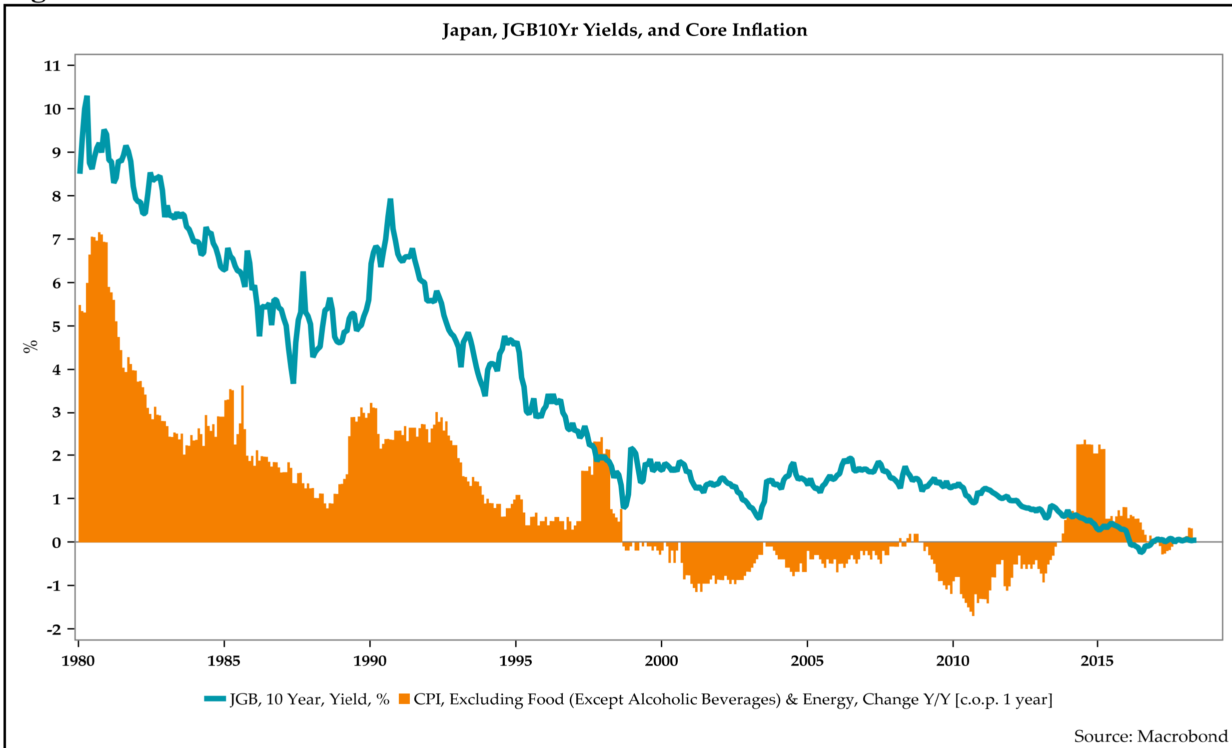
Even though Japan's government debt ratios are high and the country has run chronic primary/fiscal deficits for many years, net interest payments on government debt as a share of nGDP are low (figure 11) due to the low interest rate on government bonds, implying that the net interest income receipts of the nongovernment sectors are also low despite its substantial holdings of government debt.

Figure 11: Net Interest Payments on Government Debt, as a Share of nGDP, Are Fairly Low Due to Low Interest Rate on JGBs



Nominal yields on JGBs have been low in tandem with low core inflation and deflationary pressures (figure 12). As core inflation declined in the early 1980s, nominal yields on JGBs fell. With the increase in core inflation in the late 1980s, nominal yields on JGBs rose. This decline in core inflation resumed again beginning in the early 1990s. JGBs' nominal yields rose moderately just before the mid-1990s, but as Japan's asset bubbles burst, the decline in nominal yields continued. Bond investors ignored the temporary rise in core inflation due to higher taxes in the late 1990s. From the late 1990s until the global financial crisis, JGBs' nominal yields hovered in a range between 1 percent to 2 percent. This is a period in which Japan experienced deflationary pressures. After the global financial crisis, JGBs' nominal yields declined from around 2 percent to nearly zero, and the announcement of QQME led to a further decline in JGBs' nominal yields. Since the beginning of 2016, with the introduction of QQME with yield curve control, JGBs' nominal yields have turned negative.

Figure 12: Evolution of JGBs' Nominal Yields and the Rate of Core Inflation



There are some interesting empirical regularities in the relationship between the long-term interest rate and the short-term interest rate on government bonds. This is displayed in the figures below, using monthly data on the interest rate on short-term Treasury bills and nominal yields on long-term JGBs of various tensors. Figure 13 is a scatterplot of the year-over-year percentage point changes in the yields of JGBs of a 5-year tenor and 3-month Treasury bills. Figure 14 is a scatterplot of the year-over-year percentage point changes in the nominal yields of JGBs of a 5-year tenor and 3-month Treasury bills. Figure 15 is a scatterplot of the nominal yields JGBs of a 9-year tenor and 3-month Treasury bills. Figure 16 is a scatterplot of the year-over-year percentage point changes in the nominal yields of JGBs of a 9-year tenor and 3-month Treasury bills. The same relationships hold for nominal yields of government bonds of various tenors, though the relationship is stronger in the front end of the Treasury yield curve than it is at the back end of the yield curve.

Figure 13: Scatterplot of the Yields of 5-year JGBs and 3-month Treasury Bills

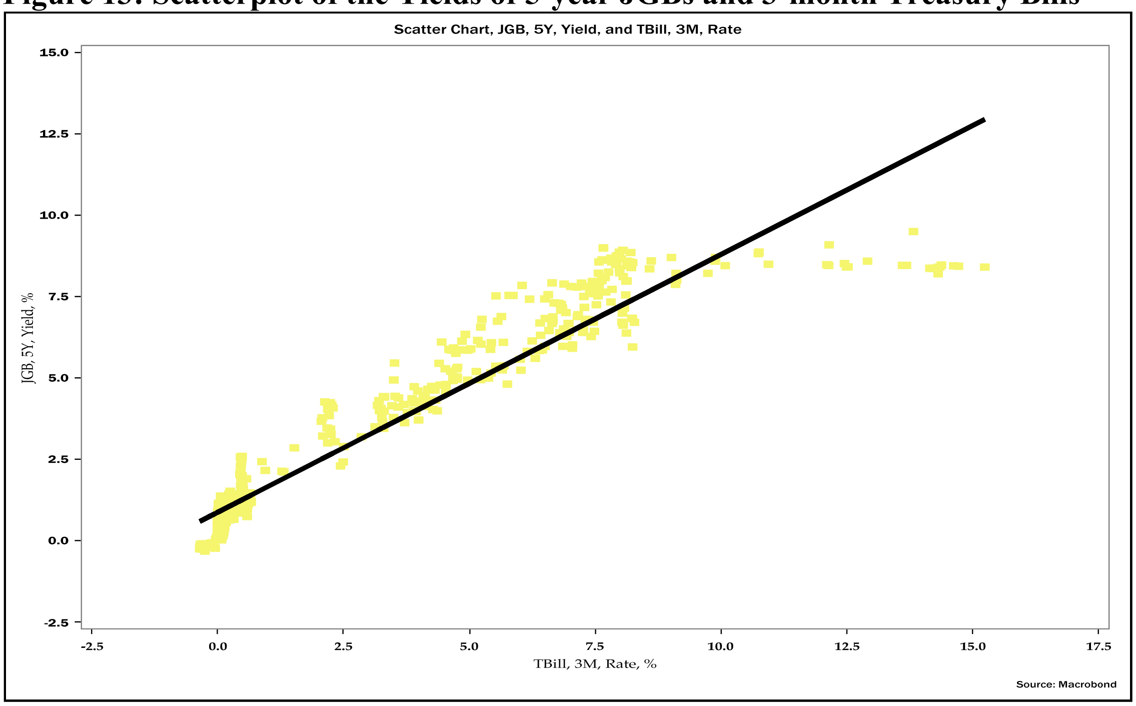


Figure 14: Scatterplot of Year-over-Year Percentage Point Changes in the Yields of 5-year JGBs and 3-month Treasury Bills

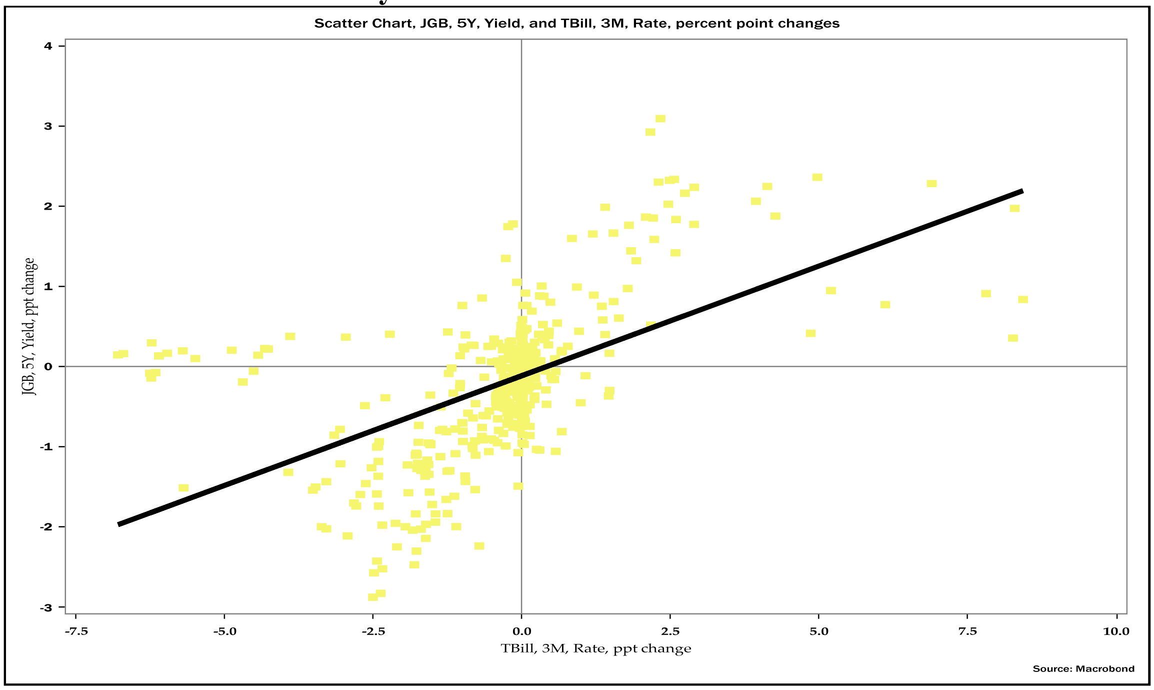


Figure 15: Scatterplot of the Yields of 9-year JGBs and 3-month Treasury Bills

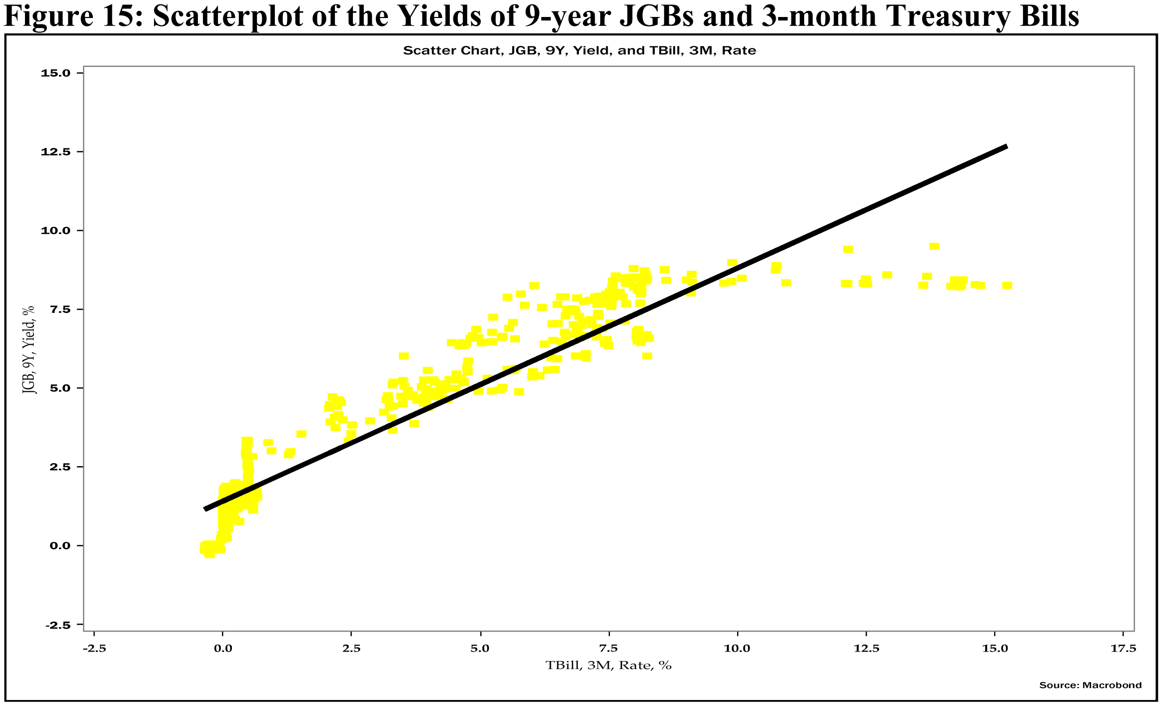
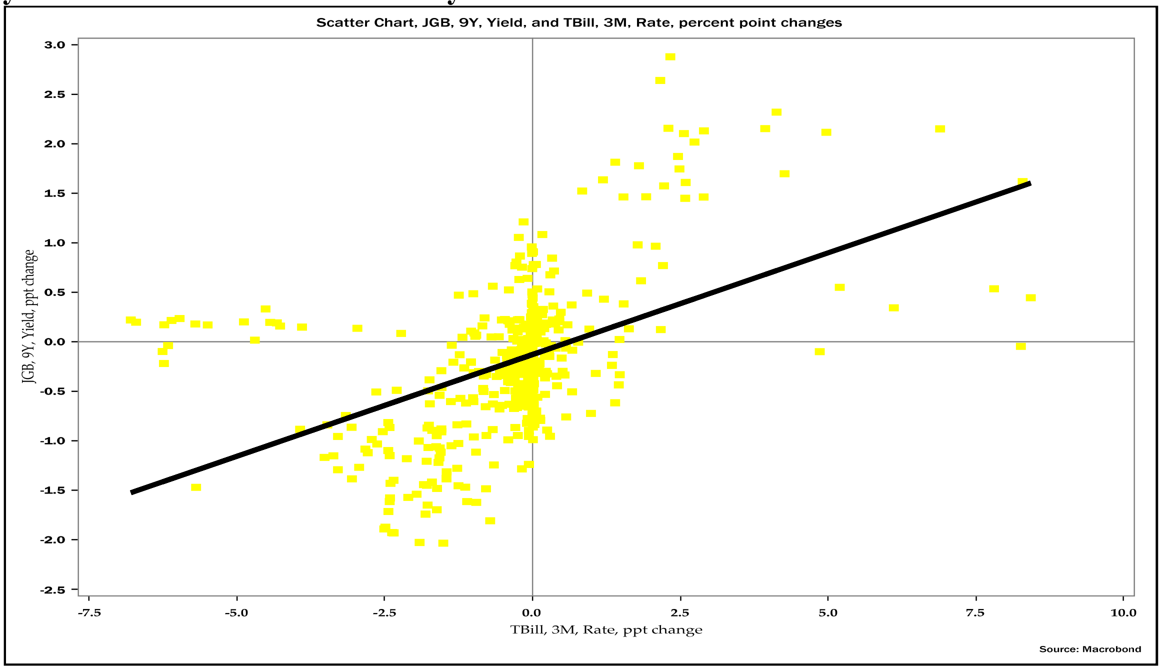


Figure 16: Scatterplot of the Year-over-Year Percentage Point Changes in the Yields of 9-year JGBs and 3-month Treasury Bills



These scatterplots suggest certain empirical regularities.[3] First, there are strong positive correlations between the long-term interest rate on JGBs and the short-term interest rate on Treasury bills. Second, there are also positive correlations between the year-over-year percentage point changes in the long-term interest rate of JGBs and the year-over-year percentage point changes in the short-term interest rate on Treasury bills during the same period. Third, the positive correlations between the levels of the nominal yields of JGBs and Treasury bills is much stronger than the positive correlation between the year-over-year percentage point changes in the nominal yields of JGBs and Treasury bills. Fourth, the strong positive correlations between the nominal yields on JGBs and Treasury bills decline as the maturity tenors of the bonds rise. Fifth, the positive correlations between the year-over-year percentage point changes in the nominal yields on JGBs and Treasury bills during the same period also decline as the maturity tenors of these securities increase.

[3] Additional scatterplots displaying: (1) the correlation between the yields of JGBs of other tenors (2, 3, 6, 7, 8, 10, 15, 20, 30, and 40 years) and the short-term interest rate on the 3-month Treasury bill, and (2) the correlation between the percentage point changes in the yields of JGBs of the same tenor and the percentage point change the short-term interest rate on the 3-month Treasury bill are available upon request.

III. DATA DESCRIPTION

This paper uses time-series macroeconomic and financial data. Quarterly data on macroeconomic and financial variables, such as the long-term interest rate, the short-term interest rate, the rate of core inflation, government fiscal ratio ratios, the pace of economic activity, and business cyclical conditions, are deployed.

Long-term interest rates are gathered from the nominal yields of JGBs of 2-, 3-, 5-, 7-, 8-, 9-, 10-, 15-, 20-, 25-, 30-, and 40-year tenors, as calibrated by Japan's Ministry of Finance. Short-term interest rates are obtained from the discount rate on Japanese government's Treasury bills of 3-month tenors.

Core inflation data are represented by two different measures. The first is measured by the year-over-year percentage change in the Consumer Price Index (CPI), excluding fresh food. The second is measured by the year-over-year percentage change in the CPI, excluding food and energy.

The pace of economic activity is measured by the year-over-year percentage change in the volume of industrial production.

Business cycle conditions are represented by whether the Japanese economy is in a recession or not, as represented by a dummy variable. It is set to one when the economy is in a recession and zero when it is not in a recession. A recession is defined as a period of economic slowdown marked by at least two successive quarters of decline in real GDP on a quarter-over-quarter basis.

Several different measures of government fiscal ratios are used. Fiscal balance ratios are measured in two different ways: (1) primary balance as a share of nGDP, and (2) government net lending/borrowing as a share of nGDP. A positive (negative) primary/fiscal balance implies a primary/fiscal surplus (deficit). Government debt ratios are also measured in two different manners: (1) gross government financial liabilities as a share of nGDP, and (2) net government financial liabilities as a share of nGDP.

Table 1 provides a summary of the data. The first column shows the label for each variable. The second column lists the variables' description and the time range for the data. The third column displays the original frequency and states whether the data has been converted to a lower frequency. The last column provides both the primary and secondary sources for the data.

Table 1: Summary of the Data

Variables	Data Description, Date Range	Frequency	Sources
Short-term interest rates			
TB3M_Q	Japanese government Treasury bill, 3 month, yield, % 1Q 1980 – 4Q 2016	Monthly; converted to quarterly	Macrobond
Japanese Government Bonds (JGBs) Yields			
JGB2Y_Q	Japanese government bond, 2 year, yield, %, 1Q 1980 – 4Q 2016	Daily; converted to quarterly	Ministry of Finance; Macrobond
JGB3Y_Q	Japanese government bond, 3 year, yield, %, 1Q 1980 – 4Q 2016	Daily; converted to quarterly	Ministry of Finance; Macrobond
JGB5Y_Q	Japanese government bond, 5 year, yield, %, 1Q 1980 – 4Q 2016	Daily; converted to quarterly	Ministry of Finance; Macrobond
JGB7Y_Q	Japanese government bond, 7 year, yield, %, 1Q 1980 – 4Q 2016	Daily; converted to quarterly	Ministry of Finance; Macrobond
JGB8Y_Q	Japanese government bond, 8 year, yield, %, 1Q 1980 – 4Q 2016	Daily; converted to quarterly	Ministry of Finance; Macrobond
JGB9Y_Q	Japanese government bond, 9 year, yield, %, 1Q 1980 – 4Q 2016	Daily; converted to quarterly	Ministry of Finance; Macrobond
JGB10Y_Q	Japanese government bond, 10 year, yield, %, 4Q 1986 – 4Q 2016	Daily; converted to quarterly	Ministry of Finance; Macrobond
JGB15Y_Q	Japanese government bond, 15 year, yield, %, 4Q 1991 – 4Q 2016	Daily; converted to quarterly	Ministry of Finance; Macrobond
JGB20Y_Q	Japanese government bond, 20 year, yield, %, 1Q 1987 – 4Q 2016	Daily; converted to quarterly	Ministry of Finance; Macrobond
JGB25Y_Q	Japanese government bond, 25 year, yield, %, 2Q 2004 – 4Q 2016	Daily; converted to quarterly	Ministry of Finance; Macrobond
JGB30Y_Q	Japanese government bond, 30 year, yield, %, 4Q 1999 – 4Q 2016	Daily; converted to quarterly	Ministry of Finance; Macrobond
JGB40Y_Q	Japanese government bond, 40 year, yield, %, 1Q 2007 – 4Q 2016	Daily; converted to quarterly	Ministry of Finance; Macrobond
Rate of Core Inflation			
CCPI_Q	Consumer price index, excluding fresh food, y/y, %, 1Q 1980 – Dec 2016	Monthly; converted to quarterly	Japanese Statistics Bureau; Macrobond
CINFL_Q	Consumer price index, excluding food & energy, y/y, %, 1Q 1980 – 4Q 2016	Monthly; converted to quarterly	Japanese Statistics Bureau; Macrobond

Variables	Data Description, Date Range	Frequency	Sources
Pace of Economic Activity			
IP_Q	Industrial production, constant prices, SA, index, y/y, % 1Q 1980 – 4Q 20016	Monthly; converted to quarterly	Ministry of Economy, Trade, and Industry; Macrobond
Government Fiscal Ratios			
PBAL_Q	Government primary balance, % of nGDP, 1Q 1980 – 4Q 2016	Quarterly	OECD Economic Outlook; Macrobond
FBAL_Q	Government net lending/borrowing, % of nGDP, 1Q 1980 – 4Q 2016	Quarterly	OECD Economic Outlook; Macrobond
GDEBT_Q	Government gross financial liabilities, % of nGDP, 1Q 1980 – 4Q 2016	Quarterly	OECD Economic Outlook; Macrobond
NDEBT_Q	Government net financial liabilities, % of nGDP, 1Q 1980 – 4Q 2016	Quarterly	OECD Economic Outlook; Macrobond
Business Cycle Conditions			
RECN_Q	Recession dummy, 1 = Recession, 0 = No recession, 1Q 1980 – 4Q 2016	Monthly; converted to quarterly	Macrobond

IV. EMPIRICAL ANALYSIS

4.1 Model Specification

The vector error correction (VEC) framework, as developed by Johansen (1988, 1991,1995), is appropriate for the present analysis, since the variables of interest are cointegrated. (It will be shown later that the variables in the model are cointegrated.) Johansen's VEC framework has cointegration relations built into the specification. It restricts the long-run behavior of the endogenous variables to converge to their cointegrating relationships while allowing for short-run adjustment dynamics. The dynamic relations between the variables—the long-term interest rate, the short-term interest rate, the rate of inflation, and the government fiscal ratio—are examined using the VEC framework.

Consider a vector autoegression (VAR) model, adapted to the VEC framework, as given below:

$$\Delta Z_t = \Gamma_1 \Delta Z_{t-1} + \ldots + \Gamma_{p-t} \Delta Z_{t-p+1} + \alpha\beta' Z_{t-p} + \nu + e_t \quad (1)$$

where

- $Z_t =$ (long-term interest rate, short-term interest rate)′ (model 1),
- $Z_t =$ (long-term interest rate, short-term interest rate, inflation rate)′ (model 2), or
- $Z_t =$ (long-term interest rate, short-term interest rate, inflation rate, government fiscal ratio)′ (model 3).

Here, $\alpha\beta' Z_{t-p}$ is the error correction component; α is an ($n \times r$) matrix that explains long-run disequilibrium; β is an ($n \times r$) matrix of cointegrating vectors that explains the long-run relationships; $\Gamma_j \Delta Z_{t-j}$ is the vector autoregressive component in the first difference; Γ_j is an ($n \times n$) matrix that stands for the short-term adjustment coefficients between variables with *p-1* number of lags; ν is a deterministic shift vector; and the model residual e_t is white noise.

4.2 Model Estimation and Analysis

The model estimation and analysis consists of several steps. First, unit root tests are conducted for each series and its first difference. Second, given that one cannot reject the null hypothesis of nonstationary variables, tests are conducted to determine whether the variables are cointegrated or not, and, if so, to determine the number of cointegrating vectors in the system. Third, tests are carried out to detect structural breaks. Fourth, several multivariate VEC models are estimated. Fifth, the results are interpreted. Sixth, impulse response analysis is provided. Finally, stability tests are carried out to assess the constancy of the estimated coefficients.

4.2.1 Unit Root Tests

Unit root tests are conducted in order to determine the univariate properties of the following variables and their first differences: nominal yields of Japan's Treasury bills of a 3-month tenor; yields of Treasury securities of 5-year and 9-year tenors; core CPI (excluding food and energy inflation); growth in the seasonally adjusted measure of the index of industrial production; the government primary balance as a percentage of nGDP; and government net financial liabilities as a percentage of nGDP.[4] The results are presented in tables 2A and 2B.

[4] Unit roots tests are also conducted on additional variables and their first differences. The results of the unit root tests on the nominal yields of JGBs of other tenors (2, 3, 6, 7, 8, 10, 15, 20, 25, 30, and 40 years) are consistent with

Table 2A displays the unit roots tests for the levels of the variables. It is evident from table 2A that the calculated augmented Dickey–Fuller (ADF) tests (Dickey and Fuller 1979, 1981) show that the test statistics are less than their critical values in all cases. The only exception is the growth rate of industrial production (IP_Q), which rejects the null hypothesis of a unit root in levels at 1 percent significance for all the specifications. Similarly, based on the Phillips–Perron (PP) tests (Phillips and Perron 1988), except for the growth rate of industrial production, in all other cases the null hypothesis of a unit root cannot be rejected.

Table 2B displays the same tests for the first difference of the variables. It shows that for the first difference of all the variables (other than the above-mentioned growth rate of industrial production) the null hypothesis of a unit root is significantly rejected. Thus, it can be concluded that except for the growth rate of industrial production, all the other series are integrated of the first order, I(1), series.

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the nominal yields of JGBs of 5-year and 9-year tenors. The results of the unit root tests on the total CPI (excluding fresh food) are consistent with core CPI inflation. The results of the unit root tests on Japanese government net lending as a percentage of nGDP and Japanese government gross financial liabilities as a percentage of nGDP are consistent with the Japanese government primary balance as a percentage of nGDP, and Japanese government net financial liabilities as a percentage of nGDP. These additional results are provided in the appendix; see tables A1 and A2.

Table 2A: Unit Root Tests (Level)

Unit Root Tests (Level)					
Variable		**Tests**	**Statistic**	**P-value**	**Obs.**
JGB5Y_Q	Trend	ADF	-2.401	0.379	147
		PP	-2.280	0.445	147
	No trend	ADF	-1.951	0.027	147
		PP	-1.974	0.296	147
	No trend, No constant	ADF	-2.597	0.010	147
		PP	-2.803	0.005	147
JGB9Y_Q	Trend	ADF	-2.890	0.166	147
		PP	-2.707	0.233	147
	No trend	ADF	-1.957	0.026	147
		PP	-2.007	0.283	147
	No trend, No constant	ADF	-2.675	0.008	147
		PP	-3.040	0.003	147
TB3M_Q	Trend	ADF	-1.470	0.839	147
		PP	-2.149	0.519	147
	No trend	ADF	-1.731	0.042	147
		PP	-1.807	0.377	147
	No trend, No constant	ADF	-1.645	0.095	147
		PP	-2.162	0.030	147
CINFL_Q	Trend	ADF	-2.537	0.283	147
		PP	-2.739	0.220	147
	No trend	ADF	-2.508	0.007	147
		PP	-2.554	0.103	147
	No trend, No constant	ADF	-2.196	0.028	147
		PP	-2.701	0.007	147
IP_Q	Trend	ADF	-4.882	0.000	147
		PP	-5.193	0.000	147
	No trend	ADF	-4.861	0.000	147
		PP	-5.165	0.000	147
	No trend, No constant	ADF	-4.806	0.000	147
		PP	-5.108	0.000	147
PBAL_Q	Trend	ADF	-1.952	0.627	147
		PP	-2.646	0.259	147
	No trend	ADF	-1.241	0.108	147
		PP	-1.869	0.347	147
	No trend, No constant	ADF	-0.500	0.494	147
		PP	-0.759	0.383	147
NDEBT_Q	Trend	ADF	-1.153	0.920	147
		PP	-1.258	0.898	147
	No trend	ADF	2.789	0.997	147
		PP	1.111	0.995	147
	No trend, No constant	ADF	0.863	0.893	147
		PP	2.293	0.994	147

Note 1: The ADF and PP test critical values are:
1 percent: -4.024; 5 percent: -3.444; 10 percent: -3.144 (trend)
1 percent: -3.494; 5 percent: -2.887; 10 percent: -2.577 (no trend)
1 percent: -2.594; 5 percent: -1.950; 10 percent: -1.613 (no trend, no constant)
Note 2: PP test, ADF test (H_0: series has a unit root).

Table 2B: Unit Root Tests (First Differences)

Unit Root Tests (First Difference)					
Variable		**Tests**	**Statistic**	**P-value**	**Obs.**
ΔJGB5Y_Q	Trend	ADF	-13.892	0.000	146
		PP	-13.961	0.000	146
	No trend	ADF	-13.868	0.000	146
		PP	-13.914	0.000	146
	No trend, No constant	ADF	-13.654	0.000	146
		PP	-13.615	0.000	146
ΔJGB9Y_Q	Trend	ADF	-14.543	0.000	146
		PP	-14.864	0.000	146
	No trend	ADF	-14.547	0.000	146
		PP	-14.839	0.000	146
	No trend, No constant	ADF	-14.279	0.000	146
		PP	-14.376	0.000	146
ΔTB3M_Q	Trend	ADF	-14.580	0.000	146
		PP	-14.465	0.000	146
	No trend	ADF	-14.544	0.000	146
		PP	-14.467	0.000	146
	No trend, No constant	ADF	-14.470	0.000	146
		PP	-14.430	0.000	146
ΔCINFL_Q	Trend	ADF	-11.153	0.000	146
		PP	-11.154	0.000	146
	No trend	ADF	-10.987	0.000	146
		PP	-11.005	0.000	146
	No trend, No constant	ADF	-10.900	0.000	146
		PP	-10.926	0.000	146
ΔIP_Q	Trend	ADF	-10.085	0.000	146
		PP	-9.924	0.000	146
	No trend	ADF	-10.117	0.000	146
		PP	-9.962	0.000	146
	No trend, No constant	ADF	-10.152	0.000	146
		PP	-10.003	0.000	146
ΔPBAL_Q	Trend	ADF	-5.491	0.000	146
		PP	-5.706	0.000	146
	No trend	ADF	-5.506	0.000	146
		PP	-5.719	0.000	146
	No trend, No constant	ADF	-5.523	0.000	146
		PP	-5.736	0.000	146
ΔNDEBT_Q	Trend	ADF	-2.893	0.165	146
		PP	-3.159	0.093	146
	No trend	ADF	-2.780	0.003	146
		PP	-3.023	0.033	146
	No trend, No constant	ADF	-1.675	0.089	146
		PP	-1.820	0.066	146

Note 1: The ADF and PP test critical values are:
1 percent: -4.024; 5 percent: -3.444; 10 percent: -3.144 (trend)
1 percent: -3.494; 5 percent: -2.887; 10 percent: -2.577 (no trend)
1 percent: -2.594; 5 percent: -1.950; 10 percent: -1.613 (no trend, no constant)
Note 2: PP test, ADF test (H_0: series has a unit root).

4.2.2 Cointegration Test

Johansen and Juselius's (1990) method for the cointergation test is used to determine whether there is a stable, long-run relationship between the short-term interest rate, the rate of core inflation rate, the government fiscal ratio, and the long-term interest rate.[5]

To analyze the cointegration relationships between the variables, eleven VAR models are defined. These are as follows:

- (JGB9Y_Q, TB3M_Q)
- (JGB9Y_Q, CINFL_Q)
- (JGB9Y_Q, PBAL_Q)
- (JGB9Y_Q, NDEBT_Q)
- (JGB9Y_Q, PBAL_Q, CINFL_Q)
- (JGB9Y_Q, NDEBT_Q, CINFL_Q)
- (JGB9Y_Q, TB3M_Q, CINFL_Q)
- (JGB9Y_Q, TB3M_Q, PBAL_Q)
- (JGB9Y_Q, TB3M_Q, NDEBT_Q)
- (JGB9Y_Q, TB3M_Q, PBAL_Q, CINFL_Q)
- (JGB9Y_Q, TB3M_Q, NDEBT_Q, CINFL_Q)

Table 3 presents test statistics for determining whether there is a long-run relationship in any of these models. The results, based on VARs, are generally found to be sensitive to the lag length used and the ordering of the variables. Thus, lag lengths are chosen by Akaike's information criterion (AIC) before determining the number of cointegrating vectors.

The Johansen cointegration test compares both trace and likelihood eigenvalue statistics to their critical values. The null hypothesis is that there is no significant difference between log likelihood of the unconstrained model with the cointegrating equations and log likelihood of the constrained model that does not include the cointegrating equations.

[5] Since the growth rate of industrial production is a stationary variable, it is not included in the cointegration test.

The test starts from the model with no cointegration and then continues with one, two, or three cointegrating vectors until it finds the first model in which the null hypothesis of no cointegrating vector cannot be rejected. For instance, in the case of (JGB9Y_Q, TB3M_Q, NDEBT_Q, CINFL_Q), the trace statistic at r=0 of 105.8183 exceeds its critical value of 54.4600. Hence, the null hypothesis of no cointegrating equations is rejected. The trace statistic at r=1 of 31.3107 is less than the critical value of 35.6500 at the 10 percent level of significance; hence, the null hypothesis that there is one cointegrating vector in the system cannot be rejected.

The maximum eigenvalue test provides more conclusive evidence regarding the exact number of cointegrating vectors in the system.

Based on the results from test statistics displayed in table 3, it may appear that there is no cointegrating equation in most of those models. However, standard cointegration techniques are biased toward accepting the null hypothesis of no cointegration in the presence of structural breaks. Hence, the potential structural breaks are identified using Gregory and Hansen’s (1996) cointegration test.

Table 3: Multivariate Cointegration Tests

Multivariate Cointegration Tests					
Trace Test			Maximum Eigenvalue Test		
Null Hypo.	Test Statistic	1% Critical Value	Null Hypo.	Test Statistic	1% Critical Value
(JGB9Y_Q, TB3M_Q); AIC lag-order=7					
r=0	14.8942*	20.04	r=0	10.5086*	18.63
r#1	4.3857	6.65	r#1	4.3857	6.65
(JGB9Y_Q, INFL_Q); AIC lag-order=1					
r=0	14.2206*	20.04	r=0	10.5272*	18.63
r#1	3.6935	6.65	r#1	3.6935	6.65
(JGB9Y_Q, PBAL_Q); AIC lag-order=7					
r=0	13.8918*	20.04	r=0	11.7198*	18.63
r#1	2.1720	6.65	r#1	2.1720	6.65
(JGB9Y_Q, NDEBT_Q); AIC lag-order=3					
r=0	10.2008*	20.04	r=0	9.3877*	18.63
r#1	1.9821	6.650	r#1	1.9821	6.65
(JGB9Y_Q, PBAL_Q, CINFL_Q); AIC lag-order=7					
r=0	31.2602*	35.65	r=0	19.8544*	25.52
r#1	11.4058	20.04	r#1	9.4609	18.63
r#2	1.9449	6.65	r#2	1.9449	6.65
(JGB9Y_Q, NDEBT_Q, CINFL_Q); AIC lag-order=2					
r=0	34.5244*	35.65	r=0	24.2136*	25.52
r#1	7.3108	20.04	r#1	7.0244	18.63
r#2	0.2686	6.65	r#2	0.2686	6.65
(JGB9Y_Q, TB3M_Q, CINFL_Q); AIC lag-order=5					
r=0	26.9784*	35.65	r=0	15.5392*	25.52
r#1	11.4392	20.04	r#1	9.3247	18.63
r#2	2.1145	6.65	r#2	2.1145	6.65
(JGB9Y_Q, TB3M_Q, PBAL_Q); AIC lag-order=7					
r=0	22.8301*	35.65	r=0	12.3581*	25.52
r#1	10.4720	20.04	r#1	8.2857	18.63
r#2	2.1864	6.65	r#2	2.1864	6.65
(JGB9Y_Q, TB3M_Q, NDEBT_Q); AIC lag-order=4					
r=0	34.6566*	35.65	r=0	22.1158*	25.52
r#1	7.5408	20.04	r#1	7.5204	18.63
r#2	0.2903	6.65	r#2	0.2903	6.65
(JGB9Y_Q, TB3M_Q, PBAL_Q, CINFL_Q); AIC lag-order=8					
r=0	38.6451*	54.46	r=0	15.8547*	32.24
r#1	22.7905	35.65	r#1	12.3776	25.52
r#2	10.4129	20.04	r#2	8.624	18.63
r#3	1.7889	6.65	r#3	1.7889	6.65
(JGB9Y_Q, TB3M_Q, NDEBT_Q, CINFL_Q); AIC lag-order=3					
r=0	105.8183	54.46	r=0	74.5076	32.24
r#1	31.3107*	35.65	r#1	22.4918*	25.52
r#2	8.8190	20.04	r#2	8.2336	18.63
r#3	0.5900	6.65	r#3	0.5854	6.65

Note 1: r denotes the number of cointegrated vectors. **Note 2:** Lag lengths were chosen by AIC.
Note 3: * Significance at the 10 percent level. **Note 4:** The test results of the number of cointegrated vectors from the model with JGB5Y_Q are the same as the model with JGB9Y_Q and are available upon request.

4.2.3 Testing for Structural Breaks

Gregory and Hansen's (1996) cointegration test is used for detecting structural breaks. It extends Engle and Granger's (1987) procedure by allowing a structural break in either the intercept or the intercept and the cointegrating coefficient. The advantage of the Gregory–Hansen test is that it allows for a one-time endogenously determined structural break in the cointegrating vector.

Three different models of (JGB9Y_Q, TB3M_Q, PBAL_Q, CINFL_Q) and (JGB9Y_Q, TB3M_Q, NDEBT_Q, CINFL_Q) are tested for structural breaks. These models are as follows:

(i) *Model C* allows for cointegration with a change in intercept only;
(ii) *Model C/T* includes a time trend into shift; and
(iii) *Model C/S* takes into consideration the simultaneous presence of both a mean and slope break.

Each of these models has a dummy variable that is determined endogenously to allow for a structural break. The dummy is zero before a breakpoint and one afterwards. The null hypothesis in all three models is that the residuals are nonstationary. The alternative hypothesis is that the residuals are stationary with one structural break at an unknown time. The unit root tests (ADF test with ADF statistic, and PP test with Zt statistic and Za statistic) on the residuals obtained from those models are used to choose the breakpoints associated with the smallest values of the unit root statistics. Asymptotic critical values are provided by Gregory and Hansen (1996).

Table 4 shows that the null hypothesis of no cointegration is rejected by most models. This is in contrast to the results presented earlier in table 3. The findings from conducting the Gregory–Hansen test imply that a structural change is present in the long-run cointegration equation. This finding supports the conjecture that a bias toward the null hypothesis of no cointegration may arise from Johansen cointegration tests.

Two dates for structural breaks are detected. These occur on 1985Q2 and 1997Q3 for most of the cases. Those two structural breaks roughly coincide with two major economic and financial events, relevant for the financial markets and JGBs' nominal yields. The 1985Q2 structural break is associated with the emergence of the bubble economy in Japan in the mid-1980s (Akram 2014, 2016; Garside 2012). The 1997Q3 structural break is related to the outbreak of the East Asian financial crisis in June 1997 (Radalet and Sachs 1998).

Table 4: Gregory–Hansen Cointegration Tests for Regime Shifts

Gregory–Hansen Cointegration Tests for Regime Shifts (Models with JGB9Y_Q and NDEBT_Q)				
	(JGB9Y_Q, TB3M_Q, PBAL_Q, CINFL_Q)		(JGB9Y_Q, TB3M_Q, NDEBT_Q, CINFL_Q)	
	Test Stat.	Breakpoint	Test Stat.	Breakpoint
ADF				
Model C	-4.28	1999Q2	-3.91	1997Q4
Model C/T	-7.04***	2004Q4	-4.56***	1985Q2
Model C/S	-8.38***	1985Q2	-8.66***	1986Q1
Zt				
Model C	-6.57***	1997Q3	-6.52***	1997Q3
Model C/T	-6.65***	1997Q4	-6.81***	1985Q2
Model C/S	-8.41***	1985Q2	-8.69***	1986Q1
Za				
Model C	-66.43***	1997Q3	-66.04***	1997Q3
Model C/T	-67.74***	1997Q4	-70.62***	1985Q2
Model C/S	-96.71***	1985Q2	-100.51***	1986Q1

Note 1: *** implies significance at the 1 percent level.
Note 2: The model specifications are denoted by C-level shift, C/T-level shift with a trend, C/T-regime trend.
Note 3: Critical values are taken from Gregory and Hansen (1996).
Note 4: The results of models with JGB5Y_Q and models with PBAL_Q are similar and available upon request.

In table 5, the modified Chow break test, as proposed by Shehata (2011), is applied on those two structural break dates (1985Q2 and 1997Q3) separately. This methodology provides three types of regressions, which are as follows: (1) independent variable (X) with a dummy; (2) X with each X multiplied with a dummy; and (3) X with both a dummy and each X multiplied with a dummy. The dummy is zero before a breakpoint and one afterwards. As shown in table 5, for all types of regression, the Chow test statistics are quite large and with p-values near zero. Thus, the Chow break test results suggest rejecting the null hypothesis of no structural breaks for both dates specified.

Incorporating these two structural breaks in the model shows evidence of cointegration between the long-term interest rate, the short-term interest rate, the rate of core inflation, and the government fiscal ratio. The break in 1985Q2 captures the emergence of the bubble economy in Japan, while the break in 1997Q3 captures the onset of the East Asian financial crisis. Incorporating these two breaks shows strong evidence of cointegration in models of (JGB9Y_Q, TB3M_Q, PBAL_Q, CINFL_Q) and (JGB9Y_Q, TB3M_Q, NDEBT_Q, CINF_Q) at the 1 percent significance level.

Table 5: Chow Test and Structural Change Regressions

Chow Test and Structural Change Regressions						
	(JGB9Y_Q, TB3M_Q, CINFL_Q, NDEBT_Q)					
	DUM1985q2			DUM1998q3		
	Chow test_1	Chow test_2	Chow test_3	Chow test_1	Chow test_2	Chow test_3
TB3M_Q	0.588***	0.399***	0.106	0.651***	0.654***	0.661***
	[0.05]	[0.09]	[0.09]	[0.03]	[0.04]	[0.04]
CINFL_Q	-0.128*	0.033	-0.241*	-0.181***	-0.188**	-0.229***
	[0.07]	[0.15]	[0.14]	[0.06]	[0.09]	[0.08]
NDEBT_Q	0.17***	0.055***	-0.121***	-0.012***	0.001	-0.002
	[0.02]	[0.014]	[0.03]	[0.00]	[0.007]	[0.009]
CONSTANT	3.734***	3.068***	10.62***	2.085***	2.511***	2.713***
	[0.39]	[0.15]	[1.07]	[0.13]	[0.19]	[0.27]
DUM	-1.512***		-7.67***	-0.757***		-0.691*
	[0.39]		[1.07]	[0.21]		[0.38]
DUM*TB3M_Q		0.134	0.445***		0.088	0.259
		[0.10]	[0.1]		[0.34]	[0.33]
DUM*CINFL_Q		-0.125	0.157		0.062	0.118
		[0.17]	[0.15]		[0.28]	[0.33]
DUM*NDEBT_Q		-0.074***	0.104***		-0.016***	-0.009
		[0.014]	[0.03]		[0.00]	[0.01]
Obs.	148	148	148	148	148	148
Adj R-squared	0.932	0.969	0.978	0.911	0.934	0.922
Chow test statistics	28.55	18.46	30.21	12.16	8.26	4.85
P-value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002

Note 1: *, **, *** implies significance at the 10 percent, 5 percent, and 1 percent level, respectively.
Note 2: Chow test types: (1) Y=X+DUM; (2) Y=X+DX; (3) Y=X+DUM+DX, where: DUM=dummy variable (0, 1), takes (0) in first period, and (1) in second period. DX=cross product of each xi times in DUM.
Note 3: The results of model with PBAL_Q are similar and available upon request.

4.2.4 Vector Error Correction (VEC) Models

Table 6 presents the estimation of the three models specified earlier:

- $Z_t =$ (long-term interest rate, short-term interest rate)′ (model 1),
- $Z_t =$ (long-term interest rate, short-term interest rate, inflation rate)′ (model 2), and
- $Z_t =$ (long-term interest rate, short-term interest rate, inflation rate, government finance)′ (model 3).[6]

In model 1, the long-term interest rate is regressed only on the short-term interest rate. The coefficient is highly significant and suggests that an increase in the short-term interest rate by 1 percentage point increases the long-term interest rate by 76.8 basis points. The addition of the other variables, one by one, leaves the coefficients on the short-term interest rate always highly significant, but its size changes across different models (from 0.558 to 0.999).

The diagnostic tests are performed to check for signs of misspecification, such as serial correlation or non-normality.

First, the Breusch–Godfrey Lagrange multiplier test of serial correlation in the residuals is implemented. The results show that the null hypothesis (that there is no serial correlation) cannot be rejected for model 3 with NDEBT_Q and model 3′ with NDEBT_Q (with P-values>0.1). Since in cointegration analysis the data has been corrected for the unit root, serial correlation is not a serious problem.

Second, the skewness statistics to test the null hypothesis that the residuals are normally distributed are computed. The results of the skewness test show that the residuals are normally distributed in $Z_t =$ (long-term interest rate, short-term interest rate, inflation rate, and government finance)′ (model 3).

[6] Model 1′, model 2′, and model 3′ use JGB5Y_Q instead of JGB9Y_Q. Additional results using nominal yields of JGBs of other tenors (2, 3, 6, 7, 8, 10, 15, 20, 25, 30, and 40 years) are consistent with the result obtained here. Tables with additional results (appendix tables A3 and A4) are available upon request.

Table 6: Johansen VEC Model

Johansen VEC Model								
	Model 1	Model 2	Model 3		Model 1′	Model 2′	Model 3′	
Dummy variables								
Long-run relationship	JGB9Y_Q				JGB5Y_Q			
TB3M_Q	-0.768***	-0.766***	-0.668***	-0.558***	-0.999***	-0.752***	-0.759***	-0.723***
	[0.05]	[0.05]	[0.03]	[0.10]	[0.08]	[0.07]	[0.03]	[0.05]
CINFL_Q		0.192**	0.154***	-0.884***		-0.4***	0.077	0.318***
		[0.08]	[0.05]	[0.17]		[0.1]	[0.05]	[0.07]
NDEBT_Q			0.012***				0.008***	
			[0.00]				[0.00]	
PBAL_Q				-0.136**				-0.067**
				[0.06]				[0.03]
CONSTANT	-2.307	-2.806	-3.542	-6.329	-0.453	-0.634	-2.308	-2.972
Error correction terms (ECT)								
Eq. JGB9Y_Q	-0.082	-0.125**	-0.207***	-0.104*				
	[0.05]	[0.06]	[0.07]	[0.06]				
Eq. JGB5Y_Q					-0.039	-0.104***	-0.196***	-0.223***
					[0.03]	[0.04]	[0.07]	[0.07]
Eq. TB3M_Q	0.309***	0.381***	0.513***	-0.116*	0.142***	0.133**	0.511***	-0.34
	[0.05]	[0.06]	[0.07]	[0.07]	[0.05]	[0.06]	[0.06]	[0.25]
Eq. CINFL_Q		-0.02	0.01	-0.292***		0.002	0.01	-0.239***
		[0.06]	[0.08]	[0.06]		[0.02]	[0.07]	[0.07]
Eq. NDEBT_Q			-0.072				0.073	
			[0.13]				[0.09]	
Eq. PBAL_Q				0.068				0.138
				[0.13]				[0.12]
Diagnostics								
Obs.	142	144	147	141	142	144	147	141
Lags	6	4	1	7	6	4	1	7
AIC	1.851	2.913	4.543	5.732	2.938	3.109	4.554	5.777
Log Likelihood	-120.155	-186.622	-292.675	-398.316	-305.78	-314.278	-293.463	-401.656
Serial Correlation test	14.475	17.973	20.545	55.1463	8.708	17.956	15.983	52.23
P-value	0.006	0.035	0.197	0.000	0.069	0.036	0.454	0.000
Skewness test	16.246	48.949	4.155	5.591	8.57	8.755	5.137	5.390
P-value	0.000	0.000	0.385	0.211	0.025	0.02	0.274	0.252

Note 1: *, **, *** implies significance at the 10 percent, 5 percent, and 1 percent level, respectively.
Note 2: Test statistics and p-values are presented in respective rows.
Note 3: The results of all other long-term interest rates with dummy variables are available upon request.

4.2.5 Interpretation of VEC Model Results

Based on the post-estimation statistics, model 3 with NDEBT_Q in table 6 is treated here as a baseline model for further examination and interpretation. After normalizing on the long-term interest rate, the cointegrating vectors associated with the largest eigenvalues yield the following cointegrating relationship:[7]

$$JGB9Y\_Q = -3.542 + 0.668TB3M\_Q - 0.154CINFL\_Q - 0.012NDEBT\_Q \quad (2)$$

The results of equation (2) show that there is a significant long-run relationship between the short-term interest rate, the rate of core inflation rate, the government fiscal balance ratio, and the long-term interest rate after incorporating structural breaks into the cointegrating vector. There is a significant positive relationship between the short-term interest rate and the long-term interest rate. A 1 percentage point increase in the short-term interest rate causes a 66.8 basis point increase in the long-term interest rate.

The results obtained show that an increase in the government net debt ratio and the primary/fiscal deficit ratio reduces the long-term interest rate on JGBs. Similarly, an increase in the primary/fiscal deficit ratio reduces the long-term interest rate on JGBs. These findings are contrary to conventional wisdom, which holds that an increase in the government debt ratio and the primary/fiscal deficit ratio crowds out available funds for the private sector's borrowing/ lending in the loanable funds market. However, theories of modern money (Wray [1998] 2003, 74–96; 2012, 110–47), endogenous money (Lavoie 2014, 182–274), and the analysis of the operational realities of the financial system involving the treasury, the central bank, the banking system, the nonbanking financial system, and the nonfinancial private sector (Bindseil 2004; Fullwiler 2008, 2016) provide plausible explanations that are aligned to the observed dynamics of the long-term interest rate in the JGB market.

If the treasury purchases goods and services from the private sector, it must pay from its account at the central bank, which acts as the banker to the treasury. As a result there is a simultaneous rise in the bank deposits of the private sector and the banking system's reserves at the central

[7] Signs in table 6 are reversed because of the normalization process.

bank. The rise in government spending results in an increase the banking system's reserves at the central bank and leads to downward pressures on the policy rate and the short-term interest rate. As the short-term interest rate declines, banks seek long-term treasury securities with higher yields. However, this causes downward pressures on the long-term interest rate.

If the private sector pays taxes or fees to the treasury, the treasury's account at the central bank is credited with reserves. As a result there is a simultaneous decline in the bank deposits of the private sector and the banking system's reserves at the central bank. The rise in government revenue that results in the decline in the banking system's reserves at the central bank leads to an upward pressure on the policy rate and the short-term interest rate. As the short-term interest rate rises, banks have less incentive to hold long-duration treasury securities over short-term treasury securities. However, this causes upward pressures on the long-term interest rate.

The error correction terms (ECT) presented in the middle panel in table 6 are derived from the long-run cointegration relationship. The significance of the ECT indicates the long-term causal relationship. Model 3, with the Japanese government net debt ratio (NDEBT_Q), has a negative and highly significant coefficient of the ECT for one of the four equations: Eq. JGB9Y_Q. This implies that there is a long-run cointegration equation, with JGB9Y_Q as the "dependent variable." In that specification, the long-run cointegration equation has significant coefficients for all the variables and is consistent with the results obtained from the cointegration tests. The value of this coefficient (-0.201) reveals the speed of return to the equilibrium long-term interest rate. It appears to be relatively moderate. A 1 percent shock away from the equilibrium long-term interest rate in quarter zero is corrected by 0.201 percent in Q1. The ECT for the other three equations are either insignificant or positive. Thus, the cointegration relation only enters significantly in the long-term interest rate equation. An examination of the adjustment coefficients in model 3, with the Japanese government primary balance ratio (PBAL_Q), shows that three of the four adjustment coefficients (Eq. JGB9Y_Q, Eq. TB3M_Q, and Eq. INF) have negative and significant signs. This indicates an adjustment process of the short-run disequilibrium in the cointegration system toward the long-run equilibrium. In contrast, the estimated ECT in the equations of PBAL_Q does not contribute to the error correction adjustment.

Turning to the short-run estimates for model 3 with NDEBT_Q (see table 7), the government net debt ratio has a negative and significant effect on the long-term interest rate when lagged one quarter (-0.056). The short-run dynamics for model 3 with PBAL_Q show that various lags of first difference variables ΔTB3M_Q(‐3), ΔTB3M_Q(-6), ΔPBAL_Q(-3), ΔPBAL_Q(-5), and ΔPBAL_Q(-6) are statistically significant. For example, changes in the short-term interest rate have a positive and significant effect when lagged three quarters (0.309), while the effect turns negative and significant when lagged six quarters (-0.124). Changes in the government primary/ fiscal balance ratio have significant effects when lagged three to six quarters, but with different signs. Thus, the net effect of the short-term interest rate and PBAL_Q on the long-term interest rate is ambiguous, while NDEBT_Q has a negative effect on the long-term interest rate in the short run. In addition, in the short run, both dummy variables have significant negative effects on the long-term interest rate. This confirms that the two structural breaks identified from the Gregory–Hansen tests are valid.

Table 7: Short-Run Adjustment Coefficients

Short-Run Adjustment Coefficients (from model 3, table 6)				
Model	**NDEBT_Q**		**PBAL_Q**	
	Coefficient	**Std. Error**	**Coefficient**	**Std. Error**
ECT	-0.207	0.08	-0.104	0.06
ΔJGB9Y_Q(-1)	-0.010	0.1	-0.075	0.11
ΔTB3M_Q(-1)	-0.072	0.07	-0.101	0.11
ΔTB3M_Q(-3)			0.309***	0.10
ΔTB3M_Q(-6)			-0.124*	0.07
ΔCINFL_Q(-1)	-0.075	0.08	-0.030	0.10
ΔNDEBT_Q(-1)	-0.056*	0.03		
ΔPBAL_Q(-1)			0.119	0.07
ΔPBAL_Q(-3)			-0.154*	0.08
ΔPBAL_Q(-5)			0.186**	0.08
ΔPBAL_Q(-6)			-0.186***	0.07
DUM85q2	-0.257**	0.12	-0.710**	0.18
DUM97q3	-0.566***	0.12	-0.720***	0.15
CONSTANT	-0.159	0.11	0.040	0.11

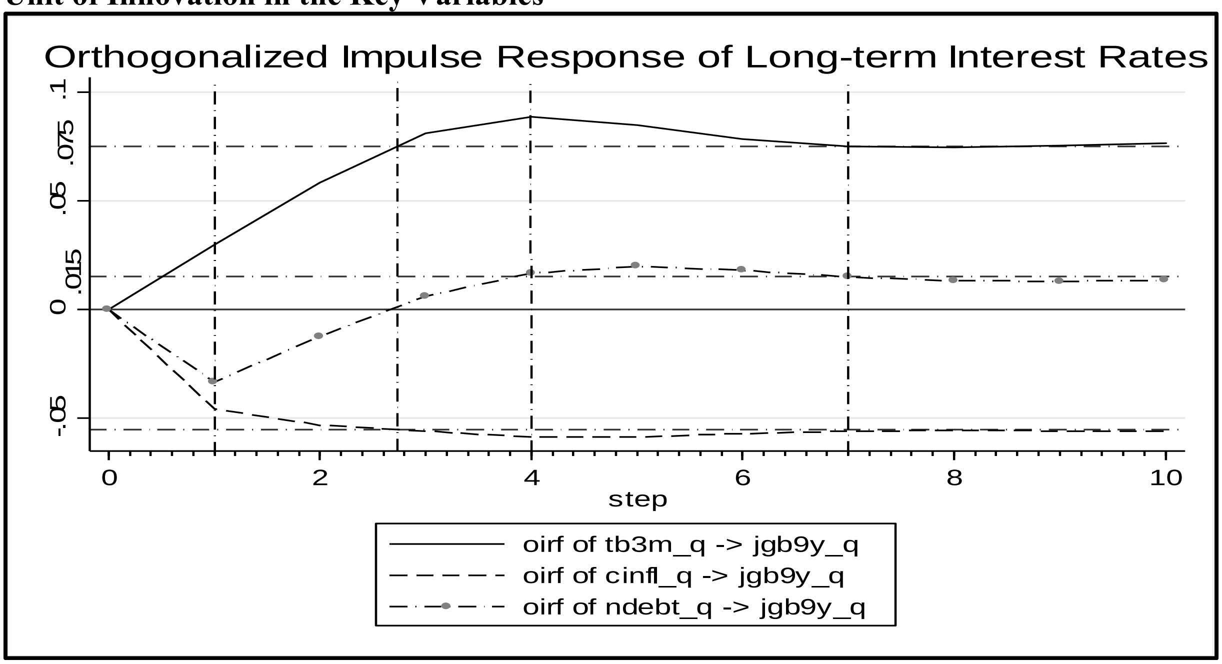
Note 1: ** and *** imply significance at 5 percent and 10 percent, respectively.
Note 2: "ΔX(-1)" represents one lag of the first difference variable; "ΔX(-2)" represents two lags of the first difference variable X.

4.3 Impulse Response Analysis

The orthogonalized impulse response function (OIRF) is used to identify the effect of one unit of innovation (exogenous shock) to key variables, such as the short-term interest rate, the rate of core inflation, and the government net debt ratio on the long-term interest rate. The OIRF also presents the duration of the response of the long-term interest rate due to the orthogonal shock to other variables in the VEC model.

Figure 17 shows the orthogonalized impulse response of the long-term interest rate with respect to one unit of innovation (exogenous shock) to key variables, such as the short-term interest rate, the rate of core inflation, and the government net debt ratio. First, the positive contemporaneous response of the long-term interest rate to a one-unit increase in the short-term interest rate is observed. The peak of 0.09 units is reached after four quarters. At the beginning of the fourth quarter, the estimated OIRF starts to decline and converges to a positive value of approximately 0.075. Second, a rise in the rate of core inflation is associated with a sharp drop in the long-term interest rate during the first quarter. The estimated OIRF converges to a negative asymptote. This indicates that an orthogonalized innovation in the rate of core inflation has a permanent negative effect on the long-term interest rate. Third, a rise in the government net debt ratio leads to a significant decline in the long-term interest rate in the first quarter, with a negative value around -0.04. A striking feature is that the estimated OIRF starts increasing after the first quarter and becomes positive by the end of the second quarter. After around seven quarters, it converges to a positive value of 0.015. Thus, seven quarters after a positive shock from the short-term interest rate and the government net debt ratio, the stabilization phase of the long-term interest rate prevails. It is characterized by a higher value of the long-term interest rate, which rises around 0.075 and 0.015, respectively, due to a positive shock in the short-term interest rate and the government net debt ratio. Finally, the long-term interest rate falls to a negative value. It declines to less than -0.05 after a positive shock from the rate of core inflation.

Figure 17: The Orthogonalized Impulse Response of the Long-Term Interest Rate to One Unit of Innovation in the Key Variables



4.4 Stability Tests

A graphical procedure is used to evaluate the constancy of the estimated coefficients, following Brown, Durbin, and Evans (1975). The procedure is based on recursive estimation to evaluate the stability of the cointegrating vector and the ECT. If the model is stable, one should expect the estimated coefficients to display random fluctuation and noise. The stability tests are carried out by starting with a subsample of 50 observations, sequentially adding one observation at a time, then running the regression until the end of the sample is reached. The results are plotted in figures 18 and 19.

Figure 18 shows the series of recursive estimated coefficients attached to the ECT. The ECT of the long-term interest rate equation (alpha1), the core inflation rate equation (alpha3), and the government net debt ratio equation (alpha4) are set to some fairly constant levels (between -0.5 and 0) through the recursive procedures. The ECT of the short-term interest rate equation (alpha2) appears to be unstable and follows a declining trend at the start of the procedures. However, as sample size increases, the estimated coefficient settles down to a value around 0.5.

Figure 19 displays the series of recursive estimated short-term coefficients of the cointegrating vector. The estimated coefficients of the short-term interest rate (beta2), the inflation rates (beta3), and government net debt ratio (beta4) are fairly stable, while the recursive intercept (beta5) fluctuates at the start of the procedures and then sets to a level around -4.

Figures 18 and 19 provide clear and distinct evidence of the stability of the coefficients in the estimated models.

Figure 18: The Series of Recursive Estimated Coefficients Attached to the Error Correction Terms (ETC)

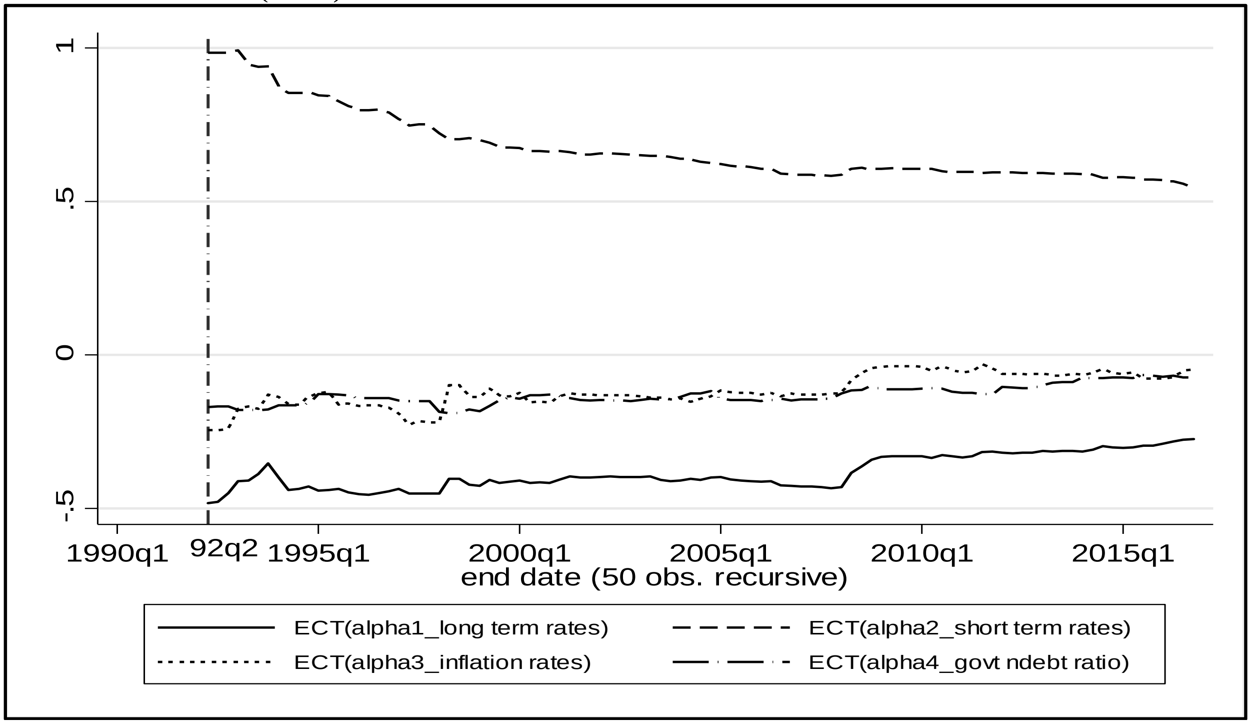
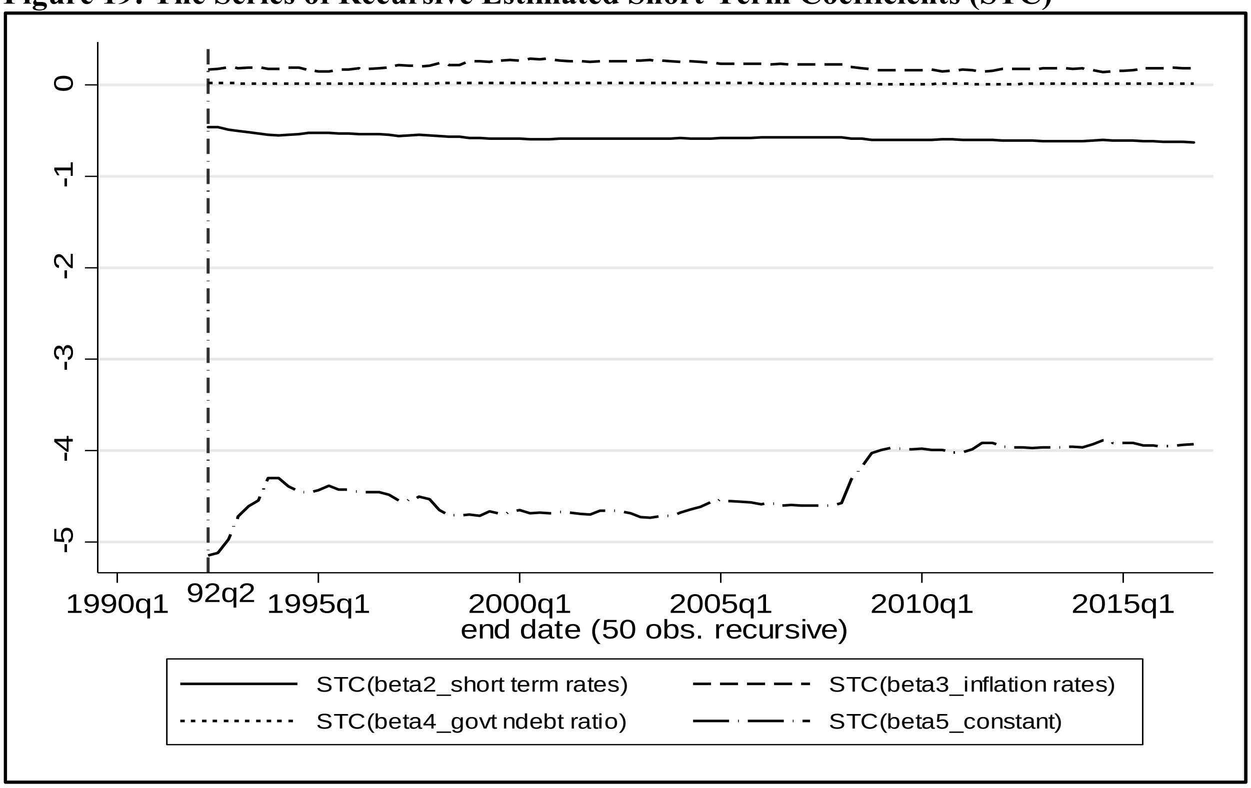


Figure 19: The Series of Recursive Estimated Short-Term Coefficients (STC)



V. IMPLICATIONS FROM A KEYNESIAN PERSPECTIVE

The empirical findings reported here have important implications for macroeconomic theory and policy.

First, the findings show that the BoJ's actions on the monetary policy rate and other monetary policy measures have a decisive effect on JGBs' nominal yields, mainly through the short-term interest rate. A lower (higher) short-term interest rate is associated with a lower (higher) long-term interest rate. By keeping the short-term interest rate low (high) by setting the policy rate low (high), the BoJ can keep the long-term interest rate on JGBs low (high) if it deems it appropriate to do so. Furthermore, the BoJ can directly influence the long-term interest rate on JGBs and other financial assets through a range of actions, including: (i) its purchase of long-duration government bonds and other financial assets from dealers and financial institutions; (ii) yield curve control; and (iii) policy pronouncements.

Second, the findings demonstrate that the BoJ effectively controls JGBs' nominal yields and the shape of the yield curve in spite of elevated ratios of government debt and government primary/fiscal deficits. Contrary to conventional wisdom, the elevated government debt ratio and chronically high government deficit ratios have not led to higher government bond yields. There is considerable debate about the effects of increased government spending and higher government borrowing and/or government debt ratios on the long-term interest rate on JGBs. Baldacci and Kumar (2010), Gruber and Kamin (2012), Lam and Tokuoka (2013), Poghosyan (2014), Reinhart and Rogoff (2009), and Tokuoka (2012) argue that higher government debt and persistently large primary/fiscal deficits lead to higher government bond yields. Atasoy, Ertuğrul, and Ozun (2014) also claim that a higher government debt ratio exerts upward pressure on government bond yields, but it is more than offset by the BoJ's large-scale asset purchasing program and the domestic private sector's holding of financial assets. However, the results reported in this study support the Keynesian perspective, as articulated in Akram and Das (2014a, 2014b, 2015, 2017), Akram and Li (2016, 2017a, 2017b), Lavoie (2014), and Wray ([1998] 2003, 2012). These studies emphasize the crucial role of monetary policy and in particular the short-term interest rate in determining the long-term interest rate on government bonds. Several recent analyses of latent factors that influence the level of government bond yields and/or the slope and the curvature of the Treasury yield curve enhance the Keynesian theory, even though those studies are usually atheoretical and are motivated solely by statistical analysis. Examples of such studies include Paccagnini (2016) for the case of the United States, and Vinod, Chakraborty, and Karun (2014) for the case of India.

Third, the findings reveal that the BoJ policy of low policy rates and the expansion of its balance sheet are not inherently inflationary. The BoJ ensures the smooth functioning of the national payments system. Keynes (1930, 370) argued that "bolder measures are sometimes advisable," noting that contrary to widely held beliefs, unconventional monetary policy is "quite free from serious dangers." The BoJ functions to accommodate financial institutions'—in particular banks'—demand for reserve balances at the targeted policy rate. The quantity of reserve balances in circulation is primarily determined by the BoJ's decisions regarding its interest rate targets, quantitative and qualitative monetary easing, and yield curve control. The experience of the past two decades has shown that the BoJ's balance sheet expands and contracts endogenously as a results of these decisions (Institute for Monetary and Economic Studies 2012). The BoJ's actions neither create nor destroy net financial assets for the nongovernment sector.

Fourth, the findings of this paper raise doubts about the conventional view regarding the fears of the consequences of expansionary fiscal policy and low interest rates in response to economic stagnation and low inflation. Doi, Hoshi, and Okimoto (2011), Hansen and Imorhooglu (2013), and Horioka, Nomoto, and Terada-Hagiwara (2014), Hoshi and Ito (2012, 2013, 2014), Lam and Tokuoka (2011), and Tokuoka (2012) maintain that Japan's high government debt and deficit ratios would cause spikes in government bond yields, runaway inflation, or even outright debt default. Their arguments are similar to those voiced in Reinhart and Rogoff's (2009) study. However, this current study shows that the BoJ's actions have been sufficient to keep JGBs' nominal yields low. It lends credence to the view that the government of Japan will be able to service its debt and keep interest payments as a share of national income low without any operational difficulties.

Fifth, there is no reason to doubt the operational ability of the government of Japan to service its debt. Lerner (1943, 1947) held that a government with monetary sovereignty is not constrained by the principles of sound finance that apply to households, businesses, and local/state governments. Agents that issue debt payable in their own liabilities are fundamentally different from agents that issue debt that is repayable only in some other entities' liabilities. Japan's considerable experience in keeping interest rates low over a protracted period supports Sims's (2013) conjectures about government debt in a regime with fiat money, as reflected in his following propositions:

- "nominal sovereign debt promises only future payments of government paper, which is always available."
- "a central bank can 'print money'—offer deposits as payment for its bills. It will not be subject to the usual sort of run, then, in which creditors fear not being paid and hence demand immediate payment. Its liabilities are denominated in government paper, which it can produce at will."

The literature on modern money theory (Mitchell 2015, 287–389; Tcherneva 2011; Wray [1998] 2003, 2012) also reaches a similar verdict for countries with: (1) their own currency and national central bank; (2) an ability to tax and spend in their in own currency; and (3) a floating exchange rate.

VI. CONCLUSION

Keynes (1930, [1936] 2007) held that the central bank influences the long-term interest rate on government bonds and the government bonds' yield curve through setting the policy rate and other monetary policy actions, which in turn determine the short-term interest rate on Treasury bills. The empirical analysis undertaken in this paper demonstrates that in Japan, the low short-term interest rate has been largely responsible for keeping long-term JGBs' nominal yields low in spite of large protracted primary/fiscal deficit ratios and elevated government debt ratios. Since the BoJ's policy rate and other monetary policy measures drive the short-term interest rate, it can be asserted that the BoJ's actions are the primary driver of JGBs' nominal yields. The empirical analysis provided here shows that a higher (lower) government debt ratio exerts downward (upward) pressure on JGBs' nominal yields. Although this is contrary to conventional wisdom, this finding is consistent with the observed phenomenon in Japan. It is also consistent with the findings of a few earlier studies, such as Akram and Das (2014a, 2014b).

Keynes (1930, 17) observed: "The efficacy of the Bank-rate for the management of managed money was a great discovery and also a most novel one… but… its precise modus operandi were not clearly understood—and have not been clearly understood… down to this day." In volume II of his *Treatise*, Keynes analyzed the effects of the central bank's policy rate, various monetary policy measures, and the short-term interest rate on long-term government bond yields. The findings of this current paper strengthen Keynes's (1930) hypothesis by showing that it can account for the dynamics of JGBs' nominal yields. It sustains and extends the results that Akram and Das (2014a, 2014b) obtained by using different econometric methods.

These findings are quite relevant to current policy issues regarding the effectiveness of fiscal stimulus, the fiscal multiplier, unconventional monetary policy, quantitative easing, and low/negative central bank policy rates, not just in Japan but also with respect to other advanced economies. The empirical analysis undertaken in this paper can inform the ongoing debates about fiscal policy, fiscal theory of price, functional finance, central banking, monetary policy, modern money theory, and financial stability.

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APPENDIX: ADDITIONAL EMPIRICAL FINDINGS

Appendix Table A1: Unit Root Tests (Level)

Unit Root Tests (Level)					
Variable		**Tests**	**Statistic**	**P-value**	**Obs.**
JGB2Y_Q	Trend	ADF	-2.846	0.181	147
		PP	-2.851	0.179	147
	No trend	ADF	-2.904	0.002	147
		PP	-2.948	0.000	147
	No trend, No constant	ADF	-3.487	0.001	147
		PP	-3.561	0.000	147
JGB3Y_Q	Trend	ADF	-2.792	0.200	147
		PP	-2.772	0.207	147
	No trend	ADF	-2.698	0.004	147
		PP	-2.758	0.065	147
	No trend, No constant	ADF	-3.282	0.001	147
		PP	-3.432	0.001	147
JGB5Y_Q	Trend	ADF	-2.401	0.379	147
		PP	-2.280	0.445	147
	No trend	ADF	-1.951	0.027	147
		PP	-1.974	0.296	147
	No trend, No constant	ADF	-2.597	0.010	147
		PP	-2.803	0.005	147
JGB6Y_Q	Trend	ADF	-2.425	0.367	147
		PP	-2.291	0.439	147
	No trend	ADF	-1.834	0.034	147
		PP	-1.843	0.358	147
	No trend, No constant	ADF	-2.493	0.013	147
		PP	-1.845	0.358	147
JGB7Y_Q	Trend	ADF	-2.665	0.251	147
		PP	-2.473	0.342	147
	No trend	ADF	-1.901	0.030	147
		PP	-1.921	0.322	147
	No trend, No constant	ADF	-2.530	0.012	147
		PP	-2.530	0.012	147
JGB8Y_Q	Trend	ADF	-2.792	0.200	147
		PP	-2.598	0.281	147
	No trend	ADF	-1.969	0.025	147
		PP	-2.019	0.278	147
	No trend, No constant	ADF	-2.662	0.008	147
		PP	-2.016	0.280	147
JGB9Y_Q	Trend	ADF	-2.890	0.166	147

Unit Root Tests (Level)					
Variable		Tests	Statistic	P-value	Obs.
		PP	-2.707	0.233	147
	No trend	ADF	-1.957	0.026	147
		PP	-2.007	0.283	147
	No trend, No constant	ADF	-2.675	0.008	147
		PP	-3.040	0.003	147
JGB10Y_Q	Trend	ADF	-2.589	0.285	120
		PP	-2.354	0.404	120
	No trend	ADF	-1.364	0.088	120
		PP	-1.170	0.687	120
	No trend, No constant	ADF	-1.731	0.079	120
		PP	-1.832	0.064	120
JGB15Y_Q	Trend	ADF	-2.773	0.207	100
		PP	-2.584	0.287	100
	No trend	ADF	-2.377	0.010	100
		PP	-2.587	0.096	100
	No trend, No constant	ADF	-2.876	0.004	100
		PP	-4.204	0.000	100
JGB20Y_Q	Trend	ADF	-2.490	0.333	119
		PP	-2.490	0.333	119
	No trend	ADF	-1.026	0.742	119
		PP	-0.767	0.824	119
	No trend, No constant	ADF	-1.450	0.137	119
		PP	-1.562	0.111	119
JGB25Y_Q	Trend	ADF	-2.223	0.467	50
		PP	-2.029	0.572	50
	No trend	ADF	3.048	1.000	50
		PP	-0.141	0.939	50
	No trend, No constant	ADF	-1.499	0.124	50
		PP	-0.141	0.939	50
JGB30Y_Q	Trend	ADF	-2.196	0.492	68
		PP	-2.219	0.472	68
	No trend	ADF	-1.129	0.132	68
		PP	-1.053	0.733	68
	No trend, No constant	ADF	-1.192	0.211	68
		PP	-1.334	0.167	68
JGB40Y_Q	Trend	ADF	-2.282	0.444	35
		PP	-2.275	0.448	35
	No trend	ADF	-0.854	0.200	35
		PP	-0.688	0.850	35

Unit Root Tests (Level)					
Variable		Tests	Statistic	P-value	Obs.
	No trend, No constant	ADF	-1.462	0.132	35
		PP	-2.026	0.042	35
TB3M_Q	Trend	ADF	-1.470	0.839	147
		PP	-2.149	0.519	147
	No trend	ADF	-1.731	0.042	147
		PP	-1.807	0.377	147
	No trend, No constant	ADF	-1.645	0.095	147
		PP	-2.162	0.030	147
CCPI_Q	Trend	ADF	-3.076	0.112	147
		PP	-3.274	0.071	147
	No trend	ADF	-3.072	0.001	147
		PP	-3.157	0.023	147
	No trend, No constant	ADF	-2.948	0.003	147
		PP	-3.141	0.002	147
CINFL_Q	Trend	ADF	-2.537	0.283	147
		PP	-2.739	0.220	147
	No trend	ADF	-2.508	0.007	147
		PP	-2.554	0.103	147
	No trend, No constant	ADF	-2.196	0.028	147
		PP	-2.701	0.007	147
IP_Q	Trend	ADF	-4.882	0.000	147
		PP	-5.193	0.000	147
	No trend	ADF	-4.861	0.000	147
		PP	-5.165	0.000	147
	No trend, No constant	ADF	-4.806	0.000	147
		PP	-5.108	0.000	147
PBAL_Q	Trend	ADF	-1.952	0.627	147
		PP	-2.646	0.259	147
	No trend	ADF	-1.241	0.108	147
		PP	-1.869	0.347	147
	No trend, No constant	ADF	-0.500	0.494	147
		PP	-0.759	0.383	147
FBAL_Q	Trend	ADF	-1.824	0.693	147
		PP	-2.577	0.291	147
	No trend	ADF	-1.360	0.088	147
		PP	-2.047	0.266	147
	No trend, No constant	ADF	-0.797	0.489	147
		PP	-1.244	0.387	147
GDEBT_Q	Trend	ADF	-1.030	0.940	147

Unit Root Tests (Level)					
Variable		Tests	Statistic	P-value	Obs.
		PP	-1.291	0.890	147
	No trend	ADF	2.813	0.997	147
		PP	1.235	0.996	147
	No trend, No constant	ADF	1.868	0.984	147
		PP	3.407	1.000	147
NDEBT_Q	Trend	ADF	-1.153	0.920	147
		PP	-1.258	0.898	147
	No trend	ADF	2.789	0.997	147
		PP	1.111	0.995	147
	No trend, No constant	ADF	0.863	0.893	147
		PP	2.293	0.994	147

Note: The ADF and PP test critical values are:
1 percent: -4.024; 5 percent: -3.444; 10 percent: -3.144 (trend)
1 percent: -3.494; 5 percent: -2.887; 10 percent: -2.577 (no trend)
1 percent: -2.594; 5 percent: -1.950; 10 percent: -1.613 (no trend, no constant)
PP test, ADF test (H_0: series has a unit root).

Appendix Table A2: Unit Root Tests (First Differences)

Unit Root Tests (First Difference)					
Variable		**Tests**	**Statistic**	**P-value**	**Obs.**
ΔJGB2Y_Q	Trend	ADF	-14.534	0.000	146
		PP	-14.352	0.000	146
	No trend	ADF	-14.428	0.000	146
		PP	-14.220	0.000	146
	No trend, No constant	ADF	-14.190	0.000	146
		PP	-13.893	0.000	146
ΔJGB3Y_Q	Trend	ADF	-14.331	0.000	146
		PP	-14.257	0.000	146
	No trend	ADF	-14.250	0.000	146
		PP	-14.147	0.000	146
	No trend, No constant	ADF	-14.024	0.000	146
		PP	-13.836	0.000	146
ΔJGB5Y_Q	Trend	ADF	-13.892	0.000	146
		PP	-13.961	0.000	146
	No trend	ADF	-13.868	0.000	146
		PP	-13.914	0.000	146
	No trend, No constant	ADF	-13.654	0.000	146
		PP	-13.615	0.000	146
ΔJGB6Y_Q	Trend	ADF	-13.761	0.000	146
		PP	-13.846	0.000	146
	No trend	ADF	-13.753	0.000	146
		PP	-13.818	0.000	146
	No trend, No constant	ADF	-13.753	0.000	146
		PP	-13.818	0.000	146
ΔJGB7Y_Q	Trend	ADF	-14.054	0.000	146
		PP	-14.239	0.000	146
	No trend	ADF	-14.046	0.000	146
		PP	-14.200	0.000	146
	No trend, No constant	ADF	-13.832	0.000	146
		PP	-13.876	0.000	146
ΔJGB8Y_Q	Trend	ADF	-14.146	0.000	146
		PP	-14.413	0.000	146
	No trend	ADF	-14.132	0.000	146
		PP	-14.363	0.000	146
	No trend, No constant	ADF	-14.132	0.000	146
		PP	-14.397	0.000	146
ΔJGB9Y_Q	Trend	ADF	-14.543	0.000	146
		PP	-14.864	0.000	146
	No trend	ADF	-14.547	0.000	146

Unit Root Tests (First Difference)					
Variable		Tests	Statistic	P-value	Obs.
		PP	-14.839	0.000	146
	No trend, No constant	ADF	-14.279	0.000	146
		PP	-14.376	0.000	146
ΔJGB10Y_Q	Trend	ADF	-13.751	0.000	119
		PP	-13.994	0.000	119
	No trend	ADF	-13.812	0.000	119
		PP	-14.059	0.000	119
	No trend, No constant	ADF	-13.728	0.000	119
		PP	-13.888	0.000	119
ΔJGB15Y_Q	Trend	ADF	-11.291	0.000	99
		PP	-12.199	0.000	99
	No trend	ADF	-11.192	0.000	99
		PP	-11.800	0.000	99
	No trend, No constant	ADF	-10.801	0.000	99
		PP	-10.935	0.000	99
ΔJGB20Y_Q	Trend	ADF	-12.258	0.000	118
		PP	-12.662	0.000	118
	No trend	ADF	-12.309	0.000	118
		PP	-12.727	0.000	118
	No trend, No constant	ADF	-12.218	0.000	118
		PP	-12.727	0.000	118
ΔJGB25Y_Q	Trend	ADF	-6.912	0.000	49
		PP	-7.214	0.000	49
	No trend	ADF	-6.845	0.000	49
		PP	-6.983	0.000	49
	No trend, No constant	ADF	-6.723	0.000	49
		PP	-6.789	0.000	49
ΔJGB30Y_Q	Trend	ADF	-7.444	0.000	67
		PP	-7.427	0.000	67
	No trend	ADF	-7.410	0.000	67
		PP	-7.378	0.000	67
	No trend, No constant	ADF	-7.404	0.000	67
		PP	-7.371	0.000	67
ΔJGB40Y_Q	Trend	ADF	-5.145	0.000	34
		PP	-5.102	0.000	34
	No trend	ADF	-5.217	0.000	34
		PP	-5.192	0.000	34
	No trend, No constant	ADF	-5.082	0.000	34
		PP	-5.019	0.000	34

Unit Root Tests (First Difference)					
Variable		Tests	Statistic	P-value	Obs.
ΔTB3M_Q	Trend	ADF	-14.580	0.000	146
		PP	-14.465	0.000	146
	No trend	ADF	-14.544	0.000	146
		PP	-14.467	0.000	146
	No trend, No constant	ADF	-14.470	0.000	146
		PP	-14.430	0.000	146
ΔCCPI_Q	Trend	ADF	-10.785	0.000	146
		PP	-10.812	0.000	146
	No trend	ADF	-10.651	0.000	146
		PP	-10.702	0.000	146
	No trend, No constant	ADF	-10.584	0.000	146
		PP	-10.649	0.000	146
ΔCINFL_Q	Trend	ADF	-11.153	0.000	146
		PP	-11.154	0.000	146
	No trend	ADF	-10.987	0.000	146
		PP	-11.005	0.000	146
	No trend, No constant	ADF	-10.900	0.000	146
		PP	-10.926	0.000	146
ΔIP_Q	Trend	ADF	-10.085	0.000	146
		PP	-9.924	0.000	146
	No trend	ADF	-10.117	0.000	146
		PP	-9.962	0.000	146
	No trend, No constant	ADF	-10.152	0.000	146
		PP	-10.003	0.000	146
ΔPBAL_Q	Trend	ADF	-5.491	0.000	146
		PP	-5.706	0.000	146
	No trend	ADF	-5.506	0.000	146
		PP	-5.719	0.000	146
	No trend, No constant	ADF	-5.523	0.000	146
		PP	-5.736	0.000	146
ΔFBAL_Q	Trend	ADF	-5.387	0.000	146
		PP	-5.624	0.000	146
	No trend	ADF	-5.403	0.000	146
		PP	-5.639	0.000	146
	No trend, No constant	ADF	-5.422	0.000	146
		PP	-5.656	0.000	146
ΔGDEBT_Q	Trend	ADF	-3.008	0.130	146
		PP	-3.376	0.055	146
	No trend	ADF	-2.934	0.046	146

Unit Root Tests (First Difference)					
Variable		**Tests**	**Statistic**	**P-value**	**Obs.**
		PP	-3.275	0.016	146
	No trend, No constant	ADF	-2.193	0.029	146
		PP	-1.659	0.091	146
ΔNDEBT_Q	Trend	ADF	-2.893	0.165	146
		PP	-3.159	0.093	146
	No trend	ADF	-2.780	0.003	146
		PP	-3.023	0.033	146
	No trend, No constant	ADF	-1.675	0.089	146
		PP	-1.820	0.066	146

Note: The ADF and PP test critical values are:
1 percent: -4.024; 5 percent: -3.444; 10 percent: -3.144 (trend)
1 percent: -3.494; 5 percent: -2.887; 10 percent: -2.577 (no trend)
1 percent: -2.594; 5 percent: -1.950; 10 percent: -1.613 (no trend, no constant)
PP test, ADF test (H_0: series has a unit root).

Appendix tables A3 and A4 are available upon request.