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Yield curve in an estimated nonlinear macro model

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ABSTRACT

This paper estimates a sticky price macro model with US macro and term structure data using Bayesian methods. The model is solved by a nonlinear method. The posterior distribution of the parameters in the model is found to be bi-modal. The degree of nominal rigidity is high at one mode ("sticky price mode") but is low at the other mode ("flexible price mode"). I find that the degree of nominal rigidity is important for identifying macro shocks that affect the yield curve. When prices are more flexible, a slowly varying inflation target of the central bank is the main driver of the overall level of the yield curve by changing long-run inflation expectations. In contrast, when prices are more sticky, a highly persistent markup shock is the main driver. The posterior probability of each mode is sensitive to the use of observed proxies for inflation expectations. Ignoring additional information from survey data on inflation expectations significantly reduces the posterior probability of the flexible price mode. Incorporating this additional information suggests that yield curve fluctuations can be better understood by focusing on the flexible price mode. Considering nonlinearities of the model solution also increases the posterior probability of the flexible price mode, although to a lesser degree than using survey data information.

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1. Introduction

Dynamic term structure models that use a few factors to explain changes in the shape of the entire yield curve are empirically successful.[1] In these models, factors are typically extracted from a statistical decomposition of the yield curve. However, the economic interpretation of such statistical factors is not clear. Recent empirical studies on the macroeconomics of the term structure (e.g., Ang and Piazzesi, 2003; Bikbov and Chernov, 2010; Diebold et al., 2006) show a close link between macroeconomic variables and bond prices. These studies augment statistical factors of the yield curve with macroeconomic variables. Despite the inclusion of macro variables, latent term structure factors without a clear economic interpretation still explain a significant portion of the variation of the yield curve.

In this paper, I set up and estimate a New Keynesian dynamic stochastic general equilibrium (DSGE) model to explain the joint fluctuations of macroeconomic variables and the yield curve. In the model, four different shocks drive economic fluctuations. They are shocks to technology, firms' price markups, the inflation target of the central bank, and a transitory monetary policy shock. I do not add latent term structure factors that are orthogonal to macro shocks and instead try to maximize the explanatory power of macro factors. By linking the estimates of shocks with empirical counterparts of latent term structure factors, I provide an economic interpretation of these purely statistical factors. In addition, the DSGE framework can shed light on the kind of endogenous amplification channels that can account for how these macro shocks

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[1] For the assessments of fit of empirical factor models of the yield curve, see Singleton (2006, Chapter 13).

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drive yield curve fluctuations. Such an explanation is not possible to explore in factor models of the yield curve augmented with observed macro variables.

This paper uses a second-order approximate solution in the estimation of the DSGE model. There are two reasons for this approach. First, Fernàndez-Villaverde et al. (2006), An (2005), and Amisano and Tristani (2007) show that there are noticeable differences in the likelihood and parameter estimates across first-order and second-order solutions. These differences are large when data are highly persistent. Bond yields have this property (see Fig. 1). Therefore, one can expect nonlinearities to be important in the estimation with yield curve data. Second, the first-order accurate solution of a DSGE model ignores terms which can contribute to term premia. I propose a method to analytically evaluate conditional expectations of no-arbitrage conditions for bond yields, based on the stochastic discount factor given by a second-order solution of the DSGE model. This approach differs from Hördahl et al. (2008), Ravenna and Seppälä (2006), and Rudebusch and Swanson (2008) who use various approximations for bond yields on top of a higher-order approximation to the macro solution.

Three main findings are obtained from this study. First, the posterior distribution of the parameters in the model is found to be bi-modal. Posterior probability is much higher for the mode with a high degree of nominal rigidity ("sticky price mode") than the mode with a low degree of nominal rigidity ("flexible price mode"). However, the posterior probability of each mode is sensitive to the inclusion of observed proxies for inflation expectations from the survey of professional forecasters. Since the flexible price mode captures the time variation of survey data better than the sticky price mode, including this additional information substantially increases the posterior probability of the flexible price mode.

Second, nominal rigidity is important in identifying the macro factors of the yield curve. When prices are more flexible, the low-frequency movements of inflation and the overall level of the yield curve are mostly driven by nominal disturbances. But if prices are sticky, real disturbances matter more. The degree of nominal rigidity also determines which shocks account for the slope of the yield curve. For instance, when nominal rigidity is low, markup shocks are the main drivers of the slope; whereas, when nominal rigidity is high, monetary policy shocks dominate.

Third, the nonlinearities of the model solution are also important for assessing the posterior probability of each mode. Ignoring nonlinearities of inflation dynamics reduces the posterior probability of the flexible price mode, although to a lesser degree than using survey data information.

This paper is related to the literature linking estimated macro shocks obtained from DSGE models with the yield curve. Evans and Marshall (2007) use empirical measures of macro shocks to identify economic determinants of the nominal

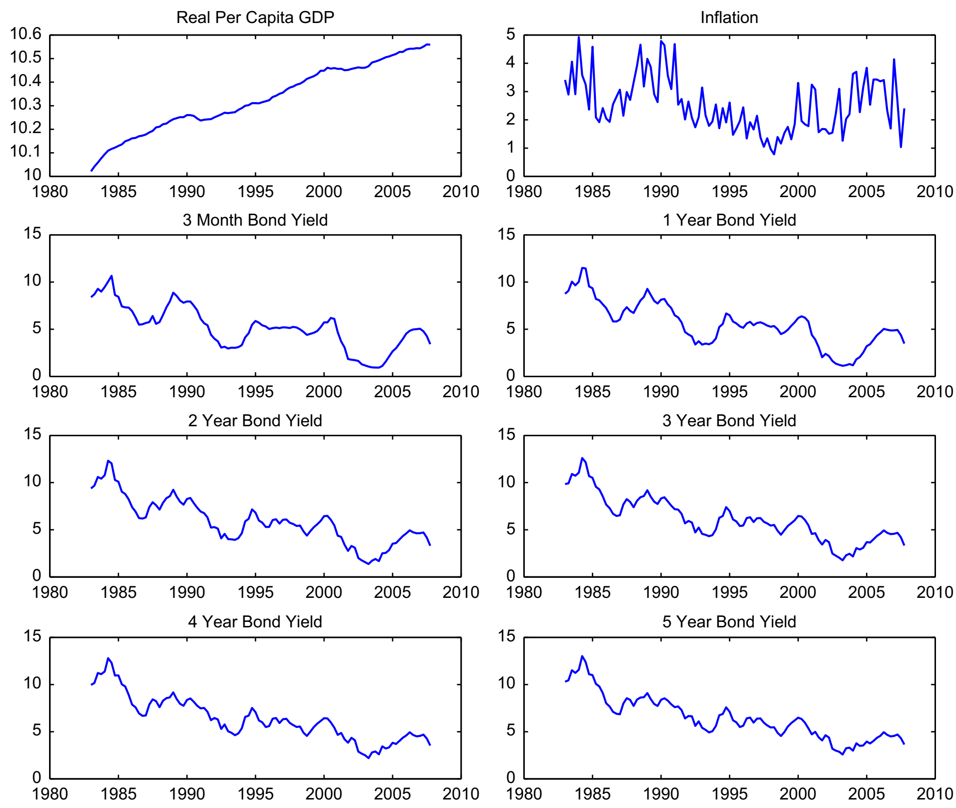

Fig. 1. Time series plots of data. *Notes*: inflation and bond yields are expressed in the annualized percentage rate.

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