Permanent structural change in the US short-term and long-term interest rates

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Abstract

This paper uses a time-varying error correction model to examine the structural change in the rate of adjustment to the long-run equilibrium and the cointegrating vector of the US short- and long-term interest rates. We show that agents expectations of interest rate movements vary according to policy changes as reflected by changes in the direction of movements of the underlying parameters.

Keywords: Singular value decomposition; Time-varying parameters; Cointegration; Kalman filter

J.E.L. Reference Numbers: C22; C13; E43

1 Introduction

The expectations hypothesis of the term structure of interest rates, which states that the observed term structure can be used to infer market participants' expectations about future interest rates, has been viewed as pertinent to assessing the impact of monetary policy, its transmission mechanism and to provide information about expectations of participants in financial markets. There is a vast literature on the term structure of interest rates that models the relationship between the short- and long-term interest rates as a cointegration system in an error correction model (ECM) (see Campbell and Shiller (1987, 1989), Lanne (2000), Chao and Chiao (1998) and Cuthbertson et. al. (1998)). Several studies have considered nonlinear effects of idiosyncratic market and economic events on interest rate dynamics as they move towards the long-run equilibrium. Tillmann (2007) shows using a Markov switching ECM (MS-ECM) that there is a faster rate of adjustment towards equilibrium during 1979-82 when the Federal Reserve switched from interest rate targeting to monetary aggregate growth targeting. Mcmillan (2004), on the other hand, shows using a threshold ECM (T-ECM) that the asymmetric rates of adjustment in the UK short- and long-term interest rates corresponded with the central bank inflation targeting behaviour.

A common feature of the abovementioned two classes of nonlinear models is that the impact of changes in the economic environment manifests in a sudden, instead of a gradual change in the speed of interest rate adjustments. It is less probable that agents learn about changes in government policy in an abrupt fashion hence their responses are unlikely to change suddenly. The notion of gradual adjustment in agents' response is consistent with the well known Lucas' (1976) critique which states that the parameters of macroeconometric models are unlikely to be stable as policy changes are made and economic agents' adaptations to the new policy take place gradually. One class of model that could capture the steady evolution of the structural parameters is the time-varying parameter models. It is common in such models to specify the parameters to evolve according to a latent factor that follows a random walk process (see Stock and Watson (1996) and Kim and Nelson (1989)).

In this paper, we adopt a time varying ECM (TV-ECM) to capture the gradual change in the speed of adjustment and the cointegrating vector for the US federal fund rate and the 10-year treasury bond rate. We show that the evolution of the parameters have different dynamic behaviour from the parameter changes in regime-switching models derived from T-ECM and MS-ECM.

The rest of the paper is organised as follows. Section 2 discusses the TV-ECM and the estimation techniques used. Section 3 presents the empirical results for the federal funds rate and the rate of 10-year treasury bond with constant maturity. Section 4 concludes the paper.

2 Time-varying error correction model

The TV-ECM model in state-space form is

$$\Delta y_t = \begin{bmatrix} y_{1,t-1} & 0 & y_{2,t-1} & 0 \\ 0 & y_{1,t-1} & 0 & y_{2,t-1} \end{bmatrix} vec(\Pi_t) + e_t \tag{1}$$

$$vec(\Pi_t) = vec(\Pi_{t-1}) + v_t \tag{2}$$

where equations (1) and (2) are the measurement and transition equations respectively, $v_t \overset{iid}{\sim} N(0, \Omega)$ is a (4×1) vector of transition errors with Ω being a (4×4) diagonal matrix of variances, $e_t \overset{iid}{\sim} N(0, \Sigma)$ is a (2×1) vector of innovations of the measurement equation and Σ is a (2×2) diagonal matrix of variances. y_t is a (2×1) vector of observed long- and short-term interest rates. The filtered latent state variables $vec(\Pi_t)$ and parameters Σ and Ω can be determined via maximum likelihood estimation using the Kalman filter (see Harvey (1989) for details). A backward smoothing recursion algorithm (see Harvey (1989)) is then applied to derive the smoothed state variable $vec(\Pi_t)$ which is conditional on the full sample.

Following the work of Kleibergen and Paap (2002, 2006) on standard ECM, at each time t, the smoothed Π_t can be decomposed via a singular value decomposition (SVD) into

$$\Pi_t = U_t \Lambda_t V_t'$$

where U_t, V_t are (2×2) orthogonal matrices and Λ_t is a (2×2) diagonal matrix containing two singular values s_{1t} and s_{2t} (such that $s_{1t} > s_{2t} \geq 0$). Since the estimation is performed on the full rank of Π_t, not on its reduced rank, s_{1t} and s_{2t} will always be greater than zero. As there is no formal rank test for TV-ECM, a trace test of Johansen is performed on the ECM. If this test suggests cointegration between the rates, then, a rank of one is imposed on all Π_t which can be easily implemented by virture of the SVD construction. The reduce rank matrix Π_t^* can be constructed from $\Pi_t^* = U_{1t} s_{1t} V_{1t}'$ where U_{1t} and V_{1t}, respectively, are the first column of U_t and V_t. Conventionally, Π_t^* is written as $\alpha_t \beta_t'$, where α_t is the speed of adjustment vector and $\beta_t = [\ I \quad -\beta_{2t}\ ]'$ is the cointegrating vector. Then, it can be shown that $\alpha_t = U_{11t} s_{1t} V_{1t}'$ and $\beta_{2t} = -U_{21t} U_{11t}^{-1}$ (see Kleibergen and Paap (2002) for proof) where U_{i1t}, $i = 1, 2$, are the row elements of U_{1t}. The dynamics of β_t and α_t show, respectively, the evolution of the speed of adjustment and the degree of cointegration over time, which to some extent depict market participants' expectations about the impending movements of interest rates.

An added advantage of our approach is that the dynamics of s_{1t} and s_{2t} provide informal[1] identification of the degree of cointegration between the short- and long-term interest rates at a particular time t. For instance, if s_{1t} is large for all t while s_{2t} is close to zero in most period but is away from zero at time t_1, it would suggest that the short- and the long-term interest rates may not be cointegrated during t_1.

3 Data and Empirical Results

We examine the relationship between the monthly US federal fund[1] rate and the 10-year treasury bond rate between 1964:07 to 2006:10. This is an interesting period to analyse changing agents' responses to different policy stance as the US economy experienced six recessions, two oil shocks, the collapse of the Bretton Woods system of fixed exchange rate, financial deregulation and the shift in monetary policy focus of the Federal Reserve Bank.

[1] To our best of our knowledge there is no formal test on determining the rank of Π_t at time t and it is beyond the scope of this paper to determine an apppropriate test for Π_t .

[1] T*he data are obtained from http://research.stlouisfed.org/fred2/categories/46.*

We first proceed[2] to test for cointegration between the two rates based on the standard ECM. Following Johansen (1988), the trace statistics and the maximum eigen statistics indicate the presence of one cointegrating vector at the 95% confidence level respectively. Similarly, visual inspection on the paths of s_{1t} and s_{2t} (see Figures 1 and 2) indicates the rates are likely to be cointegrated for most period, and are less cointegrated during the recession of 1980 to 1982.

We divide our analysis into four periods of US monetary policy regimes. The first period is from 1973 to 1980 just after the collapse of the Bretton Woods system and the first oil shock. The second period was from 1980 to 1993 which covers the second oil shock and the Volcker regime of monetary policy that focused on controlling money supply growth to combat inflation. The third period is between 1993 and 2001 during the stewardship of Greenspan when inflation targeting was common among the world central bankers, although it was not explicitly adopted by the Federal Reserve. For the US, Taylor's (1993) rule is often used to describe Federal Reserve behaviour in balancing stable inflation with sustained economic growth. This period also included the proliferations of innovative financial products in the financial markets following financial deregulation across the developed nations. The September 11 incident happened at the end of this period with the Federal Reserve taking decisive actions to cut interest rates to bolster the economy. The last period covered the period of the twin US budget and trade deficits which created a huge liquidity of the US dollar outside the US due to the financing of "the war on terror" and the rapid economic growth in China.

It is interesting to note that some of the changes in the direction of time-varying parameters roughly coincide with developments in the US in the last 30 over years. It is observed, in Figure 3, that the evolution of α_{1t} (the rate of adjustment of the short-term interest rate) appears to respond to the four episodes of monetary policy changes - trending upwards after the first oil shock, making a sharp U-turn around 1980 at the start of Volcker reign, some minor changes in direction after 1993 and 2001 and another U-turn after 2001. There

[2] We also test *the interest rates for unit root tests using augmented Dickey-Fuller test which suggest that the existence of unit roots in the interest rates.*

is evidence that the short-term interest rate is returning significantly slower to its long-run equilibrium in the later part of the sample period than in 1983. However, the dynamic of α_{2t} (the rate of adjustment of the long-trem interest rate) has remained relatively stable during this period albeit with minor fluctuations. Given that α_{2t} is very close to zero, it appears that the long-term interest rates adjust very slowly to its long-run equilibrium relationship which suggests that the short-term rate tends to lead the long-term rate. β_{2t} , which can be intepreted as the ratio of long-term Treasury bond yield over short-term interest rate, trends upward during every recession (see Figure 4) as the Fed cuts short-term interest rate to revitalise the economy. This is most pronounce after September 11.

4 Concluding Remarks

This paper uses a TV-ECM to study gradual changes in market participants' expectations about the impending movements of the short- (the Federal fund rate) and long-term (the 10-year treasury bond) interest rates when subject to different monetary policy stance. The time varying parameters are able to adequately reflect the major policy shifts with pronounced permanent structural change thereby reflecting agents' new expectations. The long-run equilibrium relationship (see Figure 5) given by $\beta_t' y_t$ appears to be stationary albeit with very large fluctuations during recessionary periods. This suggests that there are regime changes that are not adequately captured by the more gradual changes in the parameters of the TV-ECM. Future research seeks to study the term structure of interest rates by combining both permanent structural change (based on TV-ECM) and structural shift (based on T-ECM or MS-ECM) following the work of Anderson and Low (2006) to capture both types of time series dynamics.

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Figure 1. Plot of s_{1t}

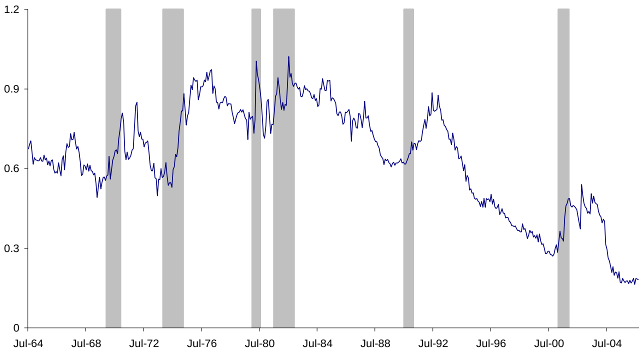


Figure 2. Plot of s_{2t}

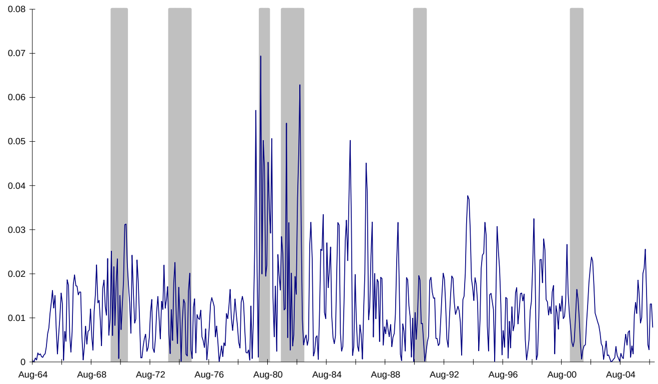


Figure 3. Plot of α_{1t} and α_{2t}

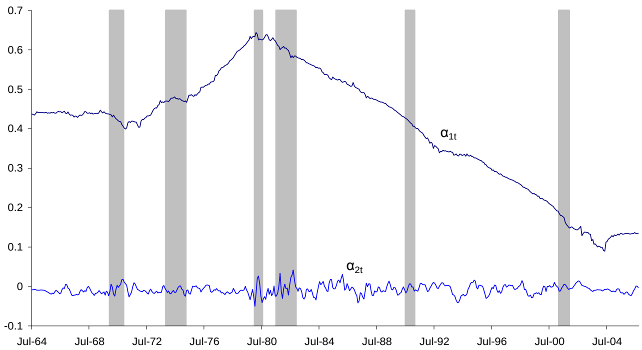


Figure 4. Plot of β_{2t}

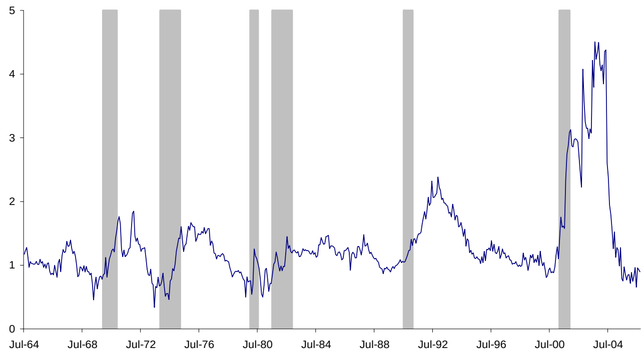
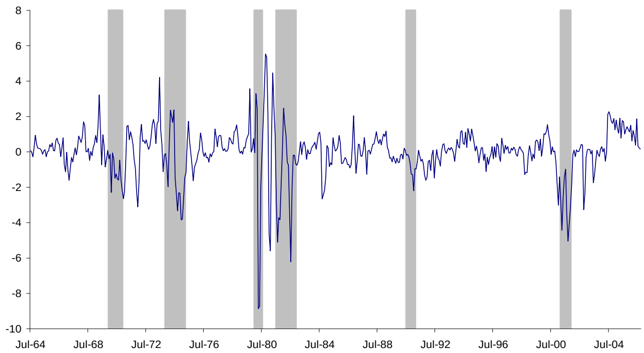


Figure 5. Plot of $\beta_t' y_t$



Shaded areas in the graphs indicate the US recession periods.