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Monetary policy and the yield curve at zero interest ☆

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ABSTRACT

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In contrast to affine term structure models, Black's (1995) model of interest rates as options has properties suitable to examine the yield curve when the short-term interest rate is near zero. We estimate a Black's model with Japan's data to extract market expectations about duration of zero interest. We find that expectations about duration have substantially varied, which contradicts with the assumption utilized in the literature. We also find a tight link between expectations about duration and survey measures of inflation expectations, which appears to be attributable to the Bank of Japan's commitment conditional on inflation. *J. Japanese Int. Economies* **38** (2015) 1–12. Bank of Japan, Japan.

1. Introduction

In response to the global financial crisis, central banks in major developed economies lowered their targets for the short-term interest rates to effectively zero. However, the history of low interest rate is

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still limited to empirically study such a situation. Research on the case of Japan helps us to understand a low interest rate environment, since Japan has experienced extended periods of low interest rates since the mid-1990s.

Even with long historical data, it is still not easy to study monetary policy when the short-term interest rate is effectively at the zero lower bound. Since the short-term interest rate is the conventional monetary policy instrument, it is used in the greatest part of empirical analyses of monetary policy. However, under a low interest rate environment, a central bank attempts to stimulate the economy by not changing the target for the short-term interest rate but, for instance, making commitments. Thus, we cannot observe monetary policy stance from the short-term interest rate, once it is stuck at the zero lower bound. Yield curve data have a potential to solve this problem, since longer-term interest rates vary reflecting market expectations about the future pass of monetary policy even when the short-term interest rate is zero.

To study monetary policy using yield curve data, the literature extensively uses affine term structure models (Duffie and Kan (1996)) which allow the short-term interest rate to be negative or do not take into account of the zero lower bound.[1] Although such models may be a good first approximation when the short-term interest rate is far from the zero lower bound, they are unreliable in low interest rate environments.[2] Despite the critical drawback, many studies still depend on affine term structure models even after facing the zero lower bound, particularly when examining the US data. Gagnon et al. (2011), for instance, examine the effects of the Federal Reserve's unconventional monetary policies using the term premia estimated with an affine term structure model employed by Kim and Wright (2005). Hamilton and Wu (2012) use their affine term structure model to examine monetary policy effects when the short-term interest rate is zero on the assumption that the risk-neutral probability of remaining at the zero lower bound next period is constant. But the probability under the risk-neutral measure, an artificial probability measure just for convenience of calculation, is hard to interpret. Perhaps more seriously, even if we can interpret this probability as an approximation for that under the actual probability measure, the constant probability appears to be inconsistent with the experiences of Japan: market perceptions about the probability of remaining at the zero lower bound have significantly varied as shown in this paper.[3]

To overcome the limitations of affine term structure models, we use Black's (1995) model of interest rates as options, which allows the probability of remaining at the zero lower bound to be time-varying.[4] Black's (1995) model employs a shadow rate that can take on negative values. The nominal spot rate is equal to the shadow rate when the shadow rate is positive, and to zero otherwise. As the shadow rate is more negative, the probability of remaining at the zero lower bound is higher, the expected duration of zero interest is longer, and the yield curve is more convex. While Black (1995) proposes the idea of the model, Gorovoi and Linetsky (2004) formulate this idea. In a version of their model, they assume that the shadow rate follows an Ornstein–Uhlenbeck process under the risk-neutral measure, as the spot rate does in Vasicek's (1977) term structure model.[5] They calibrate this model by fitting to the cross-sectional data of JGB yields at a selected date. Ueno et al. (2006) calibrate this Vasicek-type Black's model at each point of time independently with their five-year sample.

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[1] Some affine models such as Cox et al.'s (1985) take into account of the zero lower bound. But these models are not popular to study monetary policy in the literature. See Black (1995) for a critique of models with the square root process such as Cox et al.'s (1985).

[2] See Ichiue and Ueno (2013), who show that affine term structure models often produce unrealistic results.

[3] Japan's yield data after hitting the zero lower bound are also examined using affine models in the literature. For instance, Bernanke et al. (2005) use an affine model to investigate Japan's monetary policy at the zero lower bound. Since Japan started to face the zero lower bound before affine models and their estimation methods have been intensively examined, there are only limited studies that estimate affine models using data in the pre-zero lower bound period. Babbs and Nowman (1998) can be seen as an exception: they employ the Kalman filter to estimate a term structure model using data from January 1992 to March 1996.

[4] The term structure model with endogenous regime shifts, which is applied to Japan's data by Koeda (2013), also allows the probability of remaining at the zero lower bound to be time-varying, although this model typically allows interest rates to be negative.

[5] A shadow rate is allowed to be persistently negative if it follows an Ornstein–Uhlenbeck process. Without this property of shadow rate, zero could be a reflecting barrier rather than a sticky barrier. That is, the short-term interest rate is expected to rise from the zero lower bound immediately if it reaches zero. This clearly contradicts with the experiences in major developed economies: the short-term interest rate has been stuck at effectively zero for a prolonged period.