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Macroeconomic determinants of the term structure: Long-run and short-run dynamics☆

Hitesh Doshi [a], Kris Jacobs [a,*], Rui Liu [b]

[a] University of Houston, United States
[b] Duquesne University, United States

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ABSTRACT

We propose a no-arbitrage term structure model with a Taylor rule and two macroeconomic variables, real activity growth and inflation, that each contain long-run and short-run components. Variance decompositions indicate that the impact of macroeconomic variables on the term structure differs from existing models. For short maturities, inflation is relatively more important than real activity growth at short forecast horizons. For longer maturity yields, the long-run component of inflation explains most of the long-horizon forecast variance, but real activity growth matters for short forecast horizons. Unlike existing macro models, the model implies plausible term premia and expectations of short rates. The long-run components also improve the prediction of bond excess returns relative to information in the yield curve and macro variables. Measures of in-sample and out-of-sample fit confirm the benefits of allowing for long- and short-run components.

1. Introduction

The literature on modeling the term structure of default-free interest rates is extensive. Many existing term structure models use dynamic no-arbitrage models with latent factors to explain the movements of the yield curve. Early studies include Vasicek (1977) and Cox et al. (1985), which are special cases of the affine class described by Duffie and Kan (1996). The drawback of these models is that they do not readily provide information about the underlying economic determinants of the yield curve. More recently, a burgeoning literature incorporates macroeconomic factors, specifically real activity growth and inflation, into no-arbitrage term structure models.[1] These studies confirm our intuition that macroeconomic fluctuations are an important source of uncertainty that affect bond yield dynamics.

This paper contributes to the literature on the term structure of interest rates with macroeconomic variables. We propose a no-arbitrage VAR model of term structure dynamics with two macroeconomic variables, real activity growth and inflation. The macroeconomic variables contain long-run and short-run components, which amounts to autoregressive specifications for the macro variables with a time-varying stochastic mean. This specification is motivated by a strand of the macroeconomic literature which

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* Correspondence to: C.T. Bauer College of Business, 334 Melcher Hall, University of Houston, Houston, TX 77204-6021, USA.
E-mail address: kjacobs@bauer.uh.edu (K. Jacobs).

[1] The literature on term structure models with macroeconomic variables is too large to cite in full here. Some important papers include Ang and Piazzesi (2003), Diebold et al. (2006), Ang et al. (2006), Lu and Wu (2009), Ang et al. (2011), Joslin et al. (2014), and Ajello et al. (2012). See Duffee (2013a) and Gürkaynak and Wright (2012) for an overview of this literature.

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argues that macroeconomic variables, such as inflation, follow first-order autoregressive processes with time-varying parameters. The macroeconomic variables contain a slowly moving trend component that is related to the monetary policy target, and the trending component is approximated by the long-run mean of the macro variables. This decomposition has been widely used in the macroeconomic literature, see for instance (Cogley and Sargent, 2001, 2005; Erceg and Levin, 2003; Stock and Watson, 2007; Cogley et al., 2010; Faust and Wright, 2011).

We incorporate these stylized features of macroeconomic variables into the modeling of the yield curve. Our main objective is to study the impact of long-run and short-run components of the macroeconomic variables on the term structure of yields. We decompose the proportion of total forecast variance that can be attributed to each of the four state variables at different maturities, and a complex picture emerges. By ignoring the component structure of inflation and real activity growth, one would conclude that inflation is the main determinant of the variance at all maturities and for all forecast horizons. In the component model, the relative importance of inflation and real activity growth critically depends on the maturity and the forecast horizon. The short-run component of inflation explains a large proportion of the short-horizon forecast variance at the short end of the term structure. The long-run component of inflation on the other hand explains most of the long-horizon forecast variance for long-maturity yields.

Interest rate expectations and term premia implied by the model with long-run and short-run components are more plausible than those implied by existing models. Model-implied short-term interest rate expectations exhibit a substantial decline over the last two decades, consistent with survey-based expectations of inflation and policy rates (see for example Kozicki and Tinsley, 2001a; Kim and Orphanides, 2012; Wright, 2011). Term premia, estimated as the difference between long-term rates and expected future short-term rates, are more stable in the component model. This finding is particularly noteworthy because the excessive variability of term premia constitutes a puzzle in the literature on dynamic term structure models (Kim and Orphanides, 2012).

We examine the predictability of bond excess returns using macro variables and their components filtered from the component model. Incorporating the long-run components in standard predictive regressions improves the forecast performance relative to models with macro variables or relative to information in the current yield curve, especially for bonds with two- to five-year maturities. These results suggest that the filtered long-run components help uncover information that is also captured by models with hidden or unspanned risk factors (Duffee, 2011; Joslin et al., 2014).

We compare the in-sample and out-of-sample performance of the newly proposed component model with several alternative specifications that are widely used in the literature. The component model provides substantial improvements in in-sample fit relative to the benchmark macro model without long-run components, especially for long-maturity yields, and it has uniformly better out-of-sample performance than the benchmark model. For long maturities, the component model also outperforms models with three latent factors and models with three latent factors and macroeconomic variables. These results suggest that the long-run component of inflation is important for yield curve modeling, both for improving in-sample and out-of-sample performance.

Our analysis is related to several other existing strands of the fixed income literature. Some studies integrate state variables with stochastic means, which are usually referred to as shifting endpoints, into no-arbitrage models. Part of this literature focuses on latent models, see for instance Kozicki and Tinsley (1998, 2001a), who find that models with shifting endpoints perform much better for explaining long-term yields.[2] Other studies use no-arbitrage term structure models with macroeconomic variables that contain shifting endpoints. These models embed various economic restrictions, and are mainly focused on the role of the term structure in identifying the monetary policy rule and forecasting macroeconomic variables.[3] In contrast, the economic structure of our model is simpler, consisting of a simple Taylor rule as in Ang and Piazzesi (2003), and our focus is on the in- and out-of-sample performance of the term structure model and the impact of macroeconomic variables on the term structure. On the other hand, our model is more complex with respect to the richness of the risk neutralization and the structure of the effects of the macro variables.

Our analysis is also related to fixed-income studies that model change in the structure of the model and the parameters. One strand of the literature formulates and estimates regime-switching models.[4] Another literature models the effect of learning, often in the context of a more elaborate economic model.[5] While the long-run mean of inflation and real activity growth in our model can be thought of as the result of a learning process, our results may just as well be interpreted as resulting from an improved statistical specification of the macro variables.

The remainder of the paper is organized as follows. Section 2 presents the term structure model with long-run components. Section 3 describes the data and the estimation strategy. Section 4 presents the parameter estimates and the in-sample and out-of-sample model performance. Section 5 discusses the economic implications of the models, and Section 6 concludes.

2. The model

In this section, we describe the pricing model for default-free bonds. Let r_t denote the instantaneous default-free interest rate. We assume that r_t has a linear specification given by

$$r_t = \alpha_0 + \alpha_1 g_t + \alpha_2 \pi_t, \tag{1}$$

[2] Bauer and Rudebusch (2017) show that accounting for the shifting endpoints in the equilibrium real interest rate and inflation increases the accuracy of long-range interest rate forecasts.

[3] See for instance Dewachter and Lyrio (2006, 2008), Dewachter et al. (2006), and Berardi (2009).

[4] See for instance Hamilton (1988), Ang and Bekaert (2002), Ang et al. (2008), Bikbov and Chernov (2010), Bansal and Zhou (2002), and Dai et al. (2007).

[5] See for instance Dewachter and Lyrio (2008), Laubach et al. (2007), and Orphanides and Wei (2012).