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Consumption risk and the cross-section of government bond returns

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ABSTRACT

In this paper we provide a consumption-based explanation of risk in nominal US Treasury bond portfolios. We use a consumption-CAPM with Epstein–Zin–Weil recursive preferences. Our model introduces two sources of risk: uncertainty about current consumption (reflected in contemporaneous consumption growth) and uncertainty about prospects of consumption in a long run (reflected in innovations to expectations about future consumption growth). We use a novel approach to estimate pricing factors in our model: we employ a factor-augmented VAR model with common factors, extracted from a large panel of macroeconomic and financial data, as state variables. We find that the important source of risk in US bonds is related to uncertainty in prospects in future consumption and it induces a positive and significant risk premium. We find as well that covariance risk related to innovations in expectations about future consumption growth is greater for long term bond portfolios than for short term bond portfolios, which is consistent with a duration measure of risk and justifies why long term bonds require greater premium than short term bonds. Our model explains well the cross-sectional variation in average excess returns of bonds with different maturities over the period 1975–2011 and compares favorably with competing models.

1. Introduction

We investigate, using a consumption-based capital asset pricing model (C-CAPM) with Epstein–Zin–Weil recursive utility, the cross-section of excess returns on portfolios of US Treasury bonds with varying times to maturity. Specifically, we ask the following questions: what can we learn about bond risk from consumption-based models? Is there a role for consumption risk to play in the explanation of risk premia for nominal bonds with different maturities? More generally, we add to the literature on consumption-based models for pricing bonds that is "surprisingly small, given the vast amount of attention given to consumption-based models of equity pricing" (Campbell, 2007).

The evaluation of risks in nominal government bonds has attracted a considerable attention for quite some time. Campbell et al. (2010), for example, point out that this can be done in many ways. One of them is to measure the covariance of bond returns with a proxy of the marginal utility of the consumers, like the return on market portfolio (as in the classical CAPM) or the aggregate consumption growth (as in the C-CAPM). Indeed early attempts to evaluate the risks of nominal bonds followed this approach (see for example Gultekin and Rogalski (1985)). More recently, Viceira (2012) finds that the consumption beta for bonds is negative, over the 1980s and 1990s, suggesting that nominal bonds help investors hedge aggregate market risks.

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Our work is in this spirit and builds on prior works but differs in two important respects. First, we use a consumption CAPM with Epstein–Zin–Weil utility rather than the standard power utility C-CAPM. This allows us to extend a measure of investors' well-being to include not only contemporaneous consumption growth but also to reflect the future evolution of consumption and the fact that consumers care about a long run risk in consumption as well, in the spirit of Bansal and Yaron (2004) model for equities. We can investigate then whether long run consumption risk can explain positive on average risk premia paid by government bonds. Second, our test assets, which are a set of government bond portfolios with different maturities rather than a single index of government bonds, allow us to study the variation of covariance risk across assets that may be imperfect substitutes. Specifically we investigate whether consumption risk related to uncertainty in prospects in future consumption can explain why bonds with greater maturities require greater excess returns.

Our C-CAPM has two risk factors: consumption growth and innovations to expectations about future consumption growth. While consumption growth is directly measurable, the innovations to expectations about future consumption growth are not and have to be estimated. It is usually done using a Vector Autoregressive (VAR) model[1] where specific state variables are selected that are known to forecast consumption growth well. Our implementation of this methodology is, however, novel. Instead of choosing specific predictor variables we use a set of common factors obtained, following Stock and Watson (2002a,b), from a large panel of macroeconomic and financial time series. We then estimate a factor-augmented VAR, in the spirit of Bernanke et al. (2005), and extract innovations to expected future consumption growth. This approach has some advantages. First, we can be agnostic in our choice of state variables thus mitigating to some extent concerns about the choice of specific state variables (see for example Chen and Zhao (2009)). Second, there is an evidence (Stock and Watson, 2008) that common factors have good forecasting properties in the presence of structural breaks. We further add to that and demonstrate that extracted factors have good predictive power for consumption growth in in- and out-of-sample tests, which forms the empirical basis for using them as state variables in our VAR model. Third, the pre-estimation of the dynamic factors does not affect the consistency of Ordinary Least Squares (OLS) estimates in the VAR model (Bai and Ng, 2008) which is relevant in our application.

Our main group test assets are bond portfolios that are constructed using US Treasury bonds with times to maturity ranging from over a year to longer than ten years. We use also bond indices with different target maturities and zero coupon bonds as alternatives. The sample period is 1975–2011. We use a covariance risk measure that reflects how bond excess returns covary with consumption growth and innovations to expectation in future consumption growth. We estimate Euler equation with linearized stochastic discount factor (SDF) using Generalized Method of Moments (GMM) in order to study how well our two-factor C-CAPM explains the cross-section of average excess returns on government bonds. This methodology allows us also to estimate the coefficient of relative risk aversion and test the theoretical restrictions of our model. We estimate as well linearized Euler equation with Fama–MacBeth approach. Finally, we compare our measure of long run risk in consumption growth for bonds with a measure of Parker and Julliard (2005) and investigate how it is related to duration, a classical measure of bond risk.

Our main results can be summarized as follows. We find that the risk related to long run uncertainty in consumption plays an important role in pricing US government bonds and induces a risk premium that is positive and significant. We find as well that our two-factor C-CAPM explains well the cross-section of average excess returns on portfolios of US Treasury bonds with differing maturities (around 98.8% of the cross-sectional variation) over the sample period 1975–2011. We also demonstrate that the covariance risk related to innovations to expectations about future consumption growth is greater for portfolios of long term bonds than for portfolios of short term bonds. This provides a consumption risk-based explanation on why long term bonds are paying on average greater returns than short term bonds. We show as well that the covariance risk related to prospects in future consumption is consistent with a classical measure of bond risk — duration and bonds with greater duration have as well greater covariance risk. The estimates of risk aversion parameter implied by the model are lower than for equities. Finally, we find that our model performs well relative to other linear factor models and prices well a joint portfolio of bonds and equities. Our results are robust to a battery of tests: the use of alternate test assets and sample period, alternate measures of consumption growth and estimation methods.

The rest of the paper is organized as follows. Section 2 provides an overview of related research while Section 3 provides the details of our model. Section 4 outlines key features of the applied methodology and Section 5 describes the data. We discuss our empirical results including comparison with other models and tests for robustness in Section 6. Section 7 concludes the paper. The Online Appendix provides the relevant details related to theoretical aspects of our model, results of robustness tests and the description of supplementary data used in the paper.

2. Related literature

Expositions of the canonical C-CAPM for equities are now a standard textbook material but applications in the context of bonds are not common; Wolman (2006) is an example of a pedagogic guide to the consumption-based modeling of bonds. We find, as noted earlier, that there is surprisingly little empirical research on the consumption-based explanation of the cross-section of government bond returns.

Gultekin and Rogalski (1985) are possibly the first to study how well Ross's APT model and the CAPM price the cross-section of constant maturity US government bond portfolios over the 1960–1979 period.[2] They find that average returns on bond portfolios

[1] Brunnermeier and Julliard (2008), Campbell and Vuolteenaho (2004), Lustig and Nieuwerburgh (2008).
[2] Roll (1971) is an example of early efforts to apply the CAPM to zero coupon bond data.