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Nonlinear adjustment in US bond yields: An empirical model with conditional heteroskedasticity ☆

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ABSTRACT

Starting from the work by Campbell and Shiller (Campbell, J.Y. and Shiller, R.J. (1987). Cointegration and tests of present value models. Journal of Political Economy, 95(5):1062–1088.), empirical analysis of interest rates has been conducted in the framework of cointegration. However, parts of this approach have been questioned recently, as the adjustment mechanism may not follow a simple linear rule; another line of criticism points out that stationarity of the spreads is difficult to maintain empirically.

In this paper, we analyse data on US bond yields by means of an augmented VAR specification which approximates a generic nonlinear adjustment model. We argue that nonlinearity captures macro information via the shape of the yield curve and thus provides an alternative explanation for some findings that recently appeared in the literature.

Moreover, we show how conditional heteroskedasticity can be taken into account via GARCH specifications for the conditional variance, either univariate or multivariate.

1. Introduction

Interest rates have been the object of extensive research in the cointegration framework in the past 20 years, stemming from the seminal paper by Campbell and Shiller (1987). A fundamental consequence of the expectation hypothesis is that the most appropriate stochastic process to represent their time-series features is some sort of $I(1)$ process. At the same time, interest rate spreads should be stationary, possibly around a non-zero mean.

Of course, this translates into very precise hypotheses on the cointegration properties of interest rates, which should cointegrate in pairs, so the cointegration rank should be $n-1$ and the cointegration vectors should be of the form $[1,0,\ldots,-1,0,\ldots]$. Both ideas can be incorporated in a classic Vector ECM as:

$$\Gamma(L)\Delta y_t = \mu_t + \alpha\beta' y_{t-1} + \varepsilon_t, \quad (1)$$

where $\beta' y_{t-1}$ is a vector containing the $(n-1)$ lagged spreads.

However, the above model is not guaranteed to fit the data flawlessly; in some cases, the spreads may appear non-stationary and the hypothesis that the cointegration rank is $(n-1)$ may be rejected by conventional tests. Such findings could be interpreted as an outright rejection of the expectation hypothesis; on the other hand, there is the possibility that the empirical model may have to be refined.

Several authors have pointed out the shortcomings of a plain VECM model: on one hand, Ang and Piazzesi (2003) suggest that the shape of the yield curve can be influenced by macro factors and, as a consequence, the typical persistence shown by macro data may result in substantial autocorrelation in the spreads, to the point that there are even doubts on their stationarity (Giese, 2006).

On the other hand, there is some evidence that the adjustment mechanism implicit in a cointegration model may follow a nonlinear dynamic in the case of bond yields. In most cases, this effect is modelled via a threshold model à la Balke and Fomby (1997). Hansen and Seo (2002) argue that adjustment follows two regimes, and is noticeable in one but not in the other. A similar argument is put forward in Krishnakumar and Neto (2005), where the authors argue that the adjustment is brought about by the monetary authority's interventions, and therefore occurs sporadically. A serious drawback of this class of models is that inference is rather complex, and the issues arising when modelling more than two series are quite difficult to handle.

An additional complication may arise because interest rates, like any other financial variable, show considerable changes in volatility if sampled at a monthly frequency or higher. This empirical regularity is widely acknowledged and has spurred the development of the gigantic literature on conditionally heteroskedastic processes, from Engle (1982) onwards. In this context, highly heteroskedastic innovations may have a dramatic impact on standard inferential procedures: estimator efficiency is an obvious issue, but there may also be robustness concerns.

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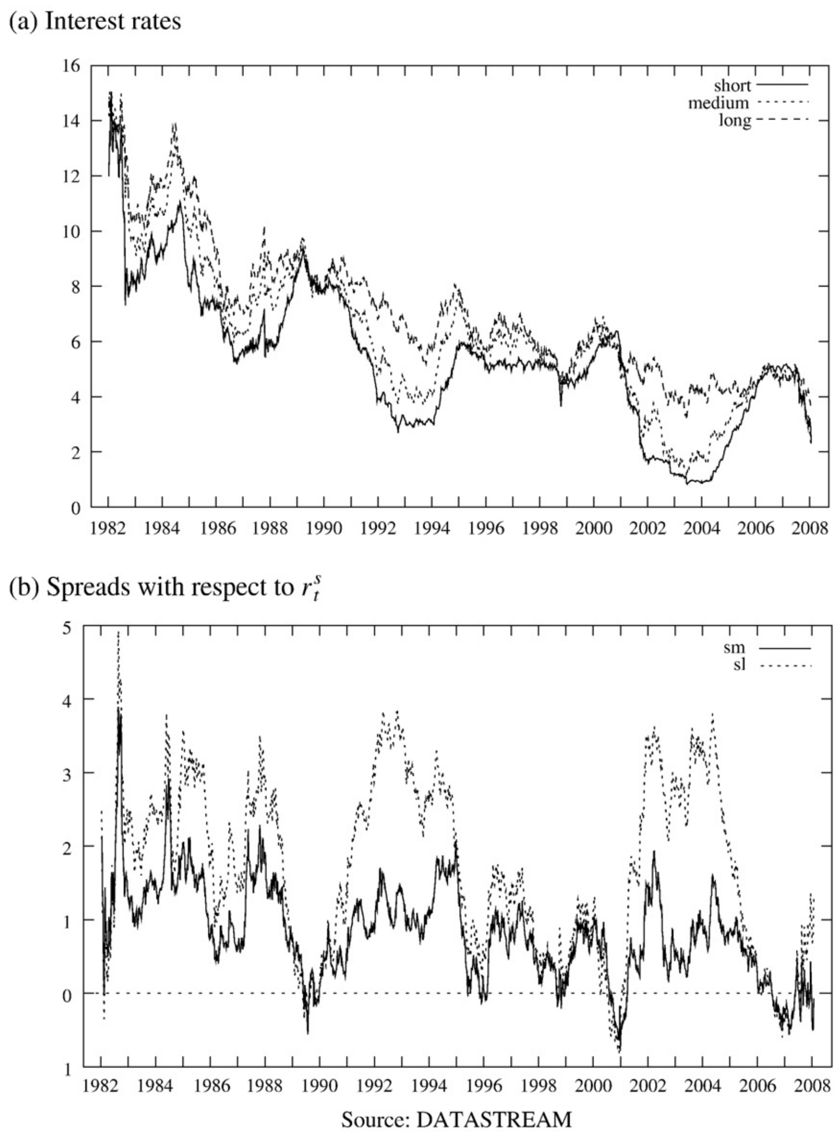

Fig. 1. The data.

In this article, we propose an empirical analysis that combines nonlinear effects in the conditional mean with conditional heteroskedasticity. The paper is structured as follows: Section 2 describes our dataset and provides some preliminary evidence to motivate our preferred models, which are presented in Section 3, while Section 4 contains the estimates, their economic interpretation and an out-of-sample comparison of the forecasts obtained with our models with some of the alternatives. Section 5 concludes.

2. Integration and cointegration properties

We have used three weekly time series for US government bonds selected for different maturities: the variables in the model are the US Treasury constant maturities 3-month (*short*, r_t^s), the US Treasury constant maturities 2-year (*medium*, r_t^m) and the US Treasury constant maturities 10-year (*long*, r_t^l). The data source is DATASTREAM.[1] The sample period goes from 1982/10/08 through 2008/01/25 and includes 1321 observations for each series; time series plots are shown in Fig. 1. The two spreads sm_t and sl_t are defined as $(r_t^m - r_t^s)$ and $(r_t^l - r_t^s)$, respectively.

The choice of modelling weekly data basically depends on the fact that monthly frequencies would not allow us to capture the adjustments occurring during the period. On the other hand, using daily data may raise other concerns, due to the fact that information arrival is not uniform through time.[2] For these reasons we assume the week as the “natural” timeframe for adjustments.

In order to ensure that monetary policy rules are broadly consistent within the sample period, the sample period starts at 1982/10/07, when the FOMC announcement was made of the switch from M1 to a target rate as the main objective, as per Thornton (2005). Moreover, in order to evaluate the out-of-sample predicting properties of our model for a reasonable time span, we kept the last 52 observations out of the sample used for estimation. These choices yield a sample size of 1269 observations, that we deem adequate for our purpose.

[1] The codes corresponding to the available series are FRTCM3M, FRTCM2Y and FRTCM10.

[2] It is well known (see Ghysels et al., 1996) that weekend effects, quote arrivals, dividend announcements or market closures can represent some examples for this evidence.