Bond Risk, Bond Return Volatility, and the Term Structure of Interest Rates

Luis M. Viceira[1]

Forthcoming *International Journal of Forecasting*
This draft: January 2010

Abstract

This paper explores time variation in bond risk, as measured by the covariation of bond returns with stock returns and with consumption growth, and in the volatility of bond returns. A robust stylized fact in empirical finance is that the spread between the yield on long-term bonds and short-term bonds forecasts positively future excess returns on bonds at varying horizons, and that the short-term nominal interest rate forecasts positively stock return volatility and exchange rate volatility. This paper presents evidence that movements in both the short-term nominal interest rate and the yield spread are positively related to changes in subsequent realized bond risk and bond return volatility. The yield spread appears to proxy for business conditions, while the short rate appears to proxy for inflation and economic uncertainty. A decomposition of bond betas into a real cash flow risk component, and a discount rate risk component shows that yield spreads have offsetting effects in each component. A widening yield spread is correlated with reduced cash-flow (or inflationary) risk for bonds, but it is also correlated with larger discount rate risk for bonds. The short rate forecasts only the discount rate component of bond beta.

JEL classification: G12.

---

[1] Graduate School of Business Administration, Baker Libray 367, Harvard University, Boston MA 02163, USA, CEPR, and NBER. Email lviceira@hbs.edu. Website http://www.people.hbs.edu/lviceira/. I am grateful to John Campbell, Jakub Jurek, André Perold, participants in the Lisbon International Workshop on the Predictability of Financial Markets, and especially to two anonymous referees and Andréas Heinen for helpful comments and suggestions. I am also very grateful to Johnny Kang for exceptionally able research assistance. I acknowledge the Division of Research at the Harvard Business School for their generous financial support.

1 Introduction

There is strong empirical evidence that the expected return on long-term bonds in excess of the return on short-term bonds is time-varying. Linear combinations of bond yields or, equivalently, forward rates, forecast future bond returns (Fama and Bliss 1987, Campbell 1987, Campbell and Shiller 1991, Cochrane and Piazzesi 2005, Fama 2005). For example, the spread between the yield on long-term bonds and the short-term interest rate forecasts positively future bond excess returns.

Standard asset pricing models predict that in equilibrium the expected excess return on an asset equals the product of the systematic risk of the asset times the aggregate price of risk. According to these models, time variation in expected bond excess returns must be the result of time variation in the aggregate price of risk, or in the quantity of bond risk, or in both.

There is also ample empirical evidence documenting the existence of common components in the time variation of expected excess returns on bonds and on stocks (Fama and French, 1989). This evidence suggests that time variation in expected bond excess returns is explained, at least partially, by a time-varying aggregate price of risk, as in the external habit formation models of Campbell and Cochrane (1999) or in the long-run consumption risk model of Bansal and Yaron (2004). Indeed, Wachter (2006) shows that external habit preferences can generate a positive forecasting relation between the yield spread and future bond excess returns, while Bansal and Shaliastovich (2008) show a similar result in the context of the long-run consumption risk model.

This paper adds to this research by investigating whether the quantity of bond risk—to which I will refer from now on simply as "bond risk"—is also time varying, and whether this time variation is correlated with variables which have been shown to explain time variation in bond excess returns. If expected bond excess returns change in response to changes in bond risk, one might expect that variables that forecast bond excess returns also explain changes in bond risk. Indeed, in concurrent work Campbell, Sunderam, and Viceira (2009) provide a rationale for systematic time variation in bond risk related to changes in the covariance of inflation with real economic variables.

I study two economically motivated measures of bond risk. The first one is the covariance—or a normalized measure of this covariance such as beta—of bond returns with stock returns. This is the measure of bond risk implied by the standard CAPM. The CAPM implies that the risk of an asset is measured as the covariance of the returns on that asset with the returns on the aggregate wealth portfolio, which is typically proxied by the stock market. From an asset allocation perspective, the covariance of stock returns and bond returns plays a central role in the asset allocation decisions of investors. The second measure of risk I consider is the covariance of bond returns with per capita consumption growth. This is the measure of bond risk implied by the standard Consumption CAPM.

The research conducted in this paper builds on previous work by Campbell (1986), Barsky (1989), Campbell and Ammer (1993), Shiller and Beltratti (1992) and others which explores the determinants of the comovement of stock and bond returns. The focus of this work has typically been the unconditional moments describing this comovement. More recently, Boyd, Hu, and Jagannathan (2005) and Andersen, Bollerslev, Diebold and Vega (2005) have shown that stock returns, interest rates and exchange rates appear to respond to macroeconomic news differently over the business cycle, suggesting the existence of a business cycle component in the variation of the second moments of returns. This paper looks explicitly at the relation between time variation in the realized second moments of bond returns—volatility and covariance with stock returns and with consumption growth—and time variation in variables which proxy for business conditions.

The use of realized second moments of returns to study time variation in risk has a long tradition in Finance that dates back at least to the work on stock return volatility of Officer (1973), Merton (1980), French, Schwert and Stambaugh (1987), and Schwert (1989). This tradition has been reinvigorated recently with theoretical and applied work by Andersen, Bollerslev, Diebold and Labys (2003), Andersen, Bollerslev, and Meddahi (2005), Barndorff-Nielsen and Shephard (2004) and many others. Their work provides the theoretical foundation for the use of time series of realized second moments as the basis for modeling the dynamics of volatility and covariance.[2] The numerous empirical applications of this work have typically focused on the study of time variation in the volatility of stock returns (both at the aggregate level and at the individual level) and in the volatility of exchange rates. This paper focuses instead on the study of time variation in bond risk and, secondarily, in bond return volatility.

One advantage to treating realized second moments as observable variables is that

---

[2] Andersen, Bollerslev, Christoffersen and Diebold (2006a, 2006b) provide an excellent summary of recent findings in this literature and their practical implications.

it greatly facilitates exploring the impact of macroeconomic and financial variables on their time series. An alternative methodology to study time variation in second moments is to treat them as latent variables. This alternative approach, which starts with the pioneering work of Engle (1982) on ARCH models, has a long tradition in Econometrics and Finance. However, this extensive and influential body of research has considered primarily autoregressive models for conditional variance, which Braun, Nelson and Sunier (1995), Bollerslev, Engle and Wooldridge (1998), Cho and Engle (1999), Engle (2002), and others have extended to a multivariate setting with joint autoregressive models for conditional covariances and variances.[3] Not until recently, with work by Sheppard (2008) and others, the latent variable methodology has considered models that allow exogenous variables to explain the dynamics of conditional second moments, in addition to their lagged values. Although I treat realized measures of bond risk as observable variables, I follow the empirical findings in the latent variable literature about the importance of an autoregressive component in conditional second moments, and allow for such component in bond risk. It is important to understand whether variables known to predict bond returns can also predict bond risk after controlling for its own lagged value.

The empirical analysis of realized bond risk in this paper shows robust empirical evidence of systematic variation in bond risk. I find that realized measures of bond risk and bond return volatility follow mean-reverting, persistent processes which can switch sign in the case of bond risk measures. Thus nominal bonds appear to be safe investments that exhibit a small or negative correlation with aggregate measures of wealth and consumption at times, and risky investments that exhibit a large positive correlation at other times. This low frequency variation in bond risk combines with high-frequency variation that appears to be driven by episodes of "flight to quality" from stocks to bonds in which bond betas experience short episodes of sharp declines.

Importantly, the low frequency variation in bond risk appears to be related to the behavior of the yield curve. The intercept of the yield curve—the short-term nominal interest rate—forecasts positively bond risk and bond return volatility, and its slope—the spread between the yield on long-term nominal bonds and the short-term nominal interest rate—forecasts positively bond risk.

The finding that the short rate also forecasts positively bond CAPM betas, bond consumption betas and bond return volatility adds to previous research showing similar forecasting ability of the short rate for stock return volatility and exchange rate

---

[3] See Andersen, Bollerslev, Chrisoffersen, and Diebold (2005) for a summary of this literature.

volatility.[4] Recent research (David and Veronesi 2004) has also shown that inflation uncertainty, as measured by a time series of cross-sectional dispersion in professional forecasts of inflation, is positively related to subsequent realized stock-bond return covariance. I show evidence that this variable is no longer a statistically significant predictor of the covariance of stock and bond returns once we control for the effect of the short rate in the same regression.

The results about the positive relation between the level of the short-term nominal interest rate and bond risk and bond return volatility lend support to the hypothesis in Glosten et al. (1993) that the short rate forecasts stock market volatility because it reflects inflation uncertainty, which in turn is likely to be correlated with aggregate economic uncertainty.[5] If the short rate proxies for inflation uncertainty and economic uncertainty, one might expect that it should also forecast bond return volatility and the covariance of stocks and bonds, in addition to stock return volatility.

Furthermore, consistent with this hypothesis, I also present empirical evidence that the effect of the short rate on the covariance of stock and bond returns, bond return volatility, and stock return volatility is much weaker in the period following the implementation of strong anti-inflationary policies by the Federal Reserve under Paul Volcker in the early 1980's, than in the period that preceded it. There is considerable empirical evidence that the last two decades of the twentieth century have been characterized by a significant and persistent reduction in the volatility of a broad array of macroeconomic variables, including inflation, aggregate and sectoral output growth, consumption growth, employment growth, and investment growth (Kim and Nelson 1999, McConnell and Perez-Quiros 2000, Stock and Watson 2002). Lettau, Ludvigson, and Wachter (2006) argue that this sustained decline in the volatility

---

[4] Campbell (1987), Breen, Glosten and Jagannathan (1989), Shanken (1990), Glosten, Jagannathan and Runkle (1993), Scruggs (1998), and others have documented a positive relation between the short nominal rate and stock market volatility. Giovannini and Jorion (1989) document a positive relation between the short nominal rate and exchange rate volatility.

[5] The argument in Glosten et al. (1993) builds on the Fisher hypothesis, which establishes a direct link between expected inflation and the short rate, and on the fact that empirically there is a positive relation between inflation volatility and its level (Fischer 1981, Brandt and Wang 2003). Also, Fama and Schwert (1977), Fama (1981), Huizinga and Mishkin (1984), Pennacchi (1991), Boudoukh and Richardson (1993), Boudoukh, Richardson and Whitelaw (1994) and others have documented a negative correlation between inflation and real activity, and between inflation and stock returns. Levi and Makin (1980), Mullineaux (1980), Hafer (1986), and Holland (1988) and others have documented a positive relation between inflation uncertainty and economic growth. This would suggest that times of higher inflation uncertainty are also times of higher aggregate uncertainty.

of macroeconomic activity can account for a substantial fraction of the run-up in aggregate stock prices during the 1990's.

The finding that the yield spread forecasts positively the bond-stock return covariance at short and long horizons suggests that the ability of the yield spread to forecast bond excess returns is related not only to changes in aggregate risk aversion—or the aggregate price of risk—, but also possibly to changes in bond risk. Moreover, in contrast to the effect of the short-rate on the second moments of bonds and stocks, the effect of the yield spread on bond beta and bond return volatility appears to be stable over time.

The price of nominal bonds varies as the result of changes in expected future inflation, expected future real interest rates, or expected future bond excess returns. The first effect is a real cash flow effect—since inflation determines the real cash flow on nominal bonds—, while the last two effects are discount rate effects. Therefore, changes in bond risk must be related to either changes in the real cash flow risk of bonds, or in the discount rate risk of bonds, or both. I use the vector autoregressive-log linearization approach of Campbell and Shiller (1988), Campbell (1991), and Campbell and Ammer (1993) to conduct an empirical decomposition of unexpected bond excess returns into real cash flow news and discount rate news components, and explore systematic time variation in the covariation of these components of bond returns with unexpected stock returns and with unexpected consumption growth.

Of course, this statistical decomposition can be sensitive to the specification of the vector autoregressive system (Campbell 1991, Campbell and Ammer 1993, Campbell, Lo, and MacKinlay 1997, Campbell and Vuolteenaho 2004, Chen and Zhao 2006). To minimize this issue, I include in the vector autoregressive system variables that plausibly help capture changes in expected inflation, ex-ante real interest rates, expected excess returns on bonds and stocks, and consumption growth.

Using this decomposition, I find empirical evidence that the short-term nominal rate is positively related to increases in the discount rate risk of nominal bonds. I also find that the yield spread is correlated with variation in both the cash flow risk and the discount rate risk of nominal bonds. It forecasts negatively the cash flow risk of bonds, and positively the discount rate risk. The latter effect dominates the former effect, resulting in an overall positive correlation of the yield spread with bond risk.

The structure of the paper is as follows. Section 2 describes the empirical measures of realized second moments of bond return and stock returns used in the paper, and presents an analysis of their univariate time series properties. Section 3 presents the main empirical results about in the paper, based on a multivariate time series analysis of the second moments of bond returns. Section 4 examines an empirical decomposition of bond CAPM and consumption betas into cash flow and discount rate betas. Section 5 concludes.

2 Empirical measures of realized second moments of bond returns

The basic empirical analysis in this paper is based on realized second moments of bond and stock returns measured at a daily frequency, in the spirit of Officer (1973), Merton (1980), French, Schwert and Stambaugh (1987), Schwert (1989), and others. Specifically, I consider the realized covariance of stock and bond returns, the realized volatility of bond returns, the realized volatility of stock returns, and normalized measures of the covariance of stocks and bonds.

The realized covariance of stock and bond returns between the end of month t and the end month $t+n$ (a proxy for integrated instantaneous covariance) is measured as

$$\sigma_{S,B}\left(t,n\right)=\frac{1}{22n}\sum_{d=t_1}^{t_D} r_{S,d}\times r_{B,d}, \tag{1}$$

where $[t_1, t_D]$ denotes the sample of available daily returns between the end of month t and the end of month $t+n$, and $r_{S,d}$ and $r_{B,d}$ are the stock and bond log returns on day d. Following standard practice in the literature on realized second moments, the number of days in a month is normalized to 22, and the mean correction is omitted. (Considering demeaned returns does not change the conclusions from the empirical analysis.)

Similarly, the realized volatility of stock and bond returns between the end of month t and the end month $t+n$, a measure of integrated instantaneous volatility, is measured as

$$\sigma_i^2\left(t,n\right)=\frac{1}{22n}\sum_{d=t_1}^{t_D} r_{i,d}^2, \tag{2}$$

where $i=S$ and B for stocks and bonds respectively.

I also consider normalized measures of the stock-bond return covariance. One such measure is correlation. Another is beta. My analysis focuses on the realized CAPM beta of bonds, because of its more natural interpretation as bond risk. Realized bond CAPM beta between the end of month t and the end month $t+n$ is measured as

$$\beta_{S,B}(t,n) = \frac{\sigma_{S,B}(t,n)}{\sigma_S^2(t,n)}. \tag{3}$$

These measures of realized second moments have been previously considered in the context of stock returns and exchange rates. Andersen, Bollerslev, Diebold and Labys (2003), Andersen, Bollerslev, and Meddahi (2005), Barndorff-Nielsen and Shephard (2004) and others have shown that the theory of quadratic variation implies that these measures converge uniformly to integrated instantaneous volatility and covariance under weak regularity conditions.

I build time series of realized second moments of bond and stock returns using daily returns on stocks and bonds extracted from the Fixed Term Indices File and the Daily Stock Indices File of the Center of Research in Security Prices (CRSP) at the University of Chicago. The CRSP Fixed Term Indices File provides daily total returns and yields on constant maturity coupon bonds, with maturities ranging from 1 year to 30 years starting on June 14, 1961. The CRSP Daily Stock Indices File provides daily total stock returns starting on July 2, 1962 through December 31, 2007. This sample is about one year shorter than the bond return sample, and thus determines the starting date for the common sample period, which extends through December 31, 2007. The empirical analysis is based on the log return on the 5-year constant maturity bond, and on the log return on the value weighted portfolio of all stocks traded in the NYSE, the AMEX, and NASDAQ.

Table 1 presents full-sample statistics of daily bond and stock returns for the common sample period (July 2, 1962 - December 31, 2007). Over this sample period, the mean log return on stocks was 10.53% per annum, the mean log return on bonds was 7.63% per annum, and the mean short-term interest rate—not shown in the table—was about 5.65% per annum. The standard deviation of stock log returns was 14.34% p.a., and the standard deviation of bond log returns is 4.67% p.a. These numbers imply that, ex-post, the Sharpe ratio of bonds was actually slightly larger than the Sharpe ratio of stocks over this sample period: 0.48 versus 0.40, based on annualized moments.

Table 1 also reports the full-sample correlation of daily stock and bond returns and the CAPM beta of bonds. Both measures reflect a positive but small covariance of daily bond returns with daily stock returns: Correlation is estimated to be 9.20%, and beta is 0.03. However, Figure 1 and Table 2 show that these full-sample estimates hide considerable variation over time in the comovement of stock and bond returns.

Figure 1 illustrates why it might be interesting to study time variation in bond risk. This figure plots 3-month rolling estimates of bond CAPM betas for the period 1963 through 2007 ($\beta(t, 3)$). It shows that the small full-sample estimate of bond beta hides considerable variation over time. It also suggests that some of this variation might be systematic: changes in beta appear to be persistent and mean reverting; periods of low bond betas are followed by periods of large bond betas. On average, realized bond betas were small through most of the 1960's and 1970's, significantly positive from the late 1970's through the mid-1990's, and significantly negative since 1997. Of course, there is considerable short-run volatility around those averages, some of which might be driven by transitory "flight to quality" events from stocks to bonds, as during the crash of October of 1987 or the Asian crisis of 1998, when bond betas fell dramatically.

Table 2 reports descriptive statistics of the realized monthly stock-bond return covariance, the CAPM beta of stocks, and the volatility of stock and bond returns. The table shows that the standard deviation of each measure of realized second moments is at least 1.5 times its mean. Realized covariance is the moment with the highest volatility relative to its mean, at 5.54 times. Realized bond CAPM beta, realized stock return volatility and realized bond return volatility also exhibit significant variability relative to their means, although it is lower than the variability of realized covariance. Overall, this confirms the visual impression from Figure 1 that realized second moments vary considerably over time

Table 2 also reports cross-correlations of realized second moments. Cross-correlation coefficients, while different from zero, are all well below 50% in absolute value. Realized stock-bond covariance and realized stock return volatility are positively correlated, with a correlation coefficient of 25%. This positive correlation helps explain why realized CAPM beta is less volatile than realized covariance. Realized bond return volatility is weakly negatively correlated with realized stock-bond covariance (-32.6%) and with realized bond CAPM beta (-16.3%), and weakly positively correlated with stock return volatility (22.2%). Thus bond return volatility tends to fall when the covariance of stock and bond return increases, and when stock return volatility falls.

To examine the persistency of time variation in realized second moments, Table 2 reports the autocorrelation function of realized covariance, realized bond CAPM beta, log bond return volatility and log stock return volatility. The table reports the autocorrelation statistics for log volatility for consistency with the subsequent multivariate analysis, which relies on log volatilities.[6] The autocorrelation function of realized second moments shows that they follow persistent processes with slowly decaying autocorrelation coefficients. This is a well known property of stock return volatility, which Table 2 shows extends to bond return volatility and to measures of the covariance of bond returns with stock returns.

A slowly decaying autocorrelation function might indicate the presence of long-range dependence. To test for that type of dependence, Table 2 also reports tests of long-memory in second moments. Specifically, the table reports Lo's (1991) modified range-over-standard-deviation (R/S) statistic, which corrects the standard R/S statistic for the presence of heteroskedasticity and short-range dependence—a "Newey-West corrected" R/S statistic. The last two rows of Table 2 report two values of the modified R/S statistic for each second moment: R/S (0) is the standard R/S statistic, which does not take into account short-range dependence in the series; R/S (12) uses autocovariances of the second moment up to order 12. The 5% and 1% critical values for this statistic under the null of no long-memory are 1.862 and 2.098 respectively, which suggest that one cannot unambiguously reject the null in all cases.

3 Time variation in bond risk, bond return volatility, and the term structure of interest rates.

3.1 Main results

This section explores whether the time variation in the second moments of bond returns documented in Section 2 is systematically related to movements in the term structure of interest rates. In particular, this section presents regressions of realized bond-stock return covariances, bond CAPM betas, and bond return volatility on

---

[6] The use of log volatility in regression analysis ensures that the variable of interest has a continuous support in the real line. The log transformation also makes sense in light of the evidence about heteroskedasticity and approximate log normality of stock returns and exchange rates (Andersen, Bollerslev, Diebold and Labys 2000, 2001).

the short-term nominal interest rate, and the spread between the yield on long-term nominal bonds and the short-term nominal interest rate. For completeness, I also present forecasting regressions for stock return volatility.

This exercise is motivated by two well established empirical regularities. First, there is robust empirical evidence that the yield spread forecasts positively bond excess returns. Second, there is also ample empirical evidence that movements in the level of interest rates are positively related to changes in stock return volatility and exchange rate volatility. Thus it is natural to ask whether the short rate also explains time variation in the second moments of bond returns, and whether this is related to changes in expected bond excess returns.

Table 3 presents regressions of bond log excess returns, measured at horizons ranging from one month to five years, onto the lagged short-term nominal interest rate and the lagged yield spread. Bond excess returns are measured as the excess log total return on a constant 5-year maturity Treasury coupon bond over the short-term nominal interest rate, taken as the log yield on a 30-day Treasury Bill. Both series are obtained from the CRSP US Treasuries and Inflation Indices File. The yield spread is the log yield on a 5-year artificial zero-coupon bond from the CRSP Fama-Bliss Discount Bond File minus the short-term rate.

The table reports t-statistics based on Newey-West standard errors, the R^2 of the regressions, and a Newey-West corrected χ^2 statistic of the significance of the slopes.[7] Both the yield spread and the short-term nominal interest rate follow persistent processes—see Table A1 and Table A2 in the Appendix. Under these conditions, Campbell and Yogo (2006) and Valkanov (2003) show that the interpretation of the regression statistics in terms of standard normal asymptotics depends crucially on the correlation of the innovations to these variables with unexpected bond excess returns.[8] When the magnitude of this correlation is small, the slope coefficients are unbiased, and the statistics admit the standard Gaussian interpretation. This is the case for the yield spread, whose innovations are only weakly correlated with unexpected bond excess returns (Table A1 and Table A2). Table 3 shows that the Newey-West corrected t-statistic on the yield spread is above 2.8 at all horizons, thus confirming for this sample period that the yield spread is a robust predictor of bond excess returns

---

[7] The number of lags included in the Newey-West correction is the horizon in months minus one. This choice of lag order is based on the fact that under the null of no predictability, the residuals of this long-horizon regression are autocorrelated up to an order equal to the number of periods in the horizon minus one.

[8] See also Torous et al. (2004), Viceira (1997), and references therein.

at all horizons, with a positive slope.

By contrast, the short rate follows a highly persistent process whose innovations are highly negatively correlated with unexpected bond excess returns (Table A1). This implies that the estimated slope coefficient on this variable is upward biased in finite samples (Stambaugh 1999)[9] and that the standard t-test of statistical significance exhibits important size distortions at all horizons. Thus even though the Newey-West corrected t-statistics on the nominal short-rate increase with investment horizon, and they are above two at horizons of 36 months or longer, the simulation results for the asymptotic distribution of regression coefficients and Newey-West corrected t-statistics shown in Torous et al. (2004, Table 3) suggest that it is questionable that the short rate forecasts bond excess returns at any horizon.

One possible interpretation of the regression results for bond excess returns is that the yield spread forecasts bond excess returns because it is an empirical proxy for time-varying bond risk. Under this interpretation, bond risk shows counter-cyclical variation, as the yield spread tends to be low around measured business cycle peaks, and high near throughs (Fama and French 1989). Of course, time variation in bond risk can be the result of time variation in the quantity of bond risk, time variation in the aggregate market price of risk, or both.

This paper focuses on the first possibility, that is, on whether the yield spread is positively correlated with measures of the quantity of bond systematic risk such as the covariance of bond returns with stock returns—as the CAPM would suggest—or the covariance of bond returns with aggregate consumption growth—as the Consumption CAPM would suggest.[10]

To examine this possibility, Table 4 and Table 5 report regressions of realized second moments measured at horizons up to 36 months on a constant, the lagged

---

[9] Stambaugh (1999) shows that estimate of the slope in return forecasting regressions suffers from small-sample bias whose sign is opposite to the sign of the correlation between innovations in returns and innovations in the predictive variable. In the bond return forecasting regression, the short rate is negatively correlated with bond returns, leading to a positive small-sample bias which helps to explain some apparent predictability. On the other hand, the yield spread is positively correlated with bond returns, leading to a negative small-sample bias which suggests that the small sample evidence of bond return predictability from the yield spread probably underestimates the true degree of predictability.

[10] Wachter (2006) considers an extension of the Campbell-Cochrane's (1999) habit formation model in which counter-cyclical variation in aggregate risk aversion leads to countercyclical time variation in real interest rates and real term premia.

value of the second moment, the lagged short-term interest rate, and the lagged yield spread. Panel A in Table 4 presents regression results for $\sigma_{S,B}(t,n)$, the n-month realized covariance of stock and bond returns defined in (1) and Panel B presents results for $\beta_{S,B}(t,n)$, the n-month realized CAPM beta of bond returns defined in (3). Table 5 reports regression results for log bond return volatility (Panel A) and for log stock return volatility (Panel B). Similar to Table 3, these two tables report Newey-West corrected t-statistics, the R^2 of the regressions, and the Newey-West corrected χ^2 statistic of the significance of the slopes. The Newey-West correction takes into consideration up to $(n-1)$ autocorrelations. Unlike the case of the short-term interest rate in Table 3, innovations in the predictors exhibit very low correlation with innovations in the dependent variables, suggesting that we can use standard Gaussian asymptotics to intepret the regression results in Table 4. Note that the 5% critical value of the χ^2 distribution with 3 degrees of freedom is 7.82, and the 1% critical value is 11.34.

Table 4 shows that the yield spread forecasts positively both the realized covariance of stock and bond returns, and its normalization given by the bond CAPM beta. The coefficient on the yield spread is statistically significant except at a 12-month horizon in the covariance regression, and significant at all horizons in the bond CAPM beta regression. These results suggest that at least part of the countercyclical variation in expected bond excess returns is driven by countercyclical variation in bond risk as measured by the comovement of bond returns with stock returns.

By contrast, Table 5 shows there is no evidence that the yield spread is related to movements in bond return volatility and stock return volatility. The slope of the yield spread in the regressions for log volatility is not statistically significant, except at a 1-month horizon for bond return volatility, and at a 12-month horizon for stock return volatility. Moreover, the point estimates of the slope change sign as we consider one return volatility or the other or, in the case of bond return volatility, one horizon or another.[11]

The regression results in Table 4 and Table 5 also show strong evidence that short rate forecasts positively both the covariance of bond and stock returns and the volatility of bond returns at all horizons. Consistent with prior empirical evidence, the short-rate also forecasts positively stock return volatility at short horizons. These

---

[11] Of course, the stock return log volatility regression results are redundant up to a nonlinear transformation given the regression results for the covariance and the bond CAPM beta. Note however that bond CAPM beta is the ratio of covariance to stock return volatility, not its log.

results thus show that the ability of the short rate to forecast positively the volatility of stock returns and exchange rates extend to the case of bond return volatility and the covariance of bond returns with stock returns. Since the short rate tends to move procyclically, these results suggest that the short rate captures a procyclical component in the time variation of the second moments of bond returns. Section 5 explores this result in more detail.

Table 4 and 5 do not report the intercepts of the second moment forecasting regressions to save space. However, it is interesting to remark that the intercepts in the regressions for realized covariance and bond CAPM beta are all negative and highly significant.[12] Thus periods of low short-term nominal interest rates and a flat yield curve tend to be times of low or negative bond betas. To the extent that the level of interest rates reflects inflation expectations, these estimates of the intercept suggest that bonds are safe assets in the sense that their returns are negatively correlated with stock returns when expected inflation is low.

Table 4 and Table 5 also show that lagged values of second moments also enter their own second moment forecasting regression significantly, but only at short horizons. In the case of bond risk, its lagged value helps explain high frequency variation, while the level and slope of the yield curve help explain its variation at lower frequencies. Excluding lagged values from the regressions shown in Table 4 still result in large R-square coefficients. For example, the R^2 of a regression of $\sigma_{S,B}(t,3)$ on a constant, the short-term interest rate, and the yield spread is 30%; the R^2 of a similar regression for $\beta_{S,B}(t,3)$ is 47%.[13] Thus movements in the intercept and the slope of the term structure of interest rates capture a large fraction of the total variability in realized bond risk. It is important to note though that term structure variables have a more difficult time fitting the last part of the sample period. While they are able to capture the general direction of realized covariance and bond beta—positive between 1994 and 1998, and negative afterwards—, they do not fit well their average level. Instead, they undershoot in the 1994-1998 period, and overshoot afterwards.

---

[12] The intercepts are also negative and statistically different from zero in regressions that omit the lagged value of the second moment.

[13] These regression results are not reported here to save space. However, they are available from the author upon request.

3.2 Stability

The period 1962-1993 was one in which the US economy experienced a long period of generally increasing short-term nominal interest rates and inflation until mid-1981, followed by another equally long period of generally declining nominal interest rates and inflation which brought them back to the levels prevailing in the 1950's and early 1960's. A recent paper (Fama, 2006) examines whether this long period of declining short rates and inflation has weakened the evidence about bond return predictability shown in Fama and Bliss (1987), and concludes that this evidence is robust to the presence of this slow mean reversion of the short rate.

Table 6 conducts a similar exercise for bond betas. It examines whether the variation in bond CAPM beta, bond return volatility and stock return volatility explained by the short rate and the yield spread between two subperiods, 1962.01–1981.07 and 1981.07–2007.12. The sample is split around the date in which the short rate reached its maximum in-sample value. The table reports regressions similar to those shown in Table 4 and Table 5, except that they add an extra term that interacts each variable with an indicator variable $IND(t)$ which is equal to zero between 1962.01 and 1981.07, and equal to one between 1981.08 and 2007.12. Panel A reports results for realized bond CAPM betas, Panel B for the log of realized bond return volatility, and Panel C for the log of realized stock return volatility. I only consider horizons up to 12 months, because each subperiod is not long enough to reliably test for changes at longer horizons. (In any case, the results do not change).

Table 6 shows that the coefficient on the short rate in all realized second moment regressions is significantly smaller in the post-1981 period and in the earlier period. The coefficient on the interaction term is negative and large in all cases. In the case of realized volatility of bond returns and stock returns, this coefficient is of roughly the same magnitude as the coefficient on the short rate, suggesting that the ability of the short rate to forecast changes in return volatility is concentrated in the period of increasing inflation and interest rates of the 1960's and 1970's.

By contrast, the effect of the spread is remarkably stable across both subsamples: The coefficient on the interaction term is not statistically significant in any of the regressions. Thus the spread forecasts positively realized bond betas and does not forecast realized volatilities in both subperiods.

3.3 Cochrane-Piazzesi tent-shaped bond return forecasting variable

There is also robust empirical evidence that a tent-shaped linear combination of forward rates—or, equivalently, bond yields—from the Fama-Bliss CRSP data file forecasts bond excess returns at multiple horizons, especially at a 12-month horizon (Cochrane and Piazzesi 2005). Thus it is interesting to ask if this variable also forecasts realized bond CAPM betas. Table 7 reports the results of this exercise.

Panel A in Table 7 reports long horizon regressions of bond log excess returns onto the short rate and the yield spread on one hand, and onto the short rate and the Cochrane-Piazzesi tent variable on the other. Note that the sample period in these regressions is slightly shorter than the sample period in the previous tables, as this variable is available only from 1964.01 through 2007.12. The 12-month horizon row essentially reproduces Cochrane-Piazzesi results for this sample period: The R^2 in the tent variable regression is 33% and the χ^2 statistic is 71. These statistics are 71% and 287% larger, respectively, than the corresponding statistics in the yield spread regression. Interestingly, however, both variables have similar ability to forecast bond excess returns at all other horizons.

Panel B in Table 7 reports forecasting regressions for realized bond CAPM betas. Table 7 shows that the yield spread and the tent variable have similar ability to forecast realized bond betas. Both regression models exhibit very similar $R^{2'}$s and χ^2 statistics, particularly at horizons 12 months or shorter.

The regression results shown in Table 7 thus suggest that the short rate and the yield spread, on the one hand, and the short rate and the tent variable on the other hand, capture similar components of the time series variation in expected bond excess returns and bond risk. Accordingly, the remaining of the paper focuses on the short rate and the yield spread as predictors of bond risk.

3.4 The short rate and inflation uncertainty

In a recent paper, David and Veronesi (2008) explore whether survey-based measures of inflation and earnings uncertainty have forecasting power for the realized covariance and volatility of stock and bond returns. They find that a survey-based measure of inflation uncertainty forecasts positively and significantly the realized covariance of bond and stock returns.

Following David and Veronesi (2008), I have constructed a survey-based measure of inflation uncertainty using the Survey of Professional Forecasters. This measure is a cross-sectional standard deviation of individual inflation forecasts at different horizons. This results in a time series of cross-sectional standard deviations at a quarterly frequency—the frequency at which the survey data is available—from the fourth quarter of 1968 through the fourth quarter of 2007.

Table 8 examines whether this measure of inflation uncertainty captures information about the time series variability of realized covariances and bond CAPM betas which the short rate and the yield spread do not. The table reports regressions of the realized covariance of stock and bond returns and realized bond CAPM betas on their lagged value, the David-Veronesi measure of inflation uncertainty, the short rate, and the yield spread. The table shows that, consistent with the results in David and Veronesi (2008), inflation uncertainty forecasts positively the realized stock-bond return covariance and bond CAPM beta when the short rate and the yield spread are excluded from the predictive regression—although the slope coefficient is only marginally significant.

However, when the short rate is included in the regression as an additional forecasting variable, the slope coefficient on inflation uncertainty ceases to be statistically significantly different from zero in both the realized covariance regression and the CAPM beta regression, and in some cases it even switches sign. By contrast, the coefficient on the short rate has a large t-statistic. The inclusion of the short-rate in the forecasting regressions does not increase the R^2 of these regressions significantly, suggesting that the short rate absorbs the effect on bond risk of the survey-based measure of inflation uncertainty.

These results lends support to the hypothesis in Glosten et al. (1993) that the short rate might reflect aggregate economic uncertainty in addition to expectations of future inflation and the real rate. Interestingly, the finding in Section 3.2 that the ability of the short rate to forecast return volatility is greatly diminished in the post-1981 period also lends support to this hypothesis, since this has been a period characterized by a significant fall in macroeconomic volatility (Kim and Nelson 1999, McConnell and Perez-Quiros 2000, Stock and Watson 2002).

4 Where does time variation in bond betas come from?

Section 3 has shown evidence that time variation in bond risk—as measured by the covariance of bond returns with stock returns—is positively related to movements in the level of short-term interest rates and in the spread between the yield on long-term bonds and the short-term interest rate. This section further explores this relation by performing a decomposition of bond returns into three components, and exploring the ability of the short rate and the yield spread to explain the time variation in the covariance of each component with realized stock returns.

This section also explores time variation in bond risk measured as the covariance of bond returns with consumption growth. Standard consumption-based asset pricing models imply that risk is related to the covariance of asset returns with the intertemporal marginal rate of substitution of consumption of the representative investor, which is typically a function of aggregate consumption growth. Thus one might also want to explore whether the covariance of bond returns with consumption growth is time varying, and whether the short rate and the yield spread are correlated with this measure of bond risk.

Unfortunately we do not observe consumption and inflation—which we need to do a bond return decomposition—at high frequencies, so the empirical analysis in this section is based on realized second moments measured at lower frequencies. Although realized second moments computed from lower frequency data are coarse measures of true second moments, Duffee (2005) shows in recent work that one can still use these realized moments to uncover economically meaningful time variation in risk.

4.1 Bond return decomposition

Using the log linear asset pricing framework of Campbell and Shiller (1988) and Campbell (1991), Campbell and Ammer (1993) derive an expression for the excess return on any asset with respect to the short-term interest rate as a function of news about future real cash flows, news about future real interest rates, and news about expected future excess returns. The Appendix shows that a straightforward adaptation of the Campbell-Ammer approach allows one to write the unexpected log nominal return on a bond in excess of the log nominal short rate as

$$\begin{aligned} xrb_{t+1} - \mathrm{E}_t\left[xrb_{t+1}\right] &= -\left(\mathrm{E}_{t+1} - \mathrm{E}_t\right)\left[\sum_{j=1}^{N} \rho_b^j \pi_{t+1+j}\right] \\ &\quad -\left(\mathrm{E}_{t+1} - \mathrm{E}_t\right)\left[\sum_{j=1}^{N} \rho_b^j r_{f,t+1+j}\right] \\ &\quad -\left(\mathrm{E}_{t+1} - \mathrm{E}_t\right)\left[\sum_{j=1}^{N} \rho_b^j xrb_{t+1+j}\right], \end{aligned} \tag{4}$$

where $xrb_{t+1} = rb^{\$}_{t+1} - y_{1,t}$, $rb^{\$}_t$ denotes the log of the nominal gross return on a nominal bond with maturity N, $y_{1,t}$denotes the short-term nominal log interest rate, π_{t+1} denotes the log inflation rate, and $r_{f,t}$ denotes the ex-ante real interest rate $(r_{f,t+1} = y_{1,t} - \mathrm{E}_t\left[\pi_{t+1}\right])$. ρ_b is a loglinearization constant described in the Appendix. This constant is equal to one when the bond is a zero-coupon bond. Otherwise, the constant is related to the average coupon yield on the bond.

The elements on the right hand side of equation (4) have a simple interpretation. The first element captures the real cash flow news component of nominal bond excess returns. Since the cash flow on a bond—coupons and principal—is fixed nominal terms, the cash flow in real terms will vary inversely with the price level. Therefore the real cash flow news component of nominal bond log excess returns is given by the negative of changes in expected future inflation. The second element and the third element capture the effect of news about discount rates—future real interest rates and excess returns or risk premia, respectively—on realized nominal bond excess returns.

The components of bond returns are unobservable, and must be estimated using econometric methods. Campbell and Ammer (1993) suggest estimating a vector autoregressive (or VAR) model that captures the dynamics of excess returns, and using these estimates to compute the news components of unexpected returns. Of course, this return decomposition is sensitive to the specification of the VAR system (Campbell 1991, Campbell and Ammer 1993, Campbell, Lo, and MacKinlay 1997, Campbell and Vuolteenaho 2004, Chen and Zhao 2006). I adopt their methodology and, to minimize specification issues, I include variables in the VAR system which one could reasonably expect to capture predictable variation in bond returns, stock returns, growth in real consumption per capita, inflation, and the ex-ante real interest rate. I also include variables that help identify bond nominal and real cash flows.

Unfortunately, the frequency of observation of some of these variables is not higher than a month or a quarter. Thus the empirical results shown in this section are all based on monthly and quarterly returns. I estimate two VAR systems. The first VAR model is based on monthly observations of excess log returns on bonds, excess log returns on stocks, log inflation, the nominal short-term log interest rate, the yield spread, and the log dividend-price ratio. The second VAR system augments the first system by including log consumption growth, and it is estimated for this reason using quarterly data. I estimate the systems using the same sample period as in the monthly regressions shown in Section 3.[14]

The residuals and the coefficient estimates from the VAR system allow the extraction of unexpected stock excess returns, unexpected bond excess returns, unexpected consumption growth, inflation news, and news about expected bond excess returns. Real interest rate news then obtain as a residual using equation (4). The Appendix provides details of the derivation of these components under the VAR specification, and reports the estimates of the VAR models.

Given estimates of the components of bond returns, unexpected stock returns, unexpected bond returns and innovations to consumption growth, it is straightforward to compute the time series of the realized covariance, the realized CAPM beta and the realized consumption beta of each component of bond returns, and to examine how these moments are related to time variation in the short rate and the yield spread.

4.2 Full sample estimates of the CAPM beta and the consumption beta of bonds

Before exploring the time variation in the second moments of bond excess returns and their components, it is useful to look at the full sample estimates of these moments. Table 9 reports full-sample estimates of the CAPM beta, the consumption beta of bond returns and the betas that result from the covariance of each component of bond excess returns with stock returns and consumption growth. That is, Table 9 reports the realized covariance of unexpected stock excess returns (Panel A) or consumption growth (Panel B) with real cash flow news— $-(\mathrm{E}_{t+1}-\mathrm{E}_t)[\sum_{j=1}^{N}\rho_b^j\pi_{t+1+j}]$—, real interest rate news — $-(\mathrm{E}_{t+1}-\mathrm{E}_t)[\sum_{j=1}^{N}\rho_b^j r_{f,t+1+j}]$—, expected excess return

---

[14] Results for a longer sample period that includes the decade of the 1950's—the earliest data for which observations of the yield spread are available—are very similar. These results are readily available from the author upon request.

news— $-(\mathrm{E}_{t+1} - \mathrm{E}_t)[\sum_{j=1}^{N} \rho_b^j xrb_{t+1+j}]$—, and unexpected bond excess returns —$xrb_{t+1} - \mathrm{E}_t\,[xrb_{t+1}]$—divided by the variance of unexpected stock excess returns or consumption growth. Note that the first three betas add up to the fourth.

Panel A shows that the full-sample estimates of the CAPM beta of bonds estimated from monthly returns and from quarterly returns are both positive but small—0.056 and 0.082, respectively. Table 2 shows a similar estimate using daily returns. But Panel A also shows that the small total CAPM beta hides substantial offsetting covariation of the components of bond returns with stock returns.

First, the estimate of the CAPM beta of the real cash flow component of bond returns is positive and it has a size at least twice the size of the total beta in both VAR models. A positive real cash flow beta implies that unexpected stock returns and inflation news are unconditionally negatively correlated in this sample period. Thus inflation contributes positively to bond risk as measured by its covariance with stock returns: Unexpected negative returns in the stock market tend to coincide with positive inflation surprises, which in turn drive bond returns down, making bonds risky in a CAPM sense.

Second, the estimate of the CAPM beta of the discount rate component of bond returns—i.e., the sum of the CAPM beta of the real rate news component plus the CAPM beta of the expected excess return news component—is negative and large in both VAR models. Its magnitude offsets in large part, but not completely, the CAPM beta of the component related to bond real cash flow news. As a result, the total CAPM beta of bonds is positive but small.

Interestingly, Panel A shows that the contribution of each component of bond discount rate news to total CAPM beta depends on whether we use the monthly VAR or the quarterly VAR to extract bond return news. At a 1-month horizon, the contribution of real interest rate news to total bond beta is large and negative, while the contribution of expected excess return news is small and positive. By contrast, at a 1-quarter horizon, both components contribute negatively to total bond beta.[15] But the net effect of the discount rate components of bond returns is the same at both frequencies: Together they tend to attenuate the contribution of the real cash flow component of bond returns to bond CAPM risk. Unexpected negative returns in

---

[15] This difference in results between the monthly and the quarterly VAR systems does not result from the fact that the quarterly VAR model also includes log consumption growth as an additional variable. A quarterly VAR model that excludes log consumption growth—and thus has an identical specification as the monthly VAR model—gives similar results.

the stock market tend to coincide with negative shocks to bond discount rates, which in turn drive bond returns up and make bonds less risky in a CAPM sense.

Panel B in Table 9 reports the full sample estimates of the consumption beta of bonds and its components. The unconditional full sample estimate of bond consumption beta is negative and large, at -0.475. Thus nominal bonds help investors hedge aggregate consumption risk. The bond return decomposition shows that the source of the negative correlation of realized bond returns with shocks to consumption growth is a large negative real cash flow component that reflects positive covariation between inflation news and shocks to consumption growth. Thus negative shocks to consumption growth tend to coincide with negative shocks to inflation which in turn drive the price of nominal bonds up. This makes nominal bonds an asset that can help investors hedge consumption risk.

The consumption beta of bond discount rate news—which results from adding up the real interest rate news beta and the expected excess return beta—is essentially zero, although this hides a large negative real interest rate news beta and a large positive expected excess return beta. A positive expected excess return beta implies that negative shocks to consumption tend to coincide with increases in bond risk premia. This is consistent with the predictions of habit consumption models in which negative surprises in consumption growth drive aggregate risk aversion up and lead to unexpected declines in asset prices (Campbell and Cochrane 1998, Wachter 2006).

4.3 Bond CAPM beta predictive regressions with monthly and quarterly returns

Prior to examining the time series variation in the CAPM betas of the components of bond returns, it is useful to verify whether the predictive regression results shown in Table 4 for realized covariances and bond CAPM betas obtained from daily returns also hold when we measure returns at lower frequencies. Table 10 reports predictive regressions of realized covariances and bond CAPM betas onto a constant, their own lagged value, the short-term nominal interest rate and the yield spread. Realized second moments are based on realizations of unexpected stock and bond excess returns extracted from the monthly VAR model.

Table 10 shows that the basic results shown in Table 4 hold reasonably well when using returns measured at a monthly frequency: Both the short rate and the yield spread positively forecast bond CAPM betas. As one might expect, Newey-West t-statistics, χ^2 statistics and R^2's are smaller, especially at short horizons, but the overall direction and significance of the results remain. Table 10 thus suggests that estimates of realized covariance and beta based on monthly observations of returns, while noisier estimates than those based on daily returns, can still uncover systematic patterns in the time series of second moments.

Table 11 reports predictive regressions for the realized CAPM betas of bond cash flow news (Panel A), real rate news (Panel B), and expected excess return news (Panel C) measured at horizons between three months and five years. The coefficient on the short rate is statistically significant only in the predictive regression for the CAPM beta of bond expected excess return news. The sign of the coefficient is positive. This result suggests that the positive relation between the level of the short interest rate and the total bond CAPM beta operates through the discount rate channel: Bonds become riskier at times of high interest rates because at those times stock returns and bond discount rates tend to move in opposite directions.

The coefficient on the yield spread is statistically significant in the three predictive regressions. Interestingly, the sign of this coefficient changes across the regressions: The yield spread forecasts negatively the real cash flow CAPM beta of bonds, and positively the discount rate CAPM beta of bonds.

A widening of the yield spread is associated with a decrease in the covariance of bond real cash flow news with unexpected stock returns or, equivalently, with an increase in the covariance of inflation news with unexpected stock returns. Table 9 shows that unexpected stock returns and inflation news are unconditionally negatively correlated; Table 11 shows that this correlation becomes less negative when the yield spread widens. Since the yield spread is a countercyclical variable (Fama and French, 1989), this result suggests that the stock market responds negatively to news of rising inflation in expansions, and less negatively or even positively in contractions. Boyd, Hu and Jagannathan (2005) also find a changing covariance between stock returns and unemployment news over the business cycle.[16]

However, a widening of the yield spread is also associated with an increase in the discount rate components of the CAPM beta of bonds. Times when the yield spread increases tend to be times when there is increased negative covariation between stock

---

[16] Specifically, they find that on average the stock market responds positively to news of rising unemployment in expansions, and negatively in contractions.

returns and bond discount rates, which makes bonds riskier. To the extent that the yield spread is a countercyclical variable, this result suggests that in recessions negative news about stocks tend to coincide with unexpected increases in bond discount rates, making stocks and bonds move in the same direction. This result is consistent with models of countercyclical variation in aggregate relative risk aversion, in which investors discount more heavily all long-term assets in bad times (Wachter 2006).

Overall, these effects suggest that in recessions—i.e., when the yield spread widens—the real cash flow (or inflation) risk of bonds decreases. But these are also times in which aggregate risk aversion increases and makes investors dislike all risky assets. The risk premium (or risk aversion) effect more than offsets the cash flow effect, and therefore bond risk moves countercyclically.

Table 12 reproduces the predictive regressions shown in Table 10 and Table 11 for bond excess returns and their components extracted from the quarterly VAR model. Betas are measured over four, twelve and twenty quarters. Table 12 shows that the basic results shown for bond returns measured at daily and monthly frequencies still hold when returns are measured at a quarterly frequency.

4.4 Bond consumption beta predictive regressions

Table 13 examines the ability of the short nominal interest rate and the yield spread to explain time variation in the realized consumption beta of bonds and its components. The predictive results shown in this table are based on bond unexpected excess returns, the news components of bond returns, and shocks to consumption growth extracted from the quarterly VAR model. Table 13 has a structure identical to that of Table 12.

Table 13 shows that the statistical evidence that the short rate and the yield spread explain time variation in bond consumption beta and its components is in general much weaker than the corresponding evidence for bond CAPM betas. In most instances, the coefficients on either the short rate or the yield spread are not statistically significant. However, we have already seen that the statistical evidence of significance of coefficients in bond CAPM regressions weakens as the return measurement frequency decreases. Therefore the weak statistical inference in consumption beta regressions could well be the result of the fact that realized second moments are based on returns and consumption measured at a relatively low (quarterly) frequency. In fact, the regression results for a longer sample period that starts in 1952 are stronger, particularly at the one-year horizon.[17]

At a one year horizon, both the short rate and the yield spread forecast positively the consumption beta of bonds. Thus increases in short-term nominal interest rates and in the yield spread forecast are correlated with increases in bond risk, both in a CAPM sense and in a Consumption-CAPM sense. Panel B, panel C, and panel D in the table report predictive regression results for the consumption betas of the components of bond returns. The short rate forecasts positively the consumption beta of bonds associated with discount rate news. The yield spread forecasts positively both the real cash flow component of bond consumption beta and the risk premium component, suggesting that a widening of the yield spread is associated with an increase in the covariance of shocks to consumption growth with both bond real cash flow news—or, equivalently, a decrease in the covariance of shocks to consumption growth with inflation news—, and bond discount rate news.

5 Conclusions

This paper documents time variation in the realized CAPM beta of bonds, the consumption beta of bonds, and bond return volatility, and shows that it is systematically related to movements in the term structure of nominal interest rates, particularly the intercept and the slope of the yield curve, which are themselves variables that proxy for business conditions. Thus this paper offers empirical evidence that the comovement of bond returns with stock returns (or consumption growth) can change significantly at business cycle frequencies.

A robust stylized fact in empirical asset pricing is that the expected excess return on long-term bonds is time varying, and that this time variation is positively related to movements in the yield spread. This paper shows evidence that time variation in bond risk, measured by both the CAPM beta of bonds and the consumption beta of bonds, is also positively related to the yield spread. This relation is robust across periods of generally increasing inflation and short-term interest rates, and periods of generally decreasing inflation and short-term interest rates. It is also robust to the inclusion in beta forecasting regressions of variables that proxy for inflation and economic uncertainty.

---

[17] These results are readily available from the author upon request.

A second stylized fact in empirical asset pricing is that short-term nominal interest rates forecast positively stock return volatility and exchange rate volatility. This paper shows that the nominal short-term interest rate also forecasts positively realized bond CAPM betas, bond consumption betas, and bond return volatility. Recent research has shown that measures of inflation uncertainty forecast positively the covariance of bond returns with stock returns (David and Veronesi 2004). This paper shows evidence that the short rate absorbs the effect of these measures on the covariance of bond and stock returns. This evidence lends support to the hypothesis in Glosten et al. (1993) that the short rate might be a market-driven empirical proxy for inflation uncertainty and, more generally, for aggregate economic uncertainty. Consistent with this hypothesis, the paper also shows that the ability of the short rate to explain time variation in bond betas, bond return volatility and stock return volatility is much weaker in the period after 1981, which has been characterized by low macroeconomic volatility.

This paper also investigates the sources of systematic time variation in bond risk by conducting a decomposition of unexpected bond returns into a real cash flow news component and a discount rate news component, and examining how the betas of each component are related to changes in the term structure of interest rates.

I find that the short-term interest rate forecasts positively the CAPM beta of all the components of bond returns. By contrast, the yield spread forecasts negatively the CAPM beta of the real cash flow news component of bond returns, which reflects the negative of the conditional covariance of stock returns with news about expected future inflation, and positively the CAPM beta of the discount rate component of bond returns. That is, a widening of the yield spread is associated with an increase in the covariance of unexpected stock returns with inflation news, which makes nominal bonds less risky from a cash-flow perspective. But it is also associated with an increase in the covariance of unexpected stock returns with bond discount rate news, which makes bonds riskier. Overall, the discount rate effect dominates the cash flow effect.

There are several possible directions of future research. First, the empirical analysis in this paper is based on standard measures of realized second moments for bond and stock returns which weight each observation equally. It would be interesting to repeat this analysis using measures of realized second moments based on the mixed data sampling (or MIDAS) technique of Ghysels, Santa-Clara and Valkanov (2005, 2006), which weights observations according to an exponentially decreasing weighting scheme that is estimated jointly with the forecasting regression equation. Second, one could adopt a latent variable approach along the lines suggested by Sheppard (2008) to explore the impact of term structure variables on bond risk and bond return volatility. A methodological extension of this approach can be helpful when exploring the determinants of time variation in the second moments of the components of bond returns, which cannot be observed at high frequencies.

A third direction of future research is to develop theoretical models, particularly in the area of term structure models, which can generate the empirical patterns uncovered in this paper, and at the same time link the relation between second moments and interest rates to underlying fundamental factors such as real interest rates and expected inflation. This is the approach followed in Campbell, Sunderam, and Viceira (2009), which builds and estimates a model of the term structure of interest rates in which the covariance of stocks and bonds changes over time as a result of a time-varying covariance of realized and expected inflation with the real economy.

A fourth direction of future research would be to examine the implications for asset allocation of changing correlations between bond returns and stock returns along the lines of Buraschi, Porchia, and Trojani (2006). This is particularly important in light of the fact uncovered in this paper that this correlation appears to move countercyclically. Campbell and Viceira (2002) and Chacko and Viceira (2005) have shown that persistent changes in expected returns and risk can lead long-term investors to optimally follow investment policies which differ significantly from the instantaneously mean-variance efficient portfolio policies that are optimal for short-term investors. This deviation reflects the desire of risk averse long-term investors to invest in assets that help them hedge time variation in investment opportunities. In this case, these investors might want to tilt their portfolios towards assets that help them hedge stock-bond correlation risk. Since nominal bonds appear to become safer—i.e., less positively correlated with stock returns— at the peak of the business cycle, when expected returns decline, nominal bonds themselves might be good correlation hedges.

6 References

Andersen, T.G., Bollerslev, T., Christoffersen, P.F., and Diebold, F.X., 2006a, "Volatility and Correlation Forecasting," in G. Elliott, C.W.J. Granger, and Allan Timmermann (eds.), *Handbook of Economic Forecasting.* Amsterdam: North-Holland, 778-878.

Andersen, T.G., Bollerslev, T., Christoffersen, P.F. and Diebold, F.X., 2006b, "Practical Volatility and Correlation Modeling for Financial Market Risk Management," in M. Carey and R. Stulz (eds.), *Risks of Financial Institutions*, University of Chicago Press for NBER, 513-548.

Andersen, T., Bollerslev, T., Diebold, F.X. and Labys, P.. 2000, "Exchange Rate Returns Standardized by Realized Volatility are (Nearly) Gaussian," *Multinational Finance Journal*, 4, 159-179.

Andersen, T. Bollerslev, T., Diebold, F.X. and Labys, P., 2001, "The Distribution of Realized Exchange Rate Volatility," *Journal of the American Statistical Association*, 96, 42-55.

Andersen, T., Bollerslev, T., Diebold, F.X. and Labys, P., 2003, "Modeling and Forecasting Realized Volatility," *Econometrica*, 71, 529-626.

Andersen, T., Bollerslev, T., Diebold, F.X. and Vega, C., 2005, "Real-Time Price Discovery in Stock, Bond and Foreign Exchange Markets," manuscript, Northwestern University, Duke University, University of Pennsylvania and University of Rochester.

Andersen, T., T. Bollerslev, and N. Meddahi, 2005, "Correcting the Errors: Volatility Forecast Evaluation Using High-Frequency Data and Realized Volatilities," *Econometrica*, 73, 279-296.

Bansal, R., and I. Shaliastovich, 2008, "A Long-Run Risks Explanation of Predictability Puzzles in Bond and Currency Markets," manuscript, Fuqua School of Business, Duke University.

Bansal, R., and Yaron, A., 2004, "Risks for the long run: A potential resolution of asset pricing puzzles," *Journal of Finance* 59, 1481-1509.

Barndorff-Nielsen, O.E., and N. Shephard, 2004, "Econometric analysis of realised covariation: high frequency based covariance, regression and correlation in financial economics," *Econometrica*, 72, 885-925.

Barsky, R. B., 1989, "Why Don't the Prices of Stocks and Bonds Move Together?," *The American Economic Review* 79(5), 1132-1145.

Bollerslev, T., Engle, R.F., Wooldridge, J.M., 1988, "A capital asset pricing model with time varying covariances," *Journal of Political Economy* 96, 116–131.

Boudoukh, J., Richardson, M., 1993, "Stock returns and inflation: a long-horizon perspective," *American Economic Review* 83, 1346–1355.

Boudoukh, J., Richardson, M., Whitelaw, R.F., 1994, "Industry returns and the Fisher effect," *Journal of Finance* 49, 1595–1615.

Boyd, J. H., J. Hu and R. Jagannathan, 2005, "The Stock Market's Reaction to Unemployment News: Why Bad News Is Usually Good for Stocks," *The Journal of Finance* 60(2), 649-672.

Brandt, M. W., and K. Q. Wang, 2003, "Time-varying risk aversion and unexpected inflation," *Journal of Monetary Economics* 50, 1457–1498.

Breen, W., Glosten, L.R., Jagannathan, R., 1989, "Economic significance of predictable variations in stock index returns," *Journal of Finance* 44, 1177–1189.

Braun, P.A., D.B. Nelson, and A. M. Sunier, 1995, "Good News, Bad News, Volatility, and Betas," *Journal of Finance* 50, 1575–1603.

Buraschi, A., P. Porchia, and F. Trojani, 2006, "Correlation Hedging," working paper, Imperial College, London, and University of St. Gallen.

Campbell, J. Y., 1986, "Bond and Stock Returns in a Simple Exchange Model," *Quarterly Journal of Economics*, 101, 785–804.

Campbell, J. Y., 1987, "Stock returns and the term structure," *Journal of Financial Economics* 18, 373–399.

Campbell, J. Y., 1991, "A variance decomposition for stock returns," *The Economic Journal*, 157-179.

Campbell, J. Y., and J. Ammer, 1993, "What moves the stock and bond markets? A variance decomposition for long-term asset returns," *Journal of Finance* 48, 3-37.

Campbell, J. Y., and J. H. Cochrane, 1999, "By Force of Habit: A Consumption-Based Explanation of Aggregate Stock Market Behavior,"*Journal of Political Economy*, 107, 205–251.

Campbell, J. Y., Lo, A. W., MacKinlay, A. C., 1997, *The Econometrics of Financial Markets*, Princeton University Press, Princeton, NJ.

Campbell, J. Y., A. Sunderam, and Luis M. Viceira, 2009,"Inflation Bets or Deflation Hedges? The Changing Risks of Nominal Bonds," NBER Working Paper 14701, Cambridge, MA.

Campbell, J. Y., and R. Shiller, 1988, "Stock prices, earnings, and expected dividends," *Journal of Finance* 43, 661-676.

Campbell, J. Y., and R. Shiller, 1991, "Term spreads and interest rates: A bird's eye view," *Review of Economic Studies* 58, 495-514.

Campbell, J.Y. and L. M. Viceira, 2002, *Strategic Asset Allocation*, Oxford University Press, Oxford, UK.

Chacko, G. and L. M. Viceira, 2005, "Dynamic Consumption and Portfolio Choice with Stochastic Volatility in Incomplete Markets ," *Review of Financial Studies*, Vol. 18, No. 4, Winter 2005.

Campbell, J. Y. and T. Vuolteenaho, 2004, "Bad beta, good beta," *American Economic Review* 94, 1249-1275.

Campbell, J. Y. and Mothohiro Yogo, 2006, "Efficient Tests of Stock Return Predictability," *Journal of Financial Economics* 81, 27–60.

Chen, L. and X. Zhao, 2006, "Return Decomposition," working paper, Michigan State University and Kent State University.

Cho, Y., and R. F. Engle, 1999, "Time-Varying Betas And Asymmetric Effects of News: Empirical Analysis of Blue Chip Stocks," NBER Working Paper 7330, Cambridge, MA.

Cochrane, J., and M. Piazzesi, 2005, "Bond risk premia," *American Economic Review* 95, 138-160.

David, A. and P. Veronesi, 2004, "Inflation and Earnings Uncertainty and Volatility Forecasts," working paper, Washington University in St. Louis and University of Chicago.

Duffee, G.R., 2005, "Time-variation in the covariance between stock returns and consumption growth," *Journal of Finance* 60, 1673-1712.

Engle, Robert F., 1982, "Autoregressive Conditional Heteroskedasticity with Estimates of the Variance of UK Inflation", *Econometrica* 50, 987–1008.

Engle, R.F., 2002, "Dynamic conditional correlation: A simple class of multivariate GARCH models," *Journal of Business and Economic Statistics* 20, 339–350.

Fama, E. F., 1981, "Stock returns, real activity, inflation and money," *American Economic Review*, 545-565.

Fama, Eugene F., 2006, "The Behavior of Interest Rates," *Review of Financial Studies* 19, 359-379.

Fama, Eugene F., and Robert R. Bliss, 1987, "The information in long- maturity forward rates," *American Economic Review*, 77, 680-692.

Fama, E., French, K., 1989, "Business conditions and expected returns on stocks and bonds," J*ournal of Financial Economics* 25, 23–49.

Fama, E., Schwert, G. W., 1977, "Asset returns and inflation," *Journal of Financial Economics* 5, 115–146.

Fischer, S., "Relative Shocks, Relative Price Variability, and Inflation," *Brookings Papers on Economic Activity*, 2, 1981, 381–431.

French, K. R., G.W. Schwert and R. F. Stambaugh, 1987, "Expected stock returns and volatility," *Journal of Financial Economics* 19, 3–29.

Ghysels, E., P. Santa-Clara, and R. Valkanov, 2005, "There is a risk-return tradeoff after all," *Journal of Financial Economics* 76, 509-548.

Ghysels, E., P. Santa-Clara, and R. Valkanov, 2006, "Predicting volatility: Getting the most out of return data sampled at different frequencies," *Journal of Econometrics* 131, 59-95.

Giovanni, A. and P. Jorion, 1989, "Interest Rates and Risk Premia in the Stock Market and in the Foreign Exchange Market," *Journal of International Money and Finance* 6, 107-123

Glosten, L. R., Jagannathan, R., Runkle, D., 1993, "On the relation between the expected value and the volatility of the nominal excess return on stocks," *Journal of Finance* 48, 1779–1801.

Hafer, R.W., 1986, “Inflation uncertainty and a test of the Friedman hypothesis,” *Journal of Macroeconomics* 8, 365–372.

Holland, A.S., 1988, “Indexation and the effect of inflation uncertainty on real GDP,” *Journal of Business* 61, 473–484.

Huizinga, J. and F.S. Mishkin, 1984, “Inflation and real interest rates on assets with different risk characteristics,” *Journal of Finance* 39, 699-712.

Kim, C.J., and C. R. Nelson, 1999, “Has the Economy Become More Stable? A Bayesian Approach Based on a Markov-Switching Model of the Business Cycle,” *The Review of Economics and Statistics*, 81, 608–616.

Lettau, M., S. C. Ludvigson, and J. A. Wachter, 2006, “The Declining Equity Premium: What Role Does Macroeconomic Risk Play?,” forthcoming *The Review of Financial Studies.*

Levi, M.D., Makin, J.H., 1980, “Inflation uncertainty and the Phillips curve: some empirical evidence.” *American Economic Review* 70, 1022–1027.

Lo, A. W., 1991, “Long-Term Memory in Stock Market Prices,” *Econometrica* 59(5), 1279-1313.

McConnell, M. M., and G. Perez-Quiros, 2000, “Output Fluctuations in the United States: What Has Changed Since the early 1980s?,” *American Economic Review*, 90(5), 1464–1476.

Merton, R.C., 1980, “On estimating the expected return on the market: An exploratory investigation,” *Journal of Financial Economics* 8, 323-361.

Mullineaux, D.J., 1980, “Unemployment, industrial production, and inflation uncertainty in the United States,” *Review of Economics and Statistics* 62, 163–169.

Officer, R., 1973, “The variability of the market factor in the New York Stock Exchange,” *Journal of Business* 46, 434-453.

Pennacchi, G.G., 1991, “Identifying the dynamics of real interest rates and inflation: evidence using survey data,” *Review of Financial Studies* 4, 53–86.

Schwert, G.W., 1989, “Why does stock market volatility change over time?,” *Journal of Finance* 44, 1207-1239.

Scruggs, John T., 1998, “Resolving the puzzling intertemporal relation between the market risk premium and conditional market variance: A two-factor approach,” *Journal of Finance* 53, 575–603.

Shanken, J. A., 1990, “Intertemporal Asset Pricing: An Empirical Investigation,” *Journal of Econometrics*, 45, 99-120.

Sheppard, K., “Economic Factors adn the Covariance of Equity Returns,” manuscript, Oxford-Man Institute of Quantitative Finance, Oxford University.

Shiller, R. J., and A. Beltratti, 1992, “Stock prices and bond yields: Can their comovements be explained in terms of present value models?,” *Journal of Monetary Economics* 30, 25-46.

Stambaugh, R. F., 1999, “Predictive regressions,” *Journal of Financial Economics* 54, 375–421.

Stock, J. H., and M. W.Watson, 2002, “Has the Business Cycle Change andWhy?,” in *NBER Macroeconomics Annual: 2002*, ed. by M. Gertler and K. Rogoff. MIT Press, Cambridge, MA.

Torous, W., R. Valkanov, and S. Yan, 2004, “On Predicting Stock Returns with Nearly Integrated Explanantory Variables,” *The Journal of Business* 77(4), pp 937-966.

Valkanov, R., 2003, “Long-Horizon Regressions: Theoretical Results and Applications,” *Journal of Financial Economics* 68, 27–60.

Viceira, L. M., 1997, “Testing for structural change in the predictability of asset returns,” unpublished manuscript, Harvard University, Cambridge, MA.

Wachter, J. A., 2006, “A Consumption-Based Model of the Term Structure of Interest Rates,” *Journal of Financial Economics* 79, 365-399.

7 Appendix: Bond return decomposition

A direct extension of the results Campbell and Ammer (1993) shows that we can decompose the unexpected log nominal return on any asset i in excess of the log nominal short rate as

$$\begin{aligned} xr_{i,t+1} - \mathrm{E}_t\left[xr_{i,t+1}\right] &\approx \pi_{t+1} - \mathrm{E}_t\left[\pi_{t+1}\right] + \left(\mathrm{E}_{t+1} - \mathrm{E}_t\right)\left[\sum_{j=0}^{\infty} \rho^j \Delta d_{t+1+j}\right] \\ &\quad - \left(\mathrm{E}_{t+1} - \mathrm{E}_t\right)\left[\sum_{j=1}^{\infty} \rho^j r_{f,t+1+j}\right] \\ &\quad - \left(\mathrm{E}_{t+1} - \mathrm{E}_t\right)\left[\sum_{j=1}^{\infty} \rho^j xr_{i,t+1+j}\right], \end{aligned} \tag{5}$$

where $xr_{i,t+1} = r^{\$}_{i,t+1} - y_{1,t}$, $r^{\$}_t$ is the log of the nominal gross return on the asset, $y_{1,t}$ is nominal short interest rate, π_{t+1} is the log inflation rate, d_t is the log real cash flow on the asset, and $r_{f,t}$ is the ex-ante real interest rate ($r_{f,t+1} = y_{1,t} - \mathrm{E}_t\left[\pi_{t+1}\right]$). The constant ρ is a loglinearization constant, given by $\rho \equiv (1 - \exp\{\overline{d-p}\})^{-1}$, $\overline{d-p}$ is the average log cash flow-price ratio, and Δ is the first-difference operator.

When the asset is a nominal bond, the nominal cash flow on the asset is constant, and the real cash flow is inversely proportional to the price level. Therefore $\Delta d_{t+1+j} = -\pi_{t+1+j}$ and (5) reduces to

$$\begin{aligned} xr_{b,t+1} - \mathrm{E}_t\left[xr_{b,t+1}\right] &\approx -\left(\mathrm{E}_{t+1} - \mathrm{E}_t\right)\left[\sum_{j=1}^{n-1} \rho_b^j \pi_{t+1+j}\right] \\ &\quad - \left(\mathrm{E}_{t+1} - \mathrm{E}_t\right)\left[\sum_{j=1}^{n-1} \rho_b^j r_{f,t+1+j}\right] \\ &\quad - \left(\mathrm{E}_{t+1} - \mathrm{E}_t\right)\left[\sum_{j=1}^{n-1} \rho_b^j xr_{b,t+1+j}\right], \end{aligned} \tag{6}$$

where n is the maturity of the bond, $\rho_b^j \equiv (1 - \exp\{\overline{-cpi - p_b}\})^{-1}$, and cpi denotes the price level and p_b denotes the log price of the bond. The first element on the right-hand side of (6) describes the impact of real cash flow news on unexpected bond excess returns; the second element describes the impact of real interest rate news; and third element describes the impact of news about excess returns—or risk premia. Together, the second and third elements describe the impact of discount rate news on unexpected bond excess returns.

Using the fact that the ex-ante real interest rate is given by $r_{f,t+1} = y_{1,t} - \mathrm{E}_t\left[\pi_{t+1}\right]$, we can write real interest rate news as a function of nominal interest rate news and inflation news:

$$(\mathrm{E}_{t+1}-\mathrm{E}_t)\left[\sum_{j=1}^{\infty}\rho^j r_{f,t+1+j}\right]=(\mathrm{E}_{t+1}-\mathrm{E}_t)\left[\sum_{j=1}^{\infty}\rho^j y_{1,t+1+j}\right]-(\mathrm{E}_{t+1}-\mathrm{E}_t)\left[\sum_{j=2}^{\infty}\rho^j \pi_{t+1+j}\right], \tag{7}$$

where the sums go to $(n-1)$ and $\rho \equiv \rho_b$ if we want to extract the real rate news for a bond of maturity n.

I extract estimates of the components on the right hand side of (6) and (7) from a monthly VAR(1) that includes, in this order, the following variables: log stock excess returns, log bond excess returns, the log dividend yield, log inflation, the log yield on T-bills, and the log yield spread. Table A1 presents estimates of the coefficients of this VAR (1) (Panel A) and the annualized standard deviation and cross-correlations of the residuals (Panel B). I also estimate a quarterly VAR(1) for the same variables, and another one that adds an additional equation for log consumption growth. I use the following notation for the VAR(1):

$$z_{t+1}=\Phi_0+\Phi_1 z_t+v_{t+1},$$

where z_{t+1} is the vector of state variables.

Given this notation, it is straightforward to show that

$$(\mathrm{E}_{t+1}-\mathrm{E}_t)\,z_{t+1+j}=\Phi_1^j v_{t+1},$$

which implies that

$$(\mathrm{E}_{t+1}-\mathrm{E}_t)\left[\sum_{j=1}^{\infty}\rho^j z_{t+1+j}\right]=\left(\sum_{j=1}^{\infty}\rho^j\Phi_1^j\right)v_{t+1}=\rho_b\Phi_1\left(I-\rho_b\Phi_1\right)^{-1}v_{t+j},$$

$$(\mathrm{E}_{t+1}-\mathrm{E}_t)\left[\sum_{j=0}^{\infty}\rho^j z_{t+1+j}\right]=\left(\sum_{j=0}^{\infty}\rho^j\Phi_1^j\right)v_{t+1}=\left(I-\rho_b\Phi_1\right)^{-1}v_{t+j},$$

$$(\mathrm{E}_{t+1}-\mathrm{E}_t)\left[\sum_{j=1}^{n-1}\rho^j z_{t+1+j}\right]=\left(\sum_{j=1}^{n-1}\rho^j\Phi_1^j\right)v_{t+1},$$

and so on.

Using these expressions and appropriate element selection vectors, we can extract news for any asset. A vector ιi that selects element i of another vector z is given by a column vector of the same dimension as z that has zeroes everywhere except for a one in position i.

In the VAR(1) systems I estimate, unexpected log stock excess returns and log bond excess returns are given by $\iota 1' v_{t+1}$ and $\iota 2' v_{t+1}$, respectively, and news about log consumption growth are given by $\iota 7' v_{t+1}$, where v_{t+1} denotes the vector of residuals from the appropriate VAR(1) system. These are the residuals of the log stock excess return equation, the log bond excess return equation, and log consumption growth equation in the appropriate VAR(1) system. I use the residuals from the stock return equation and the consumption equation to compute CAPM and Consumption CAPM betas.

For a bond of maturity n, the news components of the bond unexpected returns are given by

$$(\mathrm{E}_{t+1} - \mathrm{E}_t) \left[\sum_{j=1}^{n-1} \rho_b^j \pi_{t+1+j} \right] = \iota 4' \left(\sum_{j=1}^{n-1} \rho_b^j \Phi_1^j \right) v_{t+1} \equiv e_{\pi,t+1},$$

$$(\mathrm{E}_{t+1} - \mathrm{E}_t) \left[\sum_{j=1}^{n-1} \rho_b^j r_{f,t+1+j} \right] = \iota 5' \left(\sum_{j=1}^{n-1} \rho_b^j \Phi_1^j \right) v_{t+1} - \iota 4' \left(\sum_{j=1}^{n-2} \rho_b^j \Phi_1^j \right) v_{t+1} \equiv e_{f,t+1}$$

and

$$(\mathrm{E}_{t+1} - \mathrm{E}_t) \left[\sum_{j=1}^{\infty} \rho^j x r_{i,t+1+j} \right] = -\iota 2' v_{t+1} - e_{\pi,t+1} - e_{f,t+1}.$$

Note that the excess return component is computed as the difference between unexpected log bond excess returns and the two other components of log bond excess returns.

Figure 1
CAPM beta of bonds
(1962.07 - 2007.12)
Rolling realized beta of bonds based on 3-month windows of dialy returns on bonds and stocks.

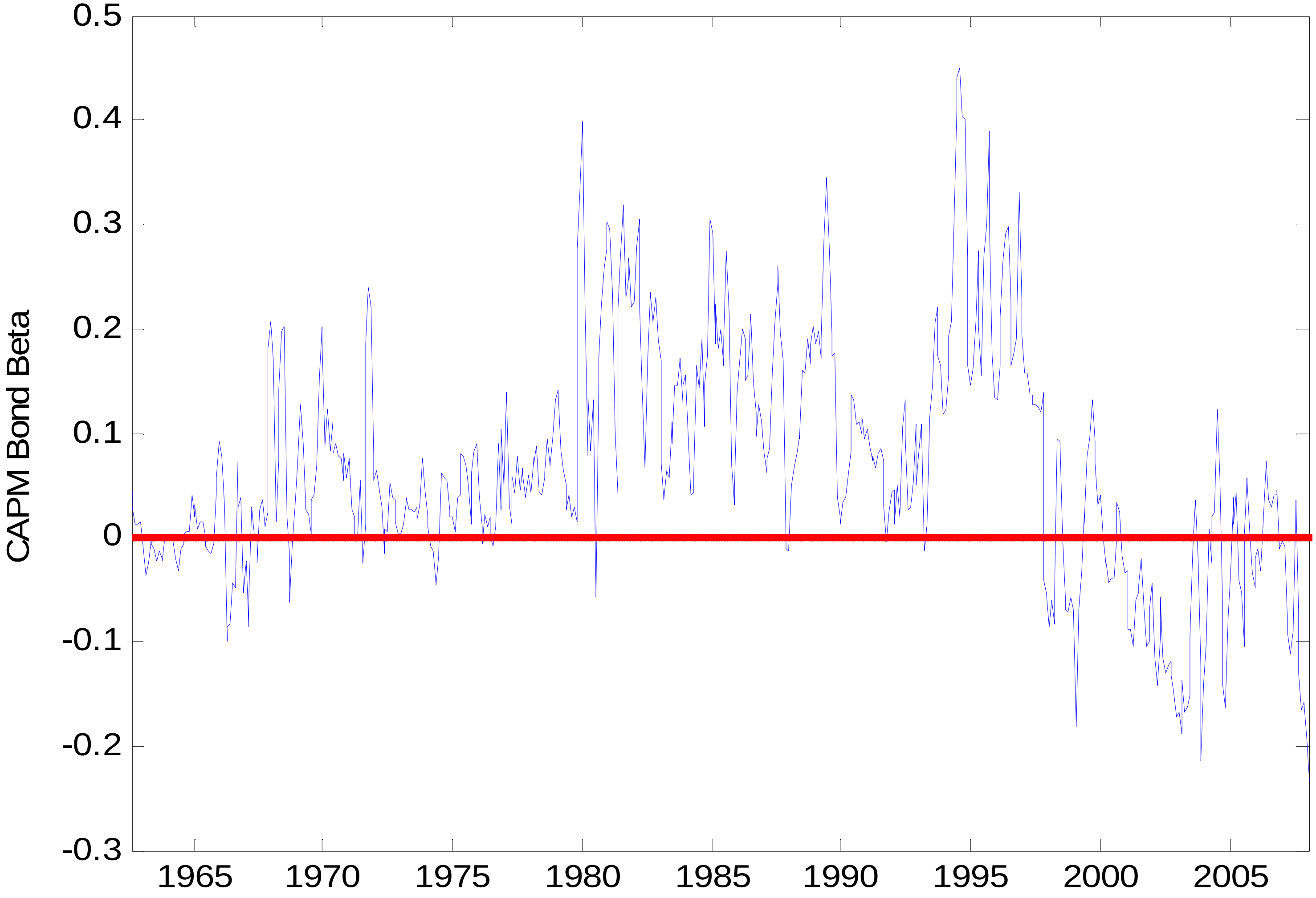

Table 1

Full sample moments of daily stock and bond returns
(1962.07.02-2007.12.31)

This table reports sample statistics of daily log stock and bond total returns. Stock returns are log returns on the stock total returns on the value weighted portfolio of all stocks traded in the NYSE, the AMEX, and NASDAQ from CRSP. Bond returns are log returns on the 5-year constant maturity bond from the CRSP Fixed Term Indices File.

	Stocks	**Bonds**	**Stocks and Bonds**
Mean return (% p.a.)	10.53	7.63	
Standard Deviation (% p.a.)	14.34	4.67	
Correlation (%)			9.20
CAPM beta of bonds			0.03

Table 2

Full sample moments of monthly realized covariance, bond beta, and the volatility of stock and bond returns
(1962.07-2007.12)

This table reports full sample statistics of monthly realized covariance, bond beta, and stock and bond return volatility. These estimates are based on the daily stock and bond returns described in Table 1. The estimators are given in equations (1) through (4) in text. ACF(#) is the autocorrelation coefficient of order #. R/S (#) is Lo's (1991) modified long-memory statistic and # is the number of autocovariances included in the computation of the statistic. The 5% and 1% critical values for this statistic under the null of no long-memory are 1.862 and 2.098 respectively. Please note that we report autocorrelation coefficients for log volatilities.

	$\gamma_{B,S}(t,1)$	$\beta_B(t,1)$	$\sigma_B^2\ t,1$	$\sigma_S^2\ t,1$
Mean	2.3 × 1e-6	0.07	$(3.89\%\ \text{p.a.})^2$	$(12.3\%\ \text{p.a.})^2$
S.D./Mean	5.54	1.89	1.54	1.84
Correlation with $\sigma_B^2\ t,1$ **(%)**	-32.6	-16.3	1.0	22.2
Correlation with $\sigma_S^2\ t,1$ **(%)**	21.3	24.9	22.2	1.0
ACF (1)	0.488	0.518	0.698	0.800
ACF (2)	0.462	0.484	0.612	0.747
ACF (3)	0.428	0.463	0.552	0.713
ACF (12)	0.267	0.420	0.387	0.546
R/S (0)	3.492	4.605	2.830	4.278
R/S (12)	2.014	2.429	1.390	1.886

Table 3

Predictive regressions for bond excess returns
(1962.07-2007.12)

Table 3 reports monthly overlapping regressions of long horizon log bond excess returns onto a constant, the log short rate y(t) and the yield spread spr(t). The short rate is the log yield on the 30-day Treasury Bill from CRSP, and the spread is the difference between the log yield on a 5-year artificial zero-coupon bond from the CRSP Fama-Bliss Discount Bond File, and the log yield on the Treasury Bill. We compute bond excess returns as the difference between the log total return a 5-year constant maturity coupon bond from CRSP, and the log yield on the Treasury Bill. The table reports coefficient estimates, the R^2 of the regression and, in brackets, Newey-West corrected t-statistics, and a Newey-West corrected χ^2 statistic of the significance of the slopes in the regression. The lag order of the Newey-West correction is equal to the horizon (in months) minus one. The χ^2 statistic has an asymptotic χ^2 statistic distribution with 2 degress of freedom. The 5% critical value of this distribution is 5.99, and the 1% critical value is 9.21.

Horizon (months)	**y(t) [t-stat]**	**spr(t) [t-stat]**	**R^2 (%) [χ^2-stat]]**
1	0.37 [0.76]	2.67 [2.96]	2.6 [9.53]
3	1.31 [1.14]	7.74 [3.35]	6.6 [11.81]
6	2.54 [1.41]	14.84 [4.13]	12.6 [17.18]
12	5.68 [1.65]	27.05 [4.30]	19.9 [19.11]
36	20.73 [3.15]	36.17 [2.84]	20.7 [13.99]
60	34.14 [4.54]	44.21 [2.90]	29.2 [21.51]

Table 4

Covariance and bond beta predictive regression
(1962.07-2007.12)

Table 4 reports monthly overlapping regressions of realized covariances (Panel A) and bond betas (Panel B) onto a constant, their own lagged value, the log short rate y(t) and the yield spread spr(t). Please refer to Table 1 and Table 3 for a description of the data underlying the construction of the left-hand side variables and right-hand side variables, respectively. The table reports coefficient estimates, the R^2 of the regression and, in brackets, Newey-West corrected t-statistics, and a Newey-West corrected χ^2 statistic of the significance of the slopes in the regression. The lag order of the Newey-West correction is equal to the horizon (in months) minus one. The χ^2 statistic has an asymptotic χ^2 statistic distribution with 3 degress of freedom. The 5% critical value of this distribution is 7.82, and the 1% critical value is 11.34.

(A) Covariance regression

Horizon (months)	**Lagged [t-stat]**	**y(t) [t-stat]**	**spr(t) [t-stat]**	**R^2 (%) [χ^2-stat]**
1	0.350	0.002	0.002	30.8
	[5.210]	[6.010]	[3.290]	[106.5]
3	0.488	0.001	0.001	45.3
	[4.920]	[4.640]	[2.230]	[100.3]
6	0.398	0.002	0.001	43.5
	[3.300]	[5.330]	[1.680]	[84.10]
12	0.389	0.001	0.001	47.5
	[1.920]	[3.790]	[0.790]	[77.28]
36	0.143	0.002	0.002	35.9
	[0.630]	[2.600]	[1.900]	[18.40]
60	-1.159	0.002	0.003	37.2
	[-0.430]	[2.620]	[1.940]	[11.19]

(B) Capm beta regression

1	0.370	19.30	31.14	34.6
	[7.290]	[5.870]	[5.120]	[239.47]
3	0.487	15.45	22.26	48.6
	[7.030]	[4.630]	[4.290]	[242.72]
6	0.565	12.30	19.80	55.3
	[6.250]	[3.180]	[3.220]	[219.02]
12	0.557	11.94	18.21	55.3
	[4.380]	[2.110]	[2.350]	[118.37]
36	0.116	20.73	27.39	31.1
	[0.550]	[2.520]	[2.230]	[17.91]
60	-0.430	31.02	38.72	36.7
	[-1.550]	[4.430]	[2.970]	[24.03]

Table 5

Volatility predictive regressions
(1962.07-2007.12)

Table 5 reports monthly overlapping regressions of realized bond return log volatility (Panel A) and stock return log volatility (Panel B) onto a constant, their own lagged value, the log short rate y(t) and the yield spread spr(t), as described in equation (6) in text. Please refer to Table 1 and Table 3 for a description of the data underlying the construction of the left-hand side variables and right-hand side variables, respectively. The table reports coefficient estimates, the R^2 of the regression and, in brackets, Newey-West corrected t-statistics, and a Newey-West corrected χ^2 statistic of the significance of the slopes in the regression. The lag order of the Newey-West correction is equal to the horizon (in months) minus one. The χ^2 statistic has an asymptotic χ^2 statistic distribution with 3 degress of freedom. The 5% critical value of this distribution is 7.82, and the 1% critical value is 11.34.

(A) Bond volatility regression

Horizon (months)	**Lagged log vol [t-stat]**	**y(t) [t-stat]**	**spr(t) [t-stat]**	**R^2 (%) [χ^2-stat]**
1	0.749	69.305	71.429	65.1
	[25.81]	[4.330]	[1.960]	[898.56]
3	0.768	66.904	18.462	68.7
	[16.74]	[3.09]	[0.390]	[402.09]
6	0.730	78.948	-22.894	66.2
	[9.330]	[2.780]	[-0.410]	[145.98]
12	0.609	95.417	-76.635	59.1
	[4.640]	[2.220]	[-1.040]	[45.67]
36	0.136	112.421	-23.386	30.6
	[1.030]	[1.840]	[-0.41]	[49.35]
60	-0.166	150.653	129.548	21.2
	[-0.550]	[1.860]	[0.980]	[10.67]

(B) Stock volatility regression

1	0.692	21.781	-3.815	49.0
	[22.14]	[1.740]	[-0.120]	[522.96]
3	0.654	30.553	-29.539	44.4
	[16.17]	[1.800]	[-0.700]	[287.97]
6	0.618	35.977	-56.441	40.8
	[9.900]	[1.710]	[-1.040]	[122.31]
12	0.567	31.293	-138.561	36.8
	[5.470]	[1.170]	[-2.370]	[46.18]
36	0.168	7.103	-132.314	7.8
	[0.940]	[0.200]	[-1.300]	[3.010]
60	-0.212	-25.298	-39.819	6.8
	[-0.830]	[-0.550]	[-0.390]	[1.070]

Table 6
Stability of capm beta and return volatility predictive regressions
(1962.07-2007.12)

Table 6 reports monthly overlapping regressions of realized bond beta (Panel A), bond return log volatility (Panel B) and stock return log volatility (Panel C) onto a constant, their own lagged value, the log short rate y(t) and the yield spread spr(t), as well as the interaction of each variable with an indicator variable IND(t) which is equal to zero between 1962.01 and 1981.07, and equal to one between 1981.08 and 2003.12. Please refer to Table 3 and Table 4 for a description of the data. The table reports coefficient estimates, the R^2 of the regression and, in brackets, Newey-West corrected t-statistics, and a Newey-West corrected χ^2 statistic of the significance of the slopes in the regression. The lag order of the Newey-West correction is equal to the horizon (in months) minus one. The χ^2 statistic has an asymptotic χ^2 statistic distribution with 6 degress of freedom. The 5% critical value of this distribution is 12.59, and the 1% critical value is 16.81.

Horizon (months)	lagged [t-stat]	IND*lagged [t-stat]	y(t) [t-stat]	IND*y(t) [t-stat]	spr(t) [t-stat]	IND*spr(t) [t-stat]	R^2 (%) [χ^2-stat]
(A) CAPM bond beta							
3	0.020	0.576	22.671	-9.006	22.627	0.277	52.4
	[0.220]	[5.450]	[6.280]	[-2.760]	[2.950]	[0.030]	[257.28]
6	0.151	0.493	20.392	-11.005	21.228	4.732	58.0
	[1.220]	[3.600]	[4.760]	[-2.960]	[2.500]	[0.450]	[257.90]
12	0.374	0.254	16.625	-12.414	12.834	18.312	58.5
	[2.070]	[1.450]	[2.790]	[-2.850]	[1.350]	[1.420]	[156.20]
(B) Bond return volatility							
3	0.620	-0.119	240.825	-217.618	208.566	-145.448	72.4
	[13.28]	[-5.270]	[6.010]	[-4.980]	[2.580]	[-1.600]	[482.06]
6	0.551	-0.121	258.334	-233.526	120.208	-58.403	71.0
	[7.110]	[-4.000]	[4.580]	[-3.710]	[1.290]	[-0.550]	[154.42]
12	0.403	-0.114	264.782	-252.636	-15.000	97.715	66.6
	[3.120]	[-3.800]	[4.310]	[-3.770]	[-0.160]	[0.860]	[57.28]
(C) Stock return volatility							
3	0.623	-0.072	84.003	-80.274	28.801	-115.416	47.1
	[16.00]	[-3.080]	[2.850]	[-2.340]	[0.470]	[-1.410]	[320.97]
6	0.580	-0.066	78.852	-64.839	-32.105	-80.164	44.1
	[9.900]	[-2.300]	[2.430]	[-1.520]	[-0.470]	[-0.790]	[134.02]
12	0.521	-0.074	77.622	-70.955	-106.700	-97.509	41.4
	[5.430]	[-2.010]	[2.020]	[-1.170]	[-1.190]	[-0.870]	[56.73]

Table 7
Short rate, spread, and tent variable
(1964.01-2007.12)

Table 7 reports monthly overlapping regressions of bond excess returns (Panel A) and realized bond beta (Panel B) onto a constant, their own lagged value (in the case of bond betas only, and not reported here), the log short rate y(t), and the yield spread spr(t) or Cochrane-Piazzesi tent-shaped linear combination of forward rates. Please refer to Tables 2 through 4 for a description of the data. The table reports coefficient estimates, the R^2 of the regression and, in brackets, Newey-West corrected t-statistics, and a Newey-West corrected χ^2 statistic of the significance of the slopes in the regression. The lag order of the Newey-West correction is equal to the horizon (in months) minus one. The χ^2 statistic in Panel A has an asymptotic χ^2 statistic distribution with 2 degress of freedom. The 5% critical value of this distribution is 5.99, and the 1% critical value is 9.21. The χ^2 statistic in Panel B has an asymptotic χ^2 statistic distribution with 3 degress of freedom. The 5% critical value of this distribution is 7.82, and the 1% critical value is 11.34.

(A) Expected return regression

Horizon (months)	**y(t) [t-stat]**	**spr(t) [t-stat]**	**tent(t) [t-stat]**	**R^2 (%) [χ^2-stat]**
3	1.352	7.791		6.5
	[1.150]	[3.320]		[11.49]
	-0.033		0.003	6.0
	[-0.030]		[3.370]	[13.28]
12	5.821	27.293		19.7
	[1.630]	[4.240]		[18.75]
	0.803		0.016	33.0
	[0.350]		[8.420]	[70.98]
36	20.378	35.502		19.1
	[2.990]	[2.650]		[11.90]
	13.986		0.017	21.2
	[2.300]		[3.510]	[24.68]

(B) Capm beta regression

3	15.474	22.315		47.8
	[4.480]	[4.200]		[226.68]
	10.638		0.006	45.9
	[3.210]		[2.340]	[202.07]
12	12.10	18.517		54.7
	[2.060]	[2.320]		[109.36]
	7.325		0.002	52.2
	[1.390]		[0.570]	[117.4]
36	21.22	29.008		31.5
	[2.54]	[2.270]		[16.68]
	13.150		0.001	24.5
	[1.540]		[0.250]	[16.87]

Table 8

Bond Risk and Inflation Uncertainty
(1968.Q4 -2007.Q4)

Table 8 reports quarterly overlapping regressions of realized covariances (Panel A) and bond betas (Panel B) onto a constant, their own lagged value, inflation uncertainty, the log short rate y(t) and the yield spread spr(t). Please refer to Table 2 and Table 3 for a description of the data. Inflation uncertainty is the cross-sectional standard deviation of inflation forecasts from the Survey of Professional Forecasters. The table reports coefficient estimates, the R2 of the regression and, in brackets, Newey-West corrected t-statistics, and a Newey-West corrected χ2 statistic of the significance of the slopes in the regression. The lag order of the Newey-West correction is equal to the horizon (in months) minus one. The χ2 statistic has an asymptotic χ2 statistic distribution with 2. 3 or 4 degress of freedom, depending on the regression.

(A) Covariance regressions

Horizon (months)	**Lagged [t-stat]**	**Infl Unc(t) [t-stat]**	**y(t) [t-stat]**	**spr(t) [t-stat]**	**R^2 (%) [χ^2-stat]**
3	0.624	0.000			41.8
	[5.90]	[1.79]			[45.12]
	0.512	0.000	0.001		46.1
	[4.61]	[0.25]	[4.28]		[59.29]
	0.453	0.000	0.002	0.002	47.8
	[3.52]	[-0.01]	[4.59]	[1.95]	[75.26]
12	0.624	0.000			41.8
	[7.06]	[1.46]			[57.29]
	0.512	0.000	0.000		46.1
	[4.99]	[0.24]	[5.18]		[78.75]
	0.453	0.000	0.000	0.002	47.8
	[3.77]	[-0.01]	[4.29]	[2.21]	[68.72]

(B) Capm beta regression

3	0.672	2.122			44.7
	[10.24]	[1.10]			[112.89]
	0.576	-1.828	11.908		48
	[6.67]	[-0.95]	[3.20]		[167.73]
	0.497	-3.091	18.069	22.070	50.5
	[5.45]	[-1.44]	[4.41]	[3.23]	[187.34]
12	0.672	2.122			44.7
	[10.81]	[0.89]			[123.37]
	0.576	-1.828	11.908		48.0
	[5.76]	[-0.90]	[2.86]		[159.67]
	0.497	-3.091	18.069	22.070	50.5
	[4.43]	[-1.44]	[3.65]	[3.65]	[128.83]

Table 9

Full sample estimates of components of bond beta

Table 9 reports full sample estimates of the components of bond beta described in section 4.2. This decomposition is based on monthly observations of unexpected stock and bond returns extracted from the VAR(1) described in text.

	Monthly VAR(1) (1962.07-2007.12)	**Quarterly VAR(1) (1962.Q3-2007.Q4)**
(A) CAPM Bond Beta		
Bond cash flow news	0.185	0.145
Bond real rate news	-0.160	-0.020
Bond excess return news	0.031	-0.043
Bond CAPM beta	0.056	0.082
(B) Consumption Bond Beta		
Bond cash flow news		-0.488
Bond real rate news		-0.268
Bond excess return news		0.282
Bond consumption beta		-0.475

Table 10

Covariance and bond beta predictive regression using monthly returns (1962.07-2007.12)

Table 10 reports monthly overlapping regressions of realized covariances (Panel A) and bond betas (Panel B) onto a constant, their own lagged value, the log short rate y(t) and the yield spread spr(t), as described in equation (6) in text. Realized covariances are based on monthly observations of unexpected stock and bond returns extracted from the VAR(1) described in text. The table reports coefficient estimates, the R^2 of the regression and, in brackets, Newey-West corrected t-statistics, and a Newey-West corrected χ^2 statistic of the significance of the slopes in the regression. The lag order of the Newey-West correction is equal to the horizon (in months) minus one. The χ^2 statistic has an asymptotic χ^2 statistic distribution with 3 degress of freedom. The 5% critical value of this distribution is 7.82, and the 1% critical value is 11.34.

(A) Covariance regression

Horizon (months)	**Lagged [t-stat]**	**y(t) [t-stat]**	**spr(t) [t-stat]**	**R^2 (%) [χ^2-stat]**
3	-0.002	0.075	0.022	13.2
	[-0.02]	[3.99]	[0.76]	[18.54]
6	0.116	0.063	0.007	23.4
	[1.45]	[4.33]	[0.27]	[23.98]
12	-0.022	0.069	0.025	29.6
	[-0.19]	[4.59]	[0.93]	[26.43]
36	-0.103	0.057	0.033	30.6
	[-0.84]	[4.47]	[1.07]	[25.61]
60	-0.579	0.073	0.072	41.0
	[-2.07]	[4.10]	[2.62]	[23.27]

(B) Capm beta regression

Horizon (months)	**Lagged [t-stat]**	**y(t) [t-stat]**	**spr(t) [t-stat]**	**R^2 (%) [χ^2-stat]**
3	0.024	45.327	47.954	4.5
	[0.86]	[4.13]	[2.07]	[26.95]
6	0.063	43.676	45.265	23.1
	[0.79]	[4.83]	[2.71]	[29.73]
12	-0.079	43.107	49.224	29.4
	[-0.60]	[4.46]	[3.22]	[34.11]
36	-0.017	31.463	28.107	28.9
	[-0.12]	[3.56]	[1.61]	[14.17]
60	-0.504	38.274	35.733	39.5
	[-2.16]	[4.04]	[2.17]	[25.94]

Table 11

Components of Bond CAPM beta (monthly return data)
(1962.07-2007.12)

Please refer to text for a description of this table.

(A) Bond Cash Flow News beta

Horizon (months)	y(t)	spr(t)	R^2 (%) [χ^2-stat]
3	4.121	-18.117	2.9
	[0.38]	[-1.16]	[9.38]
6	10.575	-23.776	8.0
	[1.54]	[-1.88]	[13.41]
12	9.722	-18.756	13.2
	[1.39]	[-1.54]	[25.50]
36	2.699	-24.217	23.4
	[0.66]	[-2.71]	[19.69]
60	-4.495	-23.356	21.7
	[-1.09]	[-2.49]	[12.19]

(B) Bond Real Rate News beta

3	-1.336	12.678	0.5
	[-0.27]	[1.26]	[2.64]
6	-1.393	11.651	2.7
	[-0.41]	[1.79]	[5.11]
12	-2.539	7.315	8
	[-0.77]	[1.19]	[10.44]
36	-0.981	5.050	25.3
	[-0.77]	[1.79]	[23.14]
60	1.782	6.443	33.0
	[1.30]	[2.10]	[10.20]

(B) Bond Excess Return News beta

3	41.520	56.146	6.8
	[3.77]	[3.15]	[32.03]
6	33.186	56.862	24.1
	[4.35]	[4.41]	[43.63]
12	33.493	57.324	32.8
	[4.57]	[4.77]	[62.86]
36	27.231	41.346	38.0
	[3.70]	[3.43]	[29.58]
60	34.519	42.519	46.9
	[4.44]	[3.11]	[19.83]

Table 12

Components of Bond CAPM beta (quarterly return data)
(1962.Q3-2007.Q4)

Please refer to text for a description of this table.

(A) Total Bond Beta

Horizon (quarters)	y(t)	spr(t)	R^2 (%) [χ^2-stat]
4	19.207	17.377	17.0
	[5.29]	[1.64]	[33.10]
12	13.487	10.184	21.0
	[2.39]	[0.73]	[12.47]
20	23.626	19.445	30.8
	[4.55]	[1.55]	[31.13]

(B) Bond Cash Flow News beta

Horizon (quarters)	y(t)	spr(t)	R^2 (%) [χ^2-stat]
4	1.196	-12.215	11.5
	[0.51]	[-2.89]	[16.83]
12	2.363	-10.367	32.8
	[1.75]	[-3.81]	[23.23]
20	-2.018	-10.451	21.1
	[-1.44]	[-3.4]	[13.08]

(C) Bond Real Rate News beta

Horizon (quarters)	y(t)	spr(t)	R^2 (%) [χ^2-stat]
4	5.081	3.399	16.6
	[3.47]	[0.89]	[21.21]
12	2.629	0.421	17.6
	[1.27]	[0.10]	[9.77]
20	5.700	3.564	18.0
	[2.59]	[0.82]	[13.37]

(D) Bond Excess Return News beta

Horizon (quarters)	y(t)	spr(t)	R^2 (%) [χ^2-stat]
4	12.470	25.930	13.6
	[3.39]	[3.03]	[17.27]
12	9.219	21.538	17.9
	[3.15]	[2.41]	[13.79]
20	12.269	16.222	30.0
	[3.59]	[1.92]	[35.83]

Table 13

Components of Bond Consumption beta (quarterly return data) (1962.Q3-2007.Q4)

Please refer to text for a description of this table.

(A) Total Bond Beta

Horizon (quarters)	y(t)	spr(t)	R^2 (%) [χ^2-stat]
4	0.143	-2.357	5.6
	[0.21]	[-1.20]	[5.08]
12	0.393	0.489	19.2
	[2.13]	[1.56]	[8.7]
20	0.192	0.054	41.6
	[2.78]	[0.38]	[86.41]

(B) Bond Cash Flow News beta

Horizon (quarters)	y(t)	spr(t)	R^2 (%) [χ^2-stat]
4	-0.118	0.365	2.8
	[-0.63]	[1.12]	[6.39]
12	-0.115	0.119	6.6
	[-0.80]	[0.68]	[5.04]
20	0.029	0.093	10.0
	[0.24]	[0.58]	[3.06]

(C) Bond Real Rate News beta

Horizon (quarters)	y(t)	spr(t)	R^2 (%) [χ^2-stat]
4	0.310	-0.836	7.6
	[2.51]	[-1.37]	[9.54]
12	0.134	-0.065	15.0
	[2.47]	[-0.74]	[10.26]
20	0.064	-0.047	9.5
	[1.25]	[-0.67]	[21.51]

(D) Bond Excess Return News beta

Horizon (quarters)	y(t)	spr(t)	R^2 (%) [χ^2-stat]
4	-0.093	-1.766	1.8
	[-0.14]	[-1.16]	[2.33]
12	0.384	0.422	14.3
	[1.58]	[1.37]	[9.15]
20	0.089	0.007	12.0
	[0.70]	[0.04]	[3.30]

APPENDIX: TABLES

Table A1
Estimates of Monthly VAR(1) model
(1967.07 – 2007.12)

A. Slopes (t-statistics in parenthesis)

	Intercept	Coefficients on lagged variables						R^2
		(1)	(2)	(3)	(4)	(5)	(6)	
(1) log stock excess returns	0.102	0.000	0.382	0.023	-1.487	-2.919	-0.210	0.063
	(3.256)	0.000	(2.994)	(3.058)	(-2.567)	(-2.503)	(-0.967)	
(2) log bond excess returns	-0.013	-0.068	0.126	-0.003	-0.505	1.000	2.779	0.074
	(-1.496)	(-3.319)	(2.392)	(-1.317)	(-1.981)	(1.771)	(3.028)	
(3) log dividend yield	-0.083	0.029	-0.417	0.980	1.696	1.970	-0.678	0.986
	(-2.563)	-0.516	(-3.229)	(128.248)	(2.712)	(1.623)	(-.306)	
(4) log inflation	0.007	0.002	-0.021	0.001	0.373	0.204	-0.470	0.388
	(3.7891)	-0.618	-(2.3577)	(3.392)	(6.702)	(2.633)	(-3.744)	
(5) log nominal yield on T-bills	0.000	0.002	-0.010	0.000	0.009	0.965	0.081	0.946
	(0.689)	-2.498	(-4.563)	(0.748)	(0.946)	(45.931)	(2.197)	
(6) log yield spread	0.000	-0.001	0.007	0.000	0.003	0.010	0.881	0.786
	(0.309)	(-1.076)	(3.719)	(0.132)	(0.428)	(0.576)	(27.121)	

B. Annualized percent standard deviations of residuals (diagonal) and cross-correlations of residuals (off-diagonal)

	(1)	(2)	(3)	(4)	(5)	(6)
(1) log stock excess returns	14.013	0.152	-0.952	-0.137	0.015	-0.126
(2) log bond excess returns	0.152	5.183	-0.152	-0.065	-0.471	-0.141
(3) log dividend yield	-0.952	-0.152	14.657	0.140	-0.011	0.120
(4) log inflation	-0.137	-0.065	0.140	0.883	0.101	-0.069
(5) log nominal yield on T-bills	0.015	-0.471	-0.011	0.101	0.175	-0.800
(6) log yield spread	-0.126	-0.141	0.120	-0.069	-0.800	0.158

Table A2
Estimates of Quarterly VAR(1) model
(1962.Q3-2007.Q4)

A. Slopes (t-statistics in parenthesis)

		Intercept	Coefficients on lagged variables							R^2
			(1)	(2)	(3)	(4)	(5)	(6)	(7)	
(1)	log stock excess returns	0.250	-0.007	0.352	0.056	-0.904	-1.971	-1.348	-0.287	0.062
		(2.483)	(-0.098)	(1.675)	(2.411)	(-.916)	(-1.445)	(-.532)	(-.164)	
(2)	log bond excess returns	-0.070	-0.057	-0.084	-0.014	0.052	1.018	3.683	0.141	0.101
		(-2.169)	(-2.468)	(-.695)	(-1.904)	(0.157)	(1.796)	(3.390)	(0.299)	
(3)	log dividend yield	-0.183	0.008	-0.356	0.955	0.810	1.060	0.258	0.355	0.952
		(-1.747)	(0.116)	(-1.679)	(39.482)	(0.807)	(0.769)	(0.102)	(0.194)	
(4)	log inflation	0.031	0.005	-0.042	0.007	0.305	0.078	-0.675	-0.113	0.493
		(3.7865)	(0.882)	-(2.668)	(3.5342)	(4.114)	(0.678)	(-3.069)	(-1.115)	
(5)	log nominal yield on T-bills	0.005	0.004	0.004	0.001	-0.001	0.903	0.034	0.003	0.860
		(1.860)	(2.025)	(0.334)	(1.872)	(-.046)	(18.214)	(0.355)	(0.046)	
(6)	log yield spread	-0.001	-0.001	0.001	0.000	0.000	0.030	0.783	-0.014	0.571
		(-.294)	(-0.509)	(0.154)	(-.478)	(-.004)	(0.918)	(12.400)	(-.280)	
(7)	log consumption growth	0.012	0.008	-0.033	0.002	-0.146	-0.040	0.066	0.383	0.288
		(2.653)	(2.526)	(-3.068)	(1.864)	(-3.064)	(-.704)	(0.591)	(6.203)	

B. Annualized percent standard deviations of residuals (diagonal) and cross-correlations of residuals (off-diagonal)

		(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1)	log stock excess returns	13.556	0.218	-0.969	-0.292	-0.185	0.052	-0.062
(2)	log bond excess returns	0.218	5.081	-0.224	-0.327	-0.771	0.173	-0.058
(3)	log dividend yield	-0.969	-0.224	13.706	0.278	0.184	-0.048	0.060
(4)	log inflation	-0.292	-0.327	0.278	1.042	0.314	-0.124	0.107
(5)	log nominal yield on T-bills	-0.185	-0.771	0.184	0.314	0.450	-0.756	0.109
(6)	log yield spread	0.052	0.173	-0.048	-0.124	-0.756	0.317	-0.100
(7)	log consumption growth	-0.062	-0.058	0.060	0.107	0.109	-0.10041	0.61682