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The zero lower bound and movements in the term structure of interest rates

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HIGHLIGHTS

- I analyze movements of the US term structure in the zero lower bound (ZLB) period.
- The expectations hypothesis implies a nonlinear link of short and long-term yields.
- The response of medium-term yields to short rates declined at the ZLB.
- I find no evidence of asymmetric effects of positive/negative short rate changes.

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ABSTRACT

The expectations hypothesis of the term structure implies a nonlinear relationship between short- and long-term rates if nominal interest rates are constrained by the zero lower bound (ZLB). This note finds limited evidence for such nonlinearities in the US term structure. The sensitivity of medium-term yields to short rate movements declined, but there is no evidence for asymmetric responses to positive versus negative short rate changes.

1. Introduction

This note studies the relationship between movements in short- and long-term interest rates at the zero lower bound (ZLB), building on theoretical results in Ruge-Murcia (2006). That paper shows that when the ZLB is taken into account, the expectations hypothesis of the term structure implies a non-linear relationship between changes in short- and long-term interest rates. As the short rate approaches zero, (1) the sensitivity of long-term rates with respect to short rate changes declines; and (2) this response becomes increasingly asymmetric, with short rate increases associated with larger absolute long rate movements than short rate declines. The extent to which these nonlinearities are present in the data is informative about the transmission of short rate changes to long-term rates—those interest rates that matter most for the real economy.

Ruge-Murcia (2006) estimates whether the nonlinearities implied by the model indeed characterize the term structure in Japan between 1995 and 2001.[1] This note similarly studies whether these effects are empirically relevant for the US term structure in recent years. The sensitivity of yields to short rate movements declined before the ZLB was reached, but rose again as the Federal Reserve's asset purchase programs were introduced. For medium-term yields sensitivity fell again only in 2013. I find no evidence for the expected asymmetric effects of short rate increases versus declines.

This note is related to the growing literature on ZLB implications for the term structure of interest rates and monetary policy effectiveness. Kim and Singleton (2012) and Krippner (2013), among others, estimate term structure models where the ZLB is modeled through a shadow short rate. The extent to which the shadow rate

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[1] See also Iwata (2010), who estimates a structural VAR using monthly Japanese data 1990–2007.

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is below the short-term interest rate is a measure of the degree to which the ZLB is binding. Swanson and Williams (2014a,b) explore whether the sensitivity of bond yields to macroeconomic data releases has declined due to the ZLB. The finding that long-term yields are surprisingly responsive to macro news for much of the ZLB period implies that monetary policy remains effective by influencing long-term yields through forward guidance and asset purchases.

The results in this paper can help determine whether policy rate cuts still have the usual effect on longer-term rates, even when short rates have already reached a low level. For example, when policy rates are at 0.75%, the central bank may be reluctant to cut rates further, which could potentially have adverse effects.[2] The results could also help judge the effect of rate hikes on longer-term yields in a ZLB-environment. The sharp interest rate increases and the associated volatility during 2013 "taper tantrum" episode, when the Fed signaled an exit from easy monetary policy, illustrates that this is an important question for policymakers and investors alike.

2. Review of the theoretical background

Ruge-Murcia (2006) considers the following term structure model:

$$r_t = \max\left(r_t^*, 0\right) \quad (1)$$

$$r_t^* = \alpha + \sum_{j=1}^{p} \psi_j r_{t-j} + \beta \mathbf{x_t} + \varepsilon_t \quad (2)$$

$$R_t = \frac{1}{n}\left(r_t + \mathbb{E}(r_{t+1} \mid I_t) + \cdots + \mathbb{E}(r_{t+n-1} \mid I_t)\right) + \theta_t. \quad (3)$$

Eq. (1) imposes the constraint that the short-term nominal interest rate, r_t, is non-negative, where r_t^* denotes the shadow rate. In (2), r_t^* depends on past short rates and on the $m \times 1$ vector of exogenous variables $\mathbf{x_t}$; α, ψ_j and the $1 \times m$ vector β are parameters, and ε_t is an i.i.d. shock. Eq. (3) says that the yield of an n-period bond R_t is determined by the expectation hypothesis, plus a liquidity and term premium θ_t which is uncorrelated with ε_t. When $r_t = 0$ the shadow rate is unobserved, and expectations of r_t^* have to be computed conditional on the information set I_t, which includes variables observed up to and including period t. Ruge-Murcia (2006) shows that the solution implies a nonlinear relationship between short rate changes and associated changes in longer-term rates:

- $\partial R_t / \partial r_t$ is increasing in r_t
- $|\Delta R_t|$ is larger if $\Delta r_t > 0$ than if $\Delta r_t < 0$.

It is not straightforward to identify these nonlinearities in the data because monetary policy actions at the ZLB may simultaneously affect r_t, θ_t, and directly (not only via short rates) $\mathbb{E}(r_{t+1} \mid I_t)$. For example, consider central bank purchases of longer-term bonds. This announcement affects the term structure via two channels: first through signaling that monetary policy will stay more expansive for longer than previously thought, affecting $\mathbb{E}(r_{t+1} \mid I_t)$. Second, there could be portfolio balance effects which change the liquidity- and term premium θ_t of longer-term assets that the central bank is purchasing. If short rates move after the announcement – as seems likely – the correlation between Δr_t and ΔR_t will reflect effects other than those running through the expectations hypothesis that are at the heart of the model.

This discussion illustrates that whereas the nonlinear effects in $\partial R_t / \partial r_t$ *should* be present at the ZLB, they may not be easily identifiable from the data. Finding nonlinearities in the data does not imply that monetary policy is powerless. When short-term rates are at the ZLB, monetary policy can still directly affect θ_t and $\mathbb{E}(r_{t+1})$, for example through forward guidance or asset purchases. The above effects are informative about whether monetary policy can still work through changes in short-term interest rates.

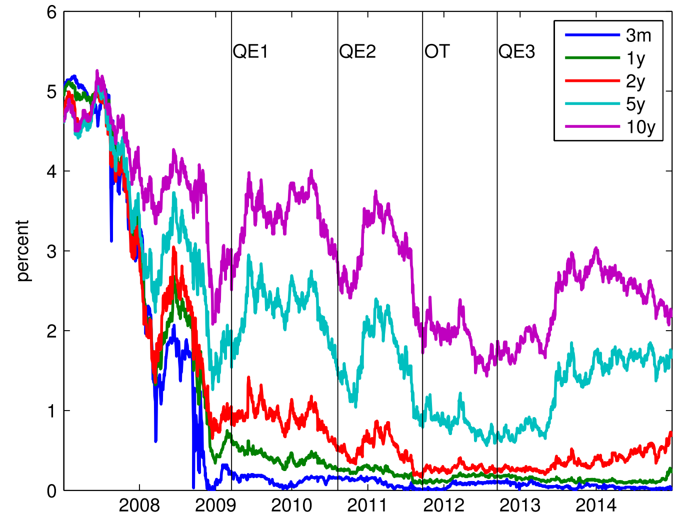

Fig. 1. US nominal government bond yields. Vertical lines mark announcements of Federal Reserve asset purchase programs (quantitative easing, operation twist).

3. Data and empirical methods

Daily data on US government bond yields of constant maturity from January 1990 to December 2014 is obtained from the Federal Reserve Board (via Datastream). Fig. 1 shows that short-term yields have hovered close to zero since late 2008, when the federal funds target rate was lowered to 0%–0.25%.

I estimate the effect of changes in short yields (3 month),[3] Δx_t, on changes in longer-term yields, Δy_t, using the following regression:

$$\Delta y_t = \beta_0 + \beta_{pos} \mathbb{1}(\Delta x_t > 0)\Delta x_t + \beta_{neg} \mathbb{1}(\Delta x_t < 0)\Delta x_t + \varepsilon_t \quad (4)$$

where $\mathbb{1}(\cdot)$ is the indicator function. This specification is also estimated in Ruge-Murcia (2006) for Japanese government bond yields over the 1995–2001 sample. I estimate how the coefficients in (4) change using rolling regressions over 1-year (250 business days) windows. Define

$$\hat{\beta}_{size,t} \equiv (\hat{\beta}_{pos,t} + \hat{\beta}_{neg,t})/2 \quad (5)$$

$$\hat{\beta}_{sign,t} \equiv \hat{\beta}_{neg,t} - \hat{\beta}_{pos,t}. \quad (6)$$

Let $\bar{\beta}_{size}$ and $\bar{\beta}_{sign}$ denote the average values of $\hat{\beta}_{size,t}$ and $\hat{\beta}_{sign,t}$ during a reference period in which short rates are well above the ZLB. Following Swanson and Williams (2014a) 1990–2000 is taken as reference period. If the ZLB is binding we expect $\hat{\beta}_{size,t} < \bar{\beta}_{size}$ and $\hat{\beta}_{sign,t} < \bar{\beta}_{sign}$.

4. Results

Table 1 reports results for the reference period 1990–2000, as well as for the ZLB-period 2009–2014. Coefficients are positive as

[2] It is sometimes argued that low rates are "hurting savers", and make it difficult for pension funds to find safe investments with sufficient return matching the maturities of funds' liabilities.

[3] I use 3-month rather than 1-month yields because 1-month yields are only available from 2001, and because they vary much less than 3-month yields during the ZLB period.