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A dynamic factor model of the yield curve components as a predictor of the economy

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ABSTRACT

In this paper, we propose an econometric model of the joint dynamic relationship between the Treasury yield curve components and the economy, for predicting business cycle turning points. The nonlinear multivariate dynamic factor model takes into account not only the popular slope, but also information extracted from the level and curvature of the yield curve, and from macroeconomic variables. We investigate the interrelationship between the phases of cyclical fluctuations in yield curve components and the phases of the business cycle. The results indicate a strong interrelationship between the yield curve and the economy. The proposed model has substantial incremental predictive value relative to alternative specifications. This result holds both in-sample and out-of-sample, using revised and real time unrevised data.

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1. Introduction

The term structure of interest rates has become one of the most popular leading indicators of economic activity, as there is substantial evidence of a systematic association between its dynamics and the future state of the economy.[2] Under the liquidity preference theory, investors require a premium in order to acquire long maturity bonds rather than the risk-free, short-term rate. Thus, the yield curve generally slopes upward. This is especially the case at the ends of recessions and in the early stages of economic expansions, when short term interest rates are at relatively low levels. On the other hand, the slope of the curve tends to flatten out or become inverted towards the middle and end of expansions. In addition, according to the expectation theory, long-term rates reflect market expectations for future short-term rates. Hence, a flat or inverted curve may indicate that the market expects a future fall in interest rates, given the prospect of future weak economic activity.

There is a large body of literature that investigates the prediction of future economic activity using the term structure of interest rates; see, for example, Ang, Piazzesi, and Wei (2006), Chauvet and Potter (2002, 2005), Estrella and Hardouvelis (1991), Estrella and Mishkin (1998), Hamilton and Kim (2002), Harvey (1988, 1989), Stock and Watson (1989), and Wright (2006), among many others, or Stock and Watson (2003) for an extensive survey of this literature. In general, linear regression models are used to forecast the growth rate of economic activity, and discrete choice models such as probit or logit specifications are used to predict the probability of a recession. While these models predominantly use the slope, Ang et al. (2006) show that more efficient and accurate forecasts

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2 The terms 'yield curve', 'term structure of interest rates' and 'term spread' generally refer to the differences in returns between government bonds of different maturities. The slope of the yield curve is the difference between long-run and short-run government bonds.

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of quarterly real GDP growth can be obtained by using information from other components of the yield curve.

This paper proposes an econometric model of the joint dynamic relationship between the components of the yield curve and the economy for predicting business cycles. In contrast to the previous literature, the proposed dynamic latent bi-factor model takes into account not only the slope, but also the information extracted from other components of the yield curve and from real economic activity, in order to forecast the beginnings and ends of recessions at a monthly frequency. In particular, we use *empirical* time series proxies of the level, slope, and curvature of the yield curve, from which we extract a latent factor that we then use to predict the economy.[3] We also consider a second latent factor representing the real sector, constructed from employment, real personal income, and industrial production, which are the commonly-monitored coincident series of economic activity at a monthly frequency. These two factors are then estimated simultaneously from the observable variables and from their relationships with each other. Since some changes in the yield curve components are cyclical and may be related to future economic expansions and recessions, we allow the latent factors to follow different two-state Markov switching processes.[4] The resulting cyclical phases of the term spreads and the economy are linked through the dependence structure of the factors in the transition equations.[5]

The proposed framework has several advantages over the previous literature on forecasting recessions using term spreads. First, our framework incorporates comprehensive information from the components of the yield curve and from the economy in a parsimonious setting. A crucial feature of this model is the fact that the nonlinear combination of several variables mitigates the instability of each individual series. Second, the methodology takes into consideration the interrelationship between the components of the yield curve and economic activity, through the dynamic factors and the Markov processes. In particular, the Markov probabilities allow for the analysis of interactions between cyclical phases of the term spreads and phases of the business cycle. Since term spreads anticipate business cycle phases with a variable lead, the proposed flexible framework enables us to study their time-varying lead–lag relationship over each expansion and recession that has occurred in the US over the last 40 years, rather than pre-imposing a structure on their linkages. As the results show, this information turns out to be very important for predicting business cycle phases.

Finally, the multivariate framework, combined with nonlinearities in the form of switching states, can capture changes in the stochastic structure of the economy, such as the possibility of recurrent breaks. Several recent papers have shown that the predictive content of the term spread is not stable over time. In general, linear regression models that use output growth as the dependent variable indicate that the forecasting ability of the term spread has decreased since the mid-1980s.[6] Although the results from binary models of recession are less clear, Chauvet and Potter (2002, 2005) find overwhelming evidence of breaks in the relationship between the yield curve and economic activity when using probit models estimated with Bayesian techniques. The results show that ignoring structural changes affects the reliability of real time forecasts severely.[7]

We investigate the in-sample and out-of-sample performances of the extracted yield curve factor for forecasting future economic activity, in terms of event timing—the beginning and end of business cycle phases, and average probability forecasts. The analysis is performed using both revised data and real time unrevised data. In addition to the proposed joint model of the term spread and the economy, as a comparison we also estimate a multivariate factor model that uses only the information on the yield components, as well as univariate nonlinear models of the yield curve components, and probit models.

Our results indicate a strong correlation between the real economy and term spreads. The latent factor extracted from their interrelationship displays a better performance for anticipating economic recessions than alternative frameworks. In particular, the yield-economy factor predicts the beginnings and ends of all recessions (including that in 2007–2009) in the sample studied, with no false peaks or troughs and no missed turns—a perfect forecast score. An important feature of the model is its usefulness for predicting not only the beginning but also the end of recessions. For example, in real time, the yield-economy factor model predicts the end of the 2007–2009 recession correctly, with a lead of 18 months, as occurring in June 2009.[8] The NBER dating committee only announced the end of this recession as having been in June 2009 fifteen months after its occurrence, in September 2010.

We also evaluate the in-sample and out-of-sample forecasting performances of the proposed models and

[3] Our goal is not to model or forecast the yield curve, but to obtain a forecasting model of the economy using yield curve components. Another strand of the literature focuses on modeling and forecasting the yield curve per se. Diebold and Li (2006) re-interpret Nelson and Siegel's (1987) term-structure model as a three-factor model of the level, slope, and curvature, and produce term-structure forecasts. Diebold, Rudebusch, and Aruoba (2006) extend this framework to examine the bivariate dynamic relationship between the yield curve and the macroeconomy. Ang and Piazzesi (2003) examine how macroeconomic variables affect bond prices and yield dynamics using a vector autoregression framework. In contrast to these studies, our aim is not to model or predict the yield curve, but to extract information from its components in order to forecast business cycle turning points.

[4] Bernadell, Coche, and Nyholm (2005) extend Diebold and Li's (2006) model by including Markov switching in the factors, with transition probabilities as functions of macro variables for producing term-structure forecasts. Nyholm (2007) extends this framework to the forecasting of recessions.

[5] The proposed Markov-switching dynamic bi-factor model is closely related to the framework applied by Chauvet (1998/1999), Chauvet and Huang (2009), and Senyuz (2008, 2011), who use this approach to study the relationships between the stock market and the economy, and the housing market and the economy.

[6] See, for example, Dotsey (1998), Friedman and Kuttner (1998), Giacomini and Rossi (2006), Haubrich and Dombrosky (1996), or Stock and Watson's (2003) survey.

[7] See Dueker (1997), Estrella and Mishkin (1998), Estrella, Rodrigues, and Schich (2003), and Neftci (1996).

[8] The NBER Business Cycle Dating Committee had not yet announced the end of the last recession at the time when this paper was first written.