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Term Structure of Interest Rates under Zero or Low Bound: The Recent Japanese Case

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Abstract

This article examines the recent term structure of interest rates in Japan. No consensus has been reached on whether or not the yield curve can be asymmetric and can be an economic predictor, although much discussion has occurred. In Japan, the zero or low-bound interest rate policy and, after that, the quantitative easing policy was conducted to boost the economy since the end of 1990s. Recession and deflation have been ongoing for more than 20 years. The term structure of interest rates uses an unusual style compared to the normal structure, especially during zero or low-bound period, as interest rates in general tend not to be negative. Using empirical methods, this article shows that the term structure is a nonlinear relationship between short- and long-term rates during the zero or low-bound policy period in Japan. For the sensitivity of short-term yields to long-term interests, there is no evidence for symmetric response to positive and negative short-term rate change; however, and only during the zero or low-bound interest rate policy era, there is a symmetric response on longer-term interest rate. Moreover, the long-term yield spread is not a good predictor of recessions.

Keywords: Monetary policy, Quantitative easing, yield curve, Zero or low interest rate.

Contents

1. Introduction

This paper examines the recent term structure of interest rates in Japan and assesses whether or not the slope of the yield curve can be a good predictor of recession. In Japan, the zero or low-bound interest rate policy and later, the quantitative easing policy, have been implemented to boost the economy. Recession and deflation have been ongoing for more than 20 years. The term structure of interest rates during these times use a style that differs from the normal situation as interest rates in general tend not to be negative. It should be noted that these analyses were conducted during recession. Although there has been much discussion about yield curves, no consensus has been reached.

Japan enjoyed high economic growth during the 1980s. Stock and land prices increased enormously starting in the middle of the 1980s. After the signing of the Plaza Accord with the G5 countries, including Japan, in 1985, the Japanese yen appreciated sharply. Usually appreciation of the yen (i.e., the domestic currency) causes a loss in international competitiveness with foreign countries, decreased exports, and recession in Japan; however, exports did not decline and the economy did not shrink. Consumer prices did not rise greatly. It was lucky for the Japanese economy that oil prices did not increase sharply. However, the bubble economy burst at the end of the 1980s, and the Japanese economy experienced recession. In the 1990s, however, the country suffered a recession with very low and sometimes negative growth rates late in the decade and in the beginning of the 2000s. The largest reason for the recession was said to be the country's weak and fragile financial system and structural problems such as delays in political and economic systems. Barriers of deregulation in many areas are typical examples.

The Bank of Japan (BOJ) introduced a new and unprecedented monetary policy, the zero interest rate policy, in February 1999. The BOJ judged that Japan's economic indicators had come to a pause, so it adopted a policy of maintaining interest rates at an unprecedented low level. Japan's experience with this quantitative easing policy, more aggressive policy, by the BOJ dates back to March 2001. Following a period of zero interest rate policy (February 1999–August 2000), the BOJ introduced this quantitative easing policy in March 2001. The main operating target for many market operations changed from the uncollateralized overnight call rate to be the outstanding balance of the current account at the BOJ. At the end of 2001, the BOJ raised the outstanding balance of the current account at the BOJ from around 10 to 15 trillion yen. Under this quantitative easing policy, the BOJ employed purchases of Japanese government bonds as the main instrument to reach its target. The BOJ, with interest rates at their zero or low bound, conceived a goal of purchasing government securities from the banking sector. This aim can be understood as sending money to the economy, promoting increases in asset prices, and removing deflationary pressures. In March 2006, the BOJ exited quantitative easing amid signs that deflation was ending and the recession had disappeared. On July 14, 2006, the zero interest rate policy ended.

After the occurrence of the subprime problems in 2007 and the Lehman shock in 2008, a huge amount of capital flowed into the Japanese financial markets in spite of the fact that the Japanese economy still was not in good condition. The Japanese yen appreciated against other currencies, which hit the Japanese economy. In October 2010, the BOJ introduced its comprehensive monetary easing policy to respond to the re-emergence of deflation and a slowing recovery. One key measure was an asset purchase program that involved government bonds as well as private assets. After that, the Japanese government changed and more aggressive fiscal policy was strongly demanded. The zero interest rate policy was in effect beginning in October 2010 and continues in force now.

- In Japan, a drastic new policy, called *Abenomics* (for Abe, the prime minister), was adopted in 2013. The Japanese government not only implemented drastic fiscal policy but also took measures to strengthen competitiveness and economic growth. Japan has been under severe economic conditions, namely, deflation. These measures included possible policy actions to reform the economic structure, such as concentrating resources on innovative research and development, strengthening the foundation for innovation, performing regulatory and institutional reforms, and changing the tax system (increasing the consumption tax and reducing the corporate tax). Moreover, by strengthening coordination between the BOJ and the government, since 2013, the Japanese government has implemented measures to achieve a new fiscal structure to ensure the credibility of the fiscal condition. BOJ introduced Abenomics, an unprecedented aggressive monetary policy, in April 2013. Kurihara and Fukushima (2013) showed that Abenomics seems to be effective at present; however, the effects have been limited. Most people consider that the recent good performance of the economy actually is mainly a result of Abenomics rather than the zero interest rate policy. However, this study shows that the zero interest rate policy has influenced activity for the long-term. Thus there is some possibility that the zero interest rate policy has caused the present good situation. It seems necessary to distinguish between the effect of the zero interest rate policy and those of quantitative easing policy or Abenomics.

Much discussion has taken place about the yield spread of interest rates. From the view of monetary policy, Bernanke and Blinder (1992) showed that monetary tightening results in short-term interest rates that are high relative to long-term interest rates. In turn, high short-term interest rates cause slowing of the economy. Kim and Singleton (2012) and Krippner (2013) noted that the extent to which the shadow rate is below the short-term interest rate is a measure of the degree to which the zero or low bound interest rates are binding. Swanson and Williams (2014) showed that long-term yields tend to be responsive to economic news for much of the zero or low-bound interest rates period, which implies that monetary policy remains effective by influencing long-term yields using forward guidance and asset purchases. One can safely say that under the zero or low-bound interest rates, some consideration would be necessary.

Ruge-Murcia (2006) showed that when zero low bound is taken into account, the hypothesis of expectations for the yield spread means a nonlinear relationship between changes in short-term interest rates and long-term ones. As the short interest rate becomes zero, the sensitivity of long-term interest rates with respect to short-term interest rates declines. This response becomes asymmetric with short-term rate increases associated with larger absolute long-term interest rate movement rather than decreases in the short-term. The extent to which these nonlinearities exist is informative about the transmission of short-term rates changes to long-term ones (Grisse, 2015). Ruge-Murcia (2006) estimated whether or not the nonlinearities of yield spread exist in Japan and found that the sensitivity of yields to

short-term rate movement decreased before the zero or low bound was reached but expanded with the BOJ's asset purchases. Gürkaynak *et al.* (2005) and Swanson and Williams (2014) showed that 1-year and 2-year treasury bond yields were unconstrained, which indicates that monetary and fiscal policy were as effective as usual. Grisse (2015) examined whether these effects exist in the US term structure and found no evidence for the expected asymmetric effects of short-term rate increases versus declines.

Also, whether or not the yield curve can be a predictor for the economy has been examined but no consensus has been reached. Mehl (2009) showed that yield curves for the United States and the Euro area for emerging economies produces information that may predict future economic growth. This means that monetary policy changes in the United States make international financial linkages strong as a result of interest rate pass-through.

This article focuses on the period of recession in Japan. Mishkin (1990a;1990b) and Estrella and Hardouvelis (1991) showed that an inversion of the slope of the yield curve indicates a recession back to the 1990s in the United States. Ahrens (2002) noted that the term structure is a predictor of recessions in eight OECD countries. Karunaratne (2002) showed that stationary variables revealed that the yield curve produces a good forecast of economic activity.

On the other hand, Plosser and Rouwenhorst (1994); Bonser-Neal and Morley (1997); Kozicki (1997); Estrella and Mishkin (1997) and Estrella *et al.* (2003) showed that evidence on the ability of the yield curve to help predict future growth for other countries has so far been difficult and is limited to a few industrialized countries. Estrella and Mishkin (1996) and Estrella and Trubin (2006) showed that empirical results depend on macroeconomic variables. Also, a variety of non-negative symmetric term structure models lead to various predictions regarding the behavior of longer-term yields around the zero or low bound (Kim and Singleton, 2012). De (2013) showed that the term structure is not a reliable predictor of economic growth.

Moreover, Mishkin (1990a;1990b;1991) indicated that the slope of the yield curve causes expected inflation changes. Greenspan (2005) showed that many factors can influence the yield curve, including the gap between long-term and short-term inflation expectations or the risk premium. Vayanos and Vila (2009) showed that each maturity of interest rates has its own clientele and substitution across financial instruments maturities is performed by risk-averse arbitrageurs. Guibaud *et al.* (2013) showed that if agents are more risk-averse, an increase in the long-term clientele increases the price and optimal supply of long-term bonds.

2. Theoretical Backgrounds

This article examines the recent term structure of interest rates in Japan and whether or not the term structure can be a good predictor for the economy. For the first objective, the following term-structure model is considered (Ruge-Murcia, 2006; Grisse, 2015).

$$r_t = a + \sum_{j=1}^{q} b_j r_{t-j} + c x_t + \varepsilon_t \tag{1}$$

$$r^*_t = \max(r_t, 0) \tag{2}$$

$$R_t = \frac{1}{n}(r_t + E(r_{t+1} \mid I_t) + \cdot\ \cdot\ \cdot + E(r_{t+n-1} \mid I_t)) + \theta_t \tag{3}$$

Equation (1) means that r_t depends on past short-term interest rates and on the m×1 vector of exogenous variables x_t; and b_t the m×1 vector c are parameters; and ε_t is a shock. Equation (1) imposes the constraint that the short-term interest rate, r^*_t, is non-negative where r_t denotes the shadow rate. Equation (3) says that the yield of an n-period bond R_t is determined by this expectation hypothesis, plus a liquidity and term premium θ_t, which is not correlated with ε_t. When $r^*_t = 0$, the shadow rate is unobserved and expectations of r_t can be calculated conditional on the information set, I_t, which includes variables observed at each period t. Ruge-Murcia (2006) and Grisse (2015) showed that the solution implies a nonlinear relationship between short-term interest rate changes and associated changes in long-term interest rates.

This article also examines whether or not the slope of the yield curve is a good predictor of the economy. The period of recession in Japan is focused. If empirical results support the relationship between the slope of the yield curve and economic activity, the relationship is positive and reflects the expectations of markets regarding future economic growth. A positive spread between long-term and short-term interest rates, that is, a steep yield curve, is linked to an expectation of an increase in economic activity. On the other hand, negative spread, that is, a flattening or inverted yield curve, is associated with an expectation of a decline in economic growth.

3. Empirical Methods

Daily and quarterly data on Japanese bond yields of constant maturity were obtained from International Financial Statistics (IMF). Daily figures are from January 1999 to July 2015. The total data are divided into two parts. One is to July 13, 2006, and the other is from July 14, 2006. On July 14, 2006, the zero interest rate policy ended. Quarterly data are from 1999Q1 to 2015Q1 and also are divided at 2006Q3. The zero interest rate policy was first introduced in Japan in 1999.

The following regression calculates the effect of changes in short yields Δy_t:

$$\Delta y_t = a + b plus (\Delta x_t > 0) \Delta x_t + b minus (\Delta x_t < 0) \Delta x_t + \varepsilon_t \tag{4}$$

Where plus and minus are the indicator function. This specification is estimated in Ruge-Murcia (2006) and Grisse (2015). The coefficients change using rolling regressions over 2-year periods are estimated as follows:

$b size, t = (b plus + b minus)/2$

$b sign, t = (b negative - b positive)$

If the zero low bound is binding, bsize is less than its average value. Also, if bsign is less than the average value of that one, the zero bound is binding.

Also, the recession is regressed by a measure of steepness. The steepness of the yield curve is defined as the difference between long-term and short-term interest rate (Estrella and Mishkin, 1996; Estrella and Trubin, 2006; Ozturk and Felipe, 2013).

A measure of the forecast for the economy is calculated as shown in Equation (5). The probit model is used for estimation. This model is used to model binary outcome variables. In this model, the standard normal distribution of

the probability is modeled as a linear combination of the predictors. It is a popular specification for a binary response model. Recession is defined as occurring if a country reports negative GDP growth. To explain the variable, 1 means recession and 0 means otherwise.

$$recession_t = a + bslope(-1) + \varepsilon_t$$

(5)

4. Empirical Results

The results are shown in Tables 1–Table 3.Tables 1 and 2 show the results of Equation (1). The sample period of Table 1 is from the beginning of 1999 to July 13, 2006.As explained above, it is mainly during zero or low-bound interest rate policy era. The period of Table 2 is from July 14, 2006, to the end of July 2015. This period is also mainly during the quantitative easing era. In both Tables 1 and 2 nY means the maturity of bonds. n denotes year and Y denotes year. Also, nMP and nMM mean maturities of bonds. n means month, P means plus, and M means minus. The results shown Tables 1 and 2 are interesting. Only the case of zero or the low-bound interest rate policy era and 10-year bond (the longest one) is significant. During that era, the interest rates moved symmetrically. However, except for the case of 1- year, the results are not significant. In Table 2 all of the coefficients show that interest rates moved asymmetrically. However, none of the coefficients are significant. Thus, during zero or the low-bound interest rate policy era, interest rates moved according to the theory for the case of long-term interest rate.

For size and sign, high volatility is found during the period of quantitative easing era. It may reflect the BOJ's large scale purchases of financial assets.

Table-1. Zero or low-bound interest rate policy era

	2Y	3Y	5Y	10Y
C	2.17E-05	2.38E-05	3.83E-05	0.0005
	(0.132)	(0.120)	(0.150)	(0.262)
3MP	6.21E-05	2.96E-05	6.51E-05	0.140**
	(0.012)	(0.005)	(0.008)	(2.332)
3MM	0.0002	0.0006	0.001	0.225**
	(0.033)	(0.074)	(0.092)	(2.254)
Adj.R2	-0.0003	-0.0003	-0.0003	0.0006
F-Statistic	0.001	0.005	0.008	3.204
Prob (F-Statistic)	0.998	0.994	0.991	0.040
Durbin-Watson	1.844	1.877	1.928	2.929

Note: Figures in parentheses are t-values. ***, **, and * denote significanceat 1, 5, and 10% respectively.

Table-2. Quantitative easing era

	2Y	3Y	5Y	10Y
C	6.64E-05	7.57E-05	0.0001	-0.0005
	(0.135)	(0.128)	(0.160)	(-0.889)
3MP	-0.002	-0.004	-0.0006	-0.026
	(-0.043)	(-0.069)	(-0.078)	(-0.355)
3MM	0.029	0.056	0.089	0.095
	(0.313)	(0.490)	(0.612)	(0.744)
Adj.R2	-0.0008	-0.0008	-0.0007	-0.0006
F-Statistic	0.062	1.152	0.240	0.280
Prob (F-Statistic)	0.939	0.858	0.786	0.755
Durbin-Watson	1.158	1.208	1.264	2.446

Note: Figures in parentheses are t-values. ***, **, and * denote significance at 1, 5, and 10% respectively.

Equation (5) was estimated to evaluate whether or not the long-term yield spread is a good predictor of recessions. The explained variable was the binary variable, *recession*. The results are shown in Table 3.

Table-3. Long-term yield spread and recession

C	**0.540*****	**0.549*****	**0.558*****	**0.529*****
	(2.747)	**(8.261)**	**(2.852)**	**(8.201)**
10Y(-1)-3m(-1)	0.019		-0.012	
	(0.116)		(-0.078)	
2Y(-1)-3m(-1)		0.462		0.407
		(0.797)		(0.704)
GDP(-1)	-0.027	-0.028		
	(-1.057)	(-1.121)		
Adj.R2	-0.013	-0.003	-0.015	-0.007
F-Statistic	0.561	0.877	0.006	0.495
Prob (F-Statistic)	0.573	0.420	0.938	0.483
Durbin-Watson	1.558	1.588	1.598	1.630

Note: Figures in parentheses are t-values. ***, **, and * denote significance at 1, 5, and 10% respectively.

In most cases, the coefficients are positive as expected; however, they are not significant. Therefore, the long-term yield spread is not a good predictor of recessions.

5. Conclusions

This study examined the term structure of interest rates in Japan during the era of zero or low interest rate policy and the era of quantitative easing policy. Using empirical methods, this article showed that the term structure has a

nonlinear relationship between short- and long-term rates under zero or the low bound in Japan. For the sensitivity of short-term yields to long-term interests, there was no evidence of a symmetrical response to positive and negative short-term rate changes in most cases; however, only in the case of zero or low-bound interest rate policy era is there a symmetrical response with longer-term interest rates. Moreover, the long-term yield spread is not a good predictor of recessions.

The results are not surprising. Zero or very low interest rates are a specific case and usually interest rates do not move into the negative. However, it is difficult to judge the case of quantitative easing policy era as it was largely related to the zero interest rate policy. The distinction is quite difficult. Also, yield spread is not a good predictor of recessions: however, there is some room for the empirical results as in reality interest rates are strongly related to future economic expectations. Further study is needed. It would be meaningful to consider economic or monetary policy.

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