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# Macroeconomic linkages between monetary policy and the term structure of interest rates<sup>☆</sup>

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## ABSTRACT

This paper studies the equilibrium term structure of nominal and real interest rates and the time-varying bond risk premia implied by a stochastic endogenous growth model with imperfect price adjustment and monetary policy shocks. The production and price-setting decisions of firms drive low-frequency movements in growth and inflation rates that are negatively related. With recursive preferences, these growth and inflation dynamics are crucial for rationalizing key stylized facts in bond markets. When calibrated to macroeconomic data, the model quantitatively explains the means and volatilities of nominal bond yields and the failure of the expectations hypothesis.

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## 1. Introduction

Explaining key features of the term structure of interest rates is a challenge for standard macroeconomic models. [Backus, Gregory, and Zin \(1989\)](#), [den Haan \(1995\)](#), and [Donaldson, Johnsen, and Mehra \(1990\)](#) show that workhorse macroeconomic models have difficulty in rationalizing the average term spread and failure of the expectations hypothesis. Empirical evidence suggests a tight link between bond yields and macroeconomic fluctuations. [Ang, Piazzesi, and Wei \(2006\)](#) and [Estrella \(2005\)](#) show that the slope of the yield curve forecasts output growth and inflation. Further, monetary policy rules (e.g., [Taylor, 1993](#)) provide a channel connecting interest rates and aggregate variables. This paper proposes a general equilibrium production-based framework to explain term structure facts jointly with the dynamics of monetary policy and the macroeconomy.

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The model embeds an endogenous growth framework of vertical innovations (e.g., Grossman and Helpman, 1991; Aghion and Howitt, 1992; Peretto, 1999) into a standard New Keynesian Dynamic Stochastic General Equilibrium (DSGE) model.<sup>1</sup> This model has several distinguishing features. First, households have recursive preferences so that they are sensitive to uncertainty about long-term growth prospects (e.g., Epstein and Zin, 1989; Bansal and Yaron, 2004). Second, the central bank sets the short-term nominal interest rate targeting inflation and output deviations (i.e., a Taylor rule). Third, expected inflation and growth prospects are related to firms' production decisions. Fourth, productivity uncertainty is time-varying.

When calibrated to match the time series properties of macroeconomic variables, such as consumption, output, investment, labor, inflation, and wage dynamics, the model can quantitatively explain the means, volatilities, and auto-correlations of nominal bond yields. The model also captures the empirical failure of the expectations hypothesis. Namely, excess bond returns can be forecasted by the forward spread (e.g., Fama and Bliss, 1987) and by a linear combination of forward rates (e.g., Cochrane and Piazzesi, 2005).

Three key ingredients allow the model to rationalize these bond market facts. First, the endogenous growth channel generates long-run risks through firms' innovation decisions as in Kung and Schmid (2014). Second, the presence of nominal rigidities helps to generate a negative relation between expected growth and inflation. Imperfect nominal price adjustment implies that equilibrium inflation is linked to the present discounted value of current and future real marginal costs. A positive productivity shock lowers marginal costs and, therefore, inflation. Also, firms invest more after an increase in productivity, which raises expected growth prospects. With recursive preferences, a negative growth-inflation relation leads to a positive and sizable nominal term premium. Third, fluctuating productivity uncertainty leads to time-varying bond risk premia.

The model links monetary policy to asset prices through the Taylor rule. For example, more aggressive inflation targeting reduces nominal risks, which lowers the average nominal term spread. A negative growth-inflation link implies that more aggressive inflation smoothing amplifies real risks and, thus, increases the equity premium. Similarly, more aggressive output stabilization lowers the equity premium but increases the nominal term spread.

This paper relates to consumption- and production-based models of the term structure. Backus, Gregory, and Zin (1989) show that a standard consumption-based model with power utility fails to account for sign, magnitude, and volatility of the term spread. Consumption-based models with richer preference specifications and model dynamics, such as Wachter (2006), Piazzesi and Schneider (2007), Gallmeyer, Hollifield, Palomino, and Zin (2007), and Bansal and Shaliastovich (2013), find more success. The bond pricing mechanisms of this paper are most closely related to Piazzesi and Schneider (2007) and

Bansal and Shaliastovich (2013). The present model endogenizes the inflation and consumption growth dynamics from Piazzesi and Schneider (2007) and Bansal and Shaliastovich (2013) and connects them to firms' production decisions.

Linking the term structure explicitly to investment and production relates to Jermann (2013), who uses a pure production-based framework to explain the average yield curve and failure of the expectations hypothesis. However, previous literature demonstrates that integrating the consumption- and production-based frameworks in a general equilibrium setting has difficulty in accounting for both term structure facts and macroeconomic dynamics. Donaldson, Johnsen, and Mehra (1990) and den Haan (1995) show that extensions of the real business cycle model with power utility cannot rationalize the sign and magnitude of the average term spread, which is related to the equity premium puzzle. Rudebusch and Swanson (2008) and Palomino (2010) show that introducing habit preferences with labor market frictions can generate a sizable nominal term premium but only with counterfactual macroeconomic implications (i.e., consumption and real wage volatility are substantially larger than the data). Rudebusch and Swanson (2012) and Binsbergen, Fernandez-Villaverde, Kojien, and Rubio-Ramirez (2012) demonstrate that introducing recursive preferences produces a large term premium but only with a very high coefficient of relative risk aversion (i.e., over 100). In contrast, this paper provides a production framework that can explain the nominal term premium along with macroeconomic fluctuations without relying on high risk aversion.

More broadly, this paper relates to general equilibrium production-based asset pricing models studying the equity premium. Jermann (1998), Lettau and Uhlig (2000), and Boldrin, Christiano, and Fisher (2001) analyze production-based asset models with habit preferences. Ai (2009), Croce (2012), Kuehn (2008), Kaltenbrunner and Lochstoer (2008), Favilukis and Lin (2012), and Kung and Schmid (2014) explore how long-run risks arise in production economies. Barro (2006), Gourio (2012), and Petrosky-Nadeau, Zhang, and Kuehn (2013) consider rare disasters. Given the positive results of this literature, it is encouraging to extend this paradigm to study the term structure of interest rates.

The paper is organized as follows. Section 2 outlines the benchmark model. Section 3 explores the quantitative implications of the model. Section 4 concludes.

## 2. Model

This section presents the benchmark model and is followed by a discussion of the qualitative implications of the model.

### 2.1. Households

Assume a representative household that has recursive utility over streams of consumption  $C_t$  and leisure  $\bar{L} - L_t$ :

$$U_t = \left\{ (1-\beta)(C_t^*)^{(1-\gamma)/\theta} + \beta(E_t[U_{t+1}^{1-\gamma}])^{\frac{1}{\theta}} \right\}^{\theta/(1-\gamma)} \quad (1)$$

<sup>1</sup> See Woodford (2003) and Galí (2008) for textbook treatments of New Keynesian models.

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