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A comparison of yield curve estimation techniques using UK data

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Abstract

I compare different methods of estimating the term structure of interest rates on a daily UK treasury bill and gilt data that spans the period from January 1995 to January 1999. In-sample and out-of-sample statistics reveal the superior pricing ability of certain methods characterised by an exponential functional form. In addition to these standard goodness of fit statistics, model performance is judged in terms of two trading strategies based on model residuals. Both strategies reveal that parsimonious representations of the term structure perform better than their spline counterparts characterised by a linear functional form. This is valid even when abnormal returns are adjusted for market movements. Linear splines overfit the data and are likely to give misleading results.

JEL classification: E43; C52; G12; G14
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1. Introduction

An important "tool" in the development and testing of financial theory is the term structure of interest or forward rates. This relationship between rates and term to maturity has proved to be critical to policy makers and to market practitioners. In particular, forward rates may serve as indicators of monetary policy and as inputs to a pricing model. Indeed, the examination of the term structure theories empowered

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by theory of contingent claims has led to the derivation of term structure models characterised by the absence of arbitrage.

There are two approaches [1] to term structure modelling. The first approach is the "term structure consistent" approach pioneered by Ho and Lee (1986) and Heath et al. (1992). Recently, Fisher and Gilles (1998) have constructed term structure models in the spirit of Heath et al. (1992) that are consistent with the unbiased expectation hypothesis. This approach works only if an estimate of the initial forward curve is inputted to the Heath et al. (1992) [2] framework. Under such conditions, the pricing and hedging of all types of interest rate claims is possible and consistent with an initial estimate of the forward or spot yield curve.

The second approach identifies a state variable with every yield of maturity τ of zero coupon bonds. This approach attributed to Duffie and Kan (1996) constructs a multifactor model of the term structure in which the yields estimated using a term structure estimation method are the state variables. Although, the idea [3] of using yields as the state variables captures almost all of the dynamics of the term structure, Steeley (1997) conducts a principal component analysis on the Bank of England's term structure estimates to find that at least two factors [4] are enough to capture almost all of the dynamics of the UK term structure. In a different study, Elton et al. (1990) employ McCulloch's (1990) term structure estimates to identify suitable proxies for the unobserved state variables that drive the US term structure of interest rates. Furthermore, Elton and Green (1998) adopt a term structure estimation method, which they augment with tax and liquidity variables [5] to account for the deviations between the actual and the model bond prices.

Despite the widespread use of the term structure of interest rates, a fundamental issue that other researchers seem to ignore is which term structure estimation method should be used in the first place to imply these estimates. Chambers et al. (1984) point out that the use of linear least squares may result in a singular matrix arising from columns that are perfectly collinear. This problem is more acute with longer maturities. An alternative problem arises when the estimation method employs cubic

[1] An alternative modelling approach to the ones mentioned is the one proposed by Ball and Torous (1983) and Schaefer and Schwartz (1987). Unlike the other single factor models that specify a process for the instantaneous short rate, Ball and Torous and Schaefer and Schwartz model the price process of pure discount bonds. Rady and Sandmann (1994) labelled this approach as the *direct approach* to debt option pricing. Another alternative and equally important modelling approach is the *pricing kernel* approach introduced by Constantinides (1992).

[2] Other term structure models that take as an input an estimate of the spot yield curve are Black et al. (1990) and Hull and White (1993). Central to each model is the use of time dependent variables that force the model estimates of the yield curve to equal that market yield curve. In such a way, the model is calibrated to market data. It is then possible to accurately recover the price of plain vanilla bonds.

[3] The idea of using yields as factors originates from the studies of Pearson and Sun (1994) and Chen and Scott (1995), who estimated two factor CIR SR models by performing a change of basis to identify the state variables with yields.

[4] Litterman and Scheinkman (1991) also recognise that the level, the steepness and curvature factors can explain 98% of the variation in yields of US coupon bonds.

[5] Elton and Green (1998) provide evidence to suggest that the tax and liquidity effects are quite small.