Journal of Empirical Finance 33 (2015) 208–222

Contents lists available at ScienceDirect

Journal of Empirical Finance

journal homepage: www.elsevier.com/locate/jempfin

Real term structure forecasts of consumption growth☆

Efthymios Argyropoulos *, Elias Tzavalis

Athens University of Economics & Business, Greece

ARTICLE INFO

Article history:
Received 9 December 2014
Accepted 16 March 2015
Available online 25 March 2015

JEL classification:
G12
E21
E27
E43

Keywords:
Real term structure of interest rates
Gaussian affine term structure models
Price of risk
Principal component analysis
Consumption forecasts

ABSTRACT

This paper employs an empirically tractable affine term structure model of real interest rates to examine the predictive ability of the real short-term interest rate and its term spread with a longer-term interest rate to predict future real consumption growth. The estimates of the model provide support of the consumption smoothing hypothesis. The paper shows that the real term structure is spanned by two mean-reverting state variables. The mean-reverting property of these variables can consistently explain the forecasting ability of the short-term real rate and term spread to forecast future consumption growth rate, over different horizons ahead. Although the risks associated with changes in these variables are both priced in the market, they are not volatile enough to obscure the information of the real term structure about future real consumption growth.

1. Introduction

In contrast to the vast amount of studies on the nominal term structure models (see, e.g., Dai and Singleton (2002), Ang et al. (2006), for a survey), there are few studies in the literature estimating term structure models of real interest rates. This may be attributed to the lack of availability of real interest rate data, for different maturity intervals. Estimating real term structure models is useful for two main reasons. First, it can indicate the number of state variables underlying this term structure of interest rates and it can reveal their mean-reverting properties and associated prices of risk. The results of this analysis can be compared to those on the nominal term structure of interest rates. Second, it can explain if the real term structure contains important information about future real consumption growth.

The information content of the real term structure of interest rates about real consumption growth has been studied in a number of studies in the literature (see, e.g., Harvey (1988), Plosser and Rouwenhorst (1994), Chapman (1997), Rendu de Lint and Stolin (2003), Berardi and Torous (2005), and Tsang (2008)).[1] These studies show that the term spread between long and short-term real (or nominal) interest rates appears to contain information about future real consumption growth and economic activity, at short or long horizons. As noted by Harvey (1988), this information of the term spread can be attributed to the desire of investors to smooth their consumption

☆ The authors acknowledge financial support from the Research Funding Program Large Shocks-Aristeia II-5413 which is co-financed by the European Union (European Social Fund — ESF) and Greek national funds through the Operational Program "Education and Lifelong Learning" of the National Strategic Reference Framework (NSRF).

* Corresponding author.
E-mail addresses: Efargyrop06@aueb.gr (E. Argyropoulos), E.Tzavalis@aueb.gr (E. Tzavalis).

[1] Note that there is also a close related literature which studies and confirms the leading indicator property of the term structure for real economic activity and consumption growth and, in particular, of the term spread between the long and short term interest rates (see, e.g., Stock and Watson (1989), Estrella (1997) and Jardet (2004)). These papers however rely on the term spread between nominal interest rates, following Donaldson et al. (1990).

http://dx.doi.org/10.1016/j.jempfin.2015.03.013
0927-5398/

over time. This is consistent with the predictions of the consumption capital asset pricing. In addition to the term spread, evidence reported in the above studies suggests that the level of real short-term real interest rate also contains significant information about the future real consumption growth.

This paper contributes into the above literature on many fronts. First, using real consumption and term structure interest rate data, instead of nominal, it estimates an empirically tractable Gaussian dynamic term structure model and derives estimates of the underlying unobserved state variables (factors) spanning the term structure of real interest rates. Then, it examines if this model fits satisfactorily into the data and tests its cross-section restrictions implied by no-profitable arbitrage conditions in the bond market. This is done based on an econometric framework, which apart from real interest rates and excess holding period returns, it also includes consumption data. Second, it employs the suggested term structure model to investigate if the short-term real interest rate and its spread with a longer term real interest rate can predict future real consumption growth, over different horizons ahead. To this end, the paper derives closed form formulas of the slope coefficients of the above variables in consumption growth regressions.

The results of the paper lead to a number of interesting conclusions. First, they show that our term structure model is consistent with the data, which provides support of the consumption smoothing hypothesis. Second, they indicate that there are two state variables (common factors) which can explain almost all of variation of the term structure of real interest rates. These variables are closely related to the first two principal component factors that can be retrieved from real interest rates. The parameter estimates of our model indicate that shocks to the above state variables are mean-reverting and the risks associated with them are priced in the market. The mean-reversion property of the state variable processes can consistently explain the information context of the short term real rate and its spread with a longer term real interest rate about future real consumption growth. Time-varying term premia effects, which reduce the speed of mean reversion of the state variables under the risk neutral measure, are not found to be big and enough to obscure the information context of real term structure about future interest rates and consumption growth rate.

The paper is organized as follows. Section 2 presents our real term structure of interest rate model and derives closed form solutions of the slope coefficients of the consumption growth regression model, employed in the literature to forecast future real consumption growth. Section 3 estimates this model and evaluates its forecasting ability on real consumption growth. This section includes unit root tests and principal component analysis for real interest rates. The unit root tests can confirm if real interest rates constitute stationary series, as it is assumed by affine term structure models. The principal component analysis can indicate the number of unknown state variables which should be assumed by the model. Our empirical analysis is based on data from the US economy. Section 4 concludes the paper and summarizes its main results.

2. Model setup

Consider an economy with production and stochastic investment opportunity sets (see, e.g., Cox et al. (1985a, 1985b), or Longstaff and Schwartz (1992)). The investment opportunity set consists of zero-coupon bonds of different maturity intervals τ, a riskless asset and a stochastic production process. We assume that this economy is characterized by K-state variables at time t, denoted as x_{it}, stacked into a $(K\times 1)$-dimensional vector $X_t=(x_{1t}x_{2t},\dots,x_{Kt})'$. These variables obey the following vector Gaussian processes[2]:

$$dX_t = k(\theta - X_t)dt + \Sigma dW_t, \tag{1}$$

where W_t denotes a $(K\times 1)$-dimensional Wiener vector process, k and Σ are $(K\times K)$-dimension matrices including in their diagonals the speed of mean-reversion and volatility parameters of processes x_{it}, denoted respectively as k_{ii} and σ_{ii}, and θ is a $(K\times 1)$-dimensional vector of the long-run means of x_{it}.

The instantaneous real interest rate r_t is assumed to be affine in the state vector X_t, i.e.,

$$r_t = \delta_0 + \delta_1' X_t, \tag{2}$$

where δ_0 is a constant and δ_1 is a $(K\times 1)$ vector of loading coefficients, $\delta_1=(\delta_{1,1},\delta_{1,2},\dots,\delta_{1,K})'$. These state variables constitute common factors which determine real consumption C_t, or its growth rate, in the economy. If inflation rate is constant, it can be proved that real consumption growth $\frac{dC_t}{C_t}$ obeys the following stochastic process:

$$\frac{dC_t}{C_t} = \left(\sum_{i=1}^{K} x_{it} - c\right)dt + \sigma_c dW_{ct}, \tag{3}$$

where c is a constant which depends on inflation rate and the proportion between consumption and wealth, and W_{ct} is a Wiener process.[3] By solving forward Eq. (3), it can be shown that the expected growth rate of consumption C_t from current period t to a future

[2] See also Vasicek (1977), Dai and Singleton (2002), Ahn (2004), Berardi and Torous (2005).

[3] Note that the above assumptions about the instantaneous real rate r_t and real consumption growth rate $\frac{dC_t}{C_t}$ (see (2) and (3), respectively) imply that there is a linear relationship between them as is predicted by the SDF model, e.g., for a power utility function, see Cochrane (2000).